Deccan Education Society's

Fergusson College (Autonomous) Pune

Learning Outcomes-Based Curriculum

for 2 years M.Sc. Programme

as per guidelines of

NEP-2020

for

S. Y. M. Sc. (Biotechnology)

With effect from Academic Year

2024-2025

Fergusson College (Autonomous), Pune
Proposed Second Year MSc Curriculum as per NEP 2020

Department of Biotechnology

M.Sc-II Biotechnology Structure

Semester	Paper Code	Paper Title	Credits
II	**BTH 601**	Genomics and Genetic Engineering	4
	BTH 602	Plant and Animal Biotechnology	4
	BTH 603	Stem Cell Biology, Regenerative medicine and Applied biotechnology	4
	BTH 604	Immunology	2
	BTH 620	Biotechnology Practical- 5	2
	BTH 621	Biotechnology Practical- 6	2

	BTH 622	Biotechnology Practical- 7	2
		Total Semester Credits	**20**
V	**BTH 651**	Proteomics and Metabolomics	2
	BTH 652	Virology and Molecular Diagnostics OR	4
	BTH 653	Nanotechnology OR	
	BTH 654	Bio-entrepreneurship	
	BTH 655	IPR and Bioethics OR	4
	BTH 656	Food Technology OR	
	BTH 657	Emerging Trends and Technologies	
	BTH 610	Research Project I	4
	BTH 660	Research Project II	6
		Total Semester Credits	**20**
		Total PG-II Credits	**40**

Teaching and Evaluation (Only for FORMAL education courses)

Course Credits	No. of Hours per Semester Theory/Practical	No. of Hours per Week Theory/Practical	Maximum Marks	CE 40 %	ESE 60%
1	**15 / 30**	**1 / 2**	**25**	**10**	**15**
2	**30 / 60**	**2 / 4**	**50**	**20**	**30**
3	**45 / 90**	**3 / 6**	**75**	**30**	**45**
4	**60 / 120**	**4 / 8**	**100**	**40**	**60**

Program Outcomes (POs) for M.Sc.	
PO1	**Disciplinary Knowledge:** Demonstrate comprehensive knowledge of the discipline that forms a part of a postgraduate programme. Execute strong theoretical and practical understanding generated from the specific programme in the area of work.
PO2	**Critical Thinking and Problem solving:** Exhibit the skill of critical thinking and understand scientific texts and place scientific statements and themes in contexts and also evaluate them in terms of generic conventions. Identify the problem by observing the situation closely, take actions and apply lateral thinking and analytical skills to design the solutions
PO3	**Social competence:** Exhibit thoughts and ideas effectively in writing and orally; communicate with others using appropriate media, build effective interactive and presenting skills

	to meet global competencies. Elicit views of others, present complex information in a clear and concise way and help reach conclusions in group settings.
PO4	**Research-related skills and Scientific temper:** Infer scientific literature, build a sense of enquiry and able to formulate, test, analyse, interpret and establish hypothesis and research questions; and to identify and consult relevant sources to find answers. Plan and write a research paper/project while emphasizing on academics and research ethics, scientific conduct and creating awareness about intellectual property rights and issues of plagiarism.
PO5	**Trans-disciplinary knowledge:** Create new conceptual, theoretical and methodological understanding that integrates and transcends beyond discipline-specific approaches to address a common problem.
PO6	**Personal and professional competence:** Perform independently and also collaboratively as a part of a team to meet defined objectives and carry out work across interdisciplinary fields. Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics.
PO7	**Effective Citizenship and Ethics:** Demonstrate empathetic social concern and equity centred national development, and ability to act with an informed awareness of moral and ethical issues and commit to professional ethics and responsibility.
PO8	**Environment and Sustainability:** Understand the impact of the scientific solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.
PO9	**Self-directed and Life-long learning:** Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes.

PSO No.	**Program Specific Outcomes (PSOs)** **Upon completion of this programme the student will be able to**
PSO1	**Academic competence:** (i) Gain strong foundation and knowledge in scientific fundamentals and acquire comprehensive understanding of the principles and practices of biotechnology including skill-based concepts, in an interdisciplinary course structure, provided by highly qualified and competent faculty. (ii) Acquire training in techniques/skills utilised in biotechnology and understand the scope and applications of biotechnology in well-equipped and state of the art laboratories. (iii) Achieve competence for higher studies, research and be employment ready in the domain of Biotechnology and allied fields. (iv) Demonstrate qualities of responsible biotechnologists that can work within the interdisciplinary framework of biotechnology and related fields

PSO2	**Personal and Professional Competence:** (i) Analyze and interpret data and provide solutions to basic problems relevant to biotechnology and related fields. (ii) Apply appropriate tools and techniques in biotechnology, combine experimental and computational approaches to design and perform experiments proficiently. (iii) Demonstrate and apply knowledge and skill in the design and development of solutions for relevant problems to cater to the requirements of biotechnology industries. (iv) Acquire good oral and written communication skills. (v) Experience the opportunity to curate/ manage or participate in a variety of co and extracurricular activities that will cater to the overall personality development.
PSO3	**Research Competence:** (i) Develop an interdisciplinary approach to conduct original research in various fields of Biotechnology and allied fields. (ii) Demonstrate appropriate skills in design of experiments with appropriate controls, critical thinking and result analysis. (iii) Apply statistical skills and computational tools to explore, analyse and authenticate biological data in experiments and research.
PSO4	**Entrepreneurial and Social competence:** (i) Implement skills and knowledge acquired in skill imparting and entrepreneurial courses in upcoming fields of Biotechnology. (ii) Develop a sense of social, ethical, environmental, and professional responsibility. (iii) Practise professional ethics in the conduct of science. (iv) Recognize the importance of Bioethics, IPR, entrepreneurship, Communication and management skills so to be ready to pursue future course of career

M.Sc- II Semester III		
BTH-601	**Genomics and Genetic Engineering**	**Credits:** 4 **Hours: 60**
	Course Outcomes (COs) **On completion of the course, the students will be able to:**	**Bloom's Cognitive Level**
CO1	State concepts related to genome organization, mapping, annotation and sequencing using databases and bioinformatics tools.	1
CO2	Outline the concept of genomics and discuss its current applications.	2
CO3	Integrate genomic strategies in identification of novel proteins, toxicity testing, discovery of drugs and microbiome.	3
CO4	Define the basics of recombinant DNA technology and its methods.	4
CO5	Comprehend strategies for expression and identification of industrially important products in prokaryotic and eukaryotic host systems.	5
CO6	Illustrate the need of advanced tools and vectors in genetic engineering and genetically modified organisms.	6

Unit No.	Content	No. Of Hours (60)
I	**Genomics:** Transition from a single gene to genomics. Genome overview at the level of Chromosome (with model organisms example). Strategies for large-scale DNA sequencing- Whole genome analysis techniques, Next generation sequencing methods; Organization, structure and mapping of genomes. Genome Annotation, Comparative Genomics, Structural and functional Genomics. Databases and tools for DNA sequencing and analysis.	**20**
II	**Applications**: Toxicogenomics, Pharmacogenomics, Gene disease association, Microbiome: Concept, Microbiome and Human health (examples), Personalized medicine. Human Microbiome Project (HMP): Goals, Significance, potential applications and challenges.	**10**

III	**Tools in genetic engineering:** DNA modifying enzymes and restriction enzymes for Genetic engineering, Cloning and expression Vectors-Plasmid, Phages, BAC, YAC, Modular. Host types and specificity for recombinant molecule production. cDNA, genomic DNA libraries and their screening.	**8**
IV	**Expression strategies and methods for producing industrially important molecules:** Strategies for production of industrially important molecules with case studies. Techniques for analyzing genes and gene expression (Microarray, qPCR, Chromatin immunoprecipitation, RNA seq and western blotting). Investigative techniques – EST, SAGE, SNP.	**12**
V	**Advanced Tools in genetic engineering:** CRISPR-Cas 9, MAGE, sRNA-based knockdown, promoter engineering, Genome re-coding, integrase, zinc finger nucleases, TALENs, Knock-out and Knock-in technologies. Current research and applications. Overview of GMOs: databases, ethics, current research and applications.	**10**

References:

1. Textbook on Cloning Expression And Purification Of Recombinant Proteins, (2022) Bose K, Springer
2. Gene Cloning and DNA Analysis: an introduction, 6th edition, (2010) T. A. Brown, Wiley-Blackwell Publisher, UK
3. Terence Brown. Genomes. 4th ed. Oxford: Wiley-Liss; 2017
4. A Complete Guide to Gene Cloning: From Basic to Advanced (2022), Nayana Patil, Aruna Sivaram, Springer Nature
5. Molecular Biology of the Gene, 6th Edition (2008), James D. Watson, Tania Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Lodwick, Pearson Education, Inc. and Dorling Kindersley Publishing, Inc. USA
6. Molecular Biotechnology: 4th edition. (2010), Glick B.R., Pasternak J.J., Patten C. L., ASM press, USA.
7. Principles of Gene Manipulation & Genomics, 7th Edition (2006), Primrose and Twyman, Blackwell Publishing, USA.
8. Molecular cloning – a laboratory manual – (Vol. 1-3), 4rd edition, (2012), Green and Sambrook, Cold Spring Harbor Laboratory Press, USA
9. Reeves, Gabrielle A., et al. "Genome and Proteome Annotation: Organization, Interpretation and Integration." Journal of the Royal Society, Interface, vol. 6, no. 31, Feb. 2009, pp. 129–47. doi:10.1098/rsif.2008.0341.

M.Sc. II Semester III		
BTH-602	**Plant and Animal Biotechnology**	**Credits: 4** **Hours:** 60
	Course Outcomes (COs) **On completion of the course, the students will be able to:**	**Bloom's Cognitive Level**
CO1	Describe the methods for *in vitro* propagation of plants	1
CO2	Explain Secondary Metabolites in plants and their biogenesis. Review their significant role in plant defense. Specify Biotechnological tools to enhance the production of secondary metabolites	2
CO3	Describe transgenic techniques used for Biotic and Abiotic stress tolerance in plants. Apply this technique to increase productivity, for quality improvement and production of antibodies in plants.	3
CO4	Implement principles of animal cell culture, media preparation, laboratory use.	4
CO5	Explain in vitro fertilization and embryo transfer technology. Describe the limitations and challenges facing the animal industries and disciplines	5
CO6	Discuss and extrapolate ethical concerns over the use of animal biotechnology	6

Sr. No	Content	Number of Hours (60)
	PLANT BIOTECHNOLOGY	**30**
I	**In vitro propagation of plants:** Micropropagation Organogenesis: Direct and Indirect Somatic embryogenesis and artificial seeds In vitro production of haploids Protoplast isolation and fusion Somaclonal variation Germplasm storage and cryopreservation.	**7**
II	**Secondary metabolites in plants-**	**6**

	Introduction and concept: Secondary metabolites in plant defence mechanisms Physiology and ecological functions of secondary metabolites Phytochemicals- Terpenes Phenolic compounds Alkaloids Therapeutic Applications of Secondary metabolites. Use of Elicitors for secondary metabolite production in plant cell cultures	
III	**Gene Transfer in plants** Gene Transfer methods (With specific examples): Non-vector based gene transfer Chemical methods Physical methods Vector mediated Agrobacterium mediated gene transfer Virus mediated gene transfer	**6**
IV	**Applications of Transgenic Technology in Plants** Transgenic plants for abiotic stress tolerance Transgenic plants for biotic stress tolerance Transgenics for quality improvement. Production of plant secondary metabolites Transgenic plants as bioreactors: Improvement in Carbohydrates, Proteins, Lipids, Plantibodies, Edible vaccines.	**7**
V	**Molecular Markers and Marker Assisted Selection (MAS)** Morphological Markers Biochemical Markers Molecular Markers: Non-PCR based and PCR based approaches Marker Assisted Selection (MAS).	**4**

	ANIMAL BIOTECHNOLOGY	30
I	**Concept of Tissue culture.** Factors affecting the success of in vitro culture; Physico chemical requirements Buffers, Balanced salt solutions and Growth Media types and formulation: natural, synthetic, sera and substitutes Maintenance of asepsis, Sterilization of media, reagents and labware Contamination: Types, Detection methods, Prevention methods Storage and transport of cell cultures Equipment required for ATC	**8**
II	**Evolution of Cell line**: Concept, properties of cell lines and types; Cell Culture Systems: Monolayer, Suspension Organ Culture, Histotypic, Organotypic Culture	**7**
III	Overview-livestock breed and their productivity, artificial breeding methods and hazards, marker assisted breeding of livestock. artificial breeding – in vitro fertilization and embryo transfer technology, artificial insemination, germ cell storage, Introduction to animal genomics, different methods for characterization of animal genomes, SNP, STR, QTL, RFLP, RAPD, genetic basis for disease resistance	**7**
IV	**Applications:** Application of animal cell culture for *in vitro* testing of drugs, in production of human and animal viral vaccines and pharmaceutical proteins. Culture Scale up and mass production of biologically important compounds. Harvesting of products, purification and assays. Hybridoma Technology, Virus propagation	**8**

References:

1. R. Ian Freshney. Culture of Animal cells, 5rd Edition, 2010. A John Wiley & Sons, Inc., Publications, USA
2. R.W.Masters. Animal Cell Culture- Practical Approach, 3rd Edition ,2000, Oxford University Press. USA
3. Robert Lanza et al. Essentials of Stem Cell Biology", Academic Press, 2nd edition, 2006.USA
4. Text book of Animal Husbandry, 8th edition, (1998) G.C. Banerjee,Oxford and IBH Publishing co.Pvt. Ltd. India

5. Molecular Biotechnology: 4th edition. (2010), Glick B.R., Pasternak J.J., Patten C. L., ASM press, USA
6. Gene Transfer to Animal Cells, 1st edition (2005), R. M. Twyman, Taylor & Francis USA.
7. Chawla, H. C. (2004) Introduction to Plant Biotechnology
8. Davies k (2004) –Plant Pigments and their Manipulation-Annual Plat Reviews-Vol 14
9. Altman,A and Hasegawa P M (2012) – Plant Biotechnology and Agriculture Prospects for the 21st century
10. Bhojwani,S S and Razdan M.K.(1996) plant Tissue Culture: Theory and Practices
11. Slater A, Scott,N W, Fowler, M R (2008) –Plant Biotechnology: Genetic manipulation of plants
12. Rai, M (2009) Fungal Biotechnology (IK International)
13. Vasil K., Thorpe T A. (1994) plant cell and Tissue Culture

M.Sc- II Semester III		
BTH-603	**Stem Cell Biology, Regenerative Medicine and Applied Biotechnology**	**Credits:** 4 **Hours: 60**
	Course Outcomes (COs) **On completion of the course, the students will be able to:**	**Bloom's Cognitive Level**
CO1	State the concept of differentiation, plasticity & trans differentiation	1
CO2	Outline the properties of stem cells and their application in regenerative medicine	2
CO3	Integrate current application in tissue engineering and Biopharmaceuticals	3
CO4	Comprehend regulations, Controversies and Market development in Applied Biotechnology	4
CO5	Analyse concept of Biosimilars and Biologics	5
CO6	Develop understanding of Current Research on Cancer Biology and Treatment	6

Sr. No	**Content**	**Number of hours (60)**
I	Cellular basis of differentiation, trans-differentiation, metaplasia and regeneration, cell lineages Stem cell self-renewal and pluripotency: molecular mechanisms Cell cycle regulation in stem cells. Embryonic, Adult and Induced Pleuripotent Stem cell	**10**

	niches	
II	Isolation, characterization and maintenance of embryonic stem cells, adult stem cells, embryonic germ cells, embryonic carcinoma cells	**5**
III	Stem Cell Therapy: Research Expansion of stem cells Applications of Stem cells in Neurodegenrative disorders, spinal cord injury, Wound healing, burns, diabetes, Orthpedic applications Infertility HIV/AIDS	**5**
IV	Genetic Manipulation of stem cells: Overview of different methods of introduction of a viz. micronuclear injection method, transduction with recombinant retroviruses, targeted gene insertion, cre-LoxP recombination and production of transgenic animals. Mouse models to study human disorders	**8**
V	Limitations, Controversies and Criticism of stem cell research and therapy	**2**
VI	Introduction to tissue engineering Overview of *in vivo* tissue organization, tissue dynamics and homeostasis Cells as building blocks: types and extraction methods. ECM, cell-cell/ cell-ECM interactions Scaffolding: Concept, Different materials used for scaffold synthesis, their advantages and drawbacks Assembly of engineered tissues: Self assembly, organ printing etc. Examples of Engineered tissues Bioartificial skin, liver, cartilage etc. Artificial meat Tissue engineering of heart valves Tissue Engineering Regulations, Controversies and Market	**10**

VII	Biopharmaceuticals: (Antibody drug conjugates, Monoclonal antibodies etc.) Different methods of production Direct Extraction, Semisynthesis, Biosimilars Applications Regulations Toxicity Screening using cell line	**10**
VIII	Applications of biotechnology in cancer Overview Biotechnology applications in Cancer Detection Biotechnology applications in Cancer Treatment Current research	**10**

References:

Books:

1. Scott F Gilbert, Development Biology, 9th edition. Sinauer Associates, USA. 2010.
2. Lewis Wolpert, Cheryll Tickle and Alfonso Martinez Arias, Principles of Development, 6th edition OUP Oxford, 2019.
3. Robert Lanza, Essentials of Stem Cell Biology, 2nd edition, Elsevier Academic Press, USA, 2009.
4. Bernard R. Glick, Jack J. Pasternak and Cheryl L. Patten, Molecular Biotechnology, 4th edition, ASM press, USA, 2010.
5. Ulrich MeyerJörg, HandschelHans Peter, WiesmannThomas Meyer, Fundamentals of Tissue Engineering and Regenerative Medicine, Springer, 2009.

Research Articles:

1. Mahla, Ranjeet Singh. "Stem cells application in regenerative medicine and disease therapeutics". International Journal of Cell Biology, issue. 7, 2016, pp. 1–24. doi:10.1155/2016/6940283. PMC 4969512. PMID 27516776.
2. Rosemann, Achim. "Why regenerative stem cell medicine progresses slower than expected". Journal of Cellular Biochemistry, vol. 115, issue no. 12, December 2014, pp. 2073–76. doi:10.1002/jcb.24894. PMID 25079695.
3. Zhang, Bin; Yeo, Ronne Wee Yeh; Tan, Kok Hian; Lim, Sai Kiang. "Focus on Extracellular Vesicles: Therapeutic Potential of Stem Cell-Derived Extracellular Vesicles". International Journal of Molecular Sciences, vol. 17, issue no. 2, February 2016.
4. Shi Yanhong, Inoue Haruhisa, Wu Joseph C and Yamanaka Shinya. “Induced Pluripotent Stem Cell Technology: A Decade of Progress”. Nature Revies Drug Discovery, vol. 16, issue no. 2, pp. 115-130. doi: 10.1038/nrd.2016.245

Web Resources:

1. https://pubmed.ncbi.nlm.nih.gov/6349488/
2. Screening of toxic compounds in tissue culture. Ekwall B. Toxicology. 1980;17(2):127-42. doi: 10.1016/0300-483x(80)90085-2. PMID: 7209994

M.Sc.-II Semester III		
BTH-604	**Immunology**	**Credits: 2** **Hours:** 30
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's Cognitive Level**
CO1	Recall components of immune system and types of immunity	1
CO2	Outline and review the types, regulation, cellular and molecular basis of innate immune responses.	2
CO3	Develop the understanding of adaptive immunity	3
CO4	Categorize the types of hypersensitivity reactions	4
CO5	Interpret the immune responses in autoimmune responses	5
CO6	Design and discuss the immunological basis of graft acceptance and rejection	6

Sr. No.	**Content**	**Hours (30)**
I	**Overview of the immune system:** Introduction to the Immune system. Immune system cells, tissues and organs.	**3**
II	**Innate immunity:** Understanding the physical and chemical barriers, Cells of the innate immune system. Molecular process of inflammation. Regulation and Function of Complement	**6**
III	**Adaptive immunity**: Structure and function of MHC molecules. Antigen presentation and processing. T cell maturation and TCR structure B cell maturation and BCR structure VDJ recombination and Germinal center responses	**9**

V	**Hypersensitivity Reactions:** Understand hypersensitivity reactions -I, II, III, IV with examples.	**2**
VI	**Autoimmunity**: Autoimmune diseases with examples. Molecular mimicry, Autoimmune therapy.	**5**
VII	**Transplant immunology**: Classification of Grafts, Immunological basis of acceptance of autografts and rejection of allografts GVHD and Immunosuppressive therapy.	**5**

References:

1. Kuby Immunology, Judy Owen, Jenni Punt, Sharon Stranford., 8th edition (2022), Freeman and Co., NY
2. Cellular and Molecular Immunology, Abul Abbas, Andrew H. Lichtman, Shiv Pillai 10th Edition 2021 Elsevier.
3. Janeway's Immunobiology, Kenneth M. Murphy, Casey Weaver 9th Edition 2016 W. W. Norton & Company
4. Immunology, 9th edition (2020), David Male, Jonathan Brostoff, David Roth Roitt and Mosby, USA.
5. Roitt's Essential Immunology (2017), 13th edition, Wiley and Black Well.
6. The Elements of Immunology, F.H. Khan (2009), Pearson Education.
7. Textbook of Basic and Clinical Immunology, 1st edition (2013), Sudha Gangal and Shubhangi Sontakke, University Press, India.

M.Sc- II Semester III		
BTH- 620	**Practical-1** **Practicals in Genomics and Genetic Engineering**	**Credits:** 2 **Hours: 60**
	Course Outcomes (COs) **On completion of the course, the students will be able to:**	**Bloom's Cognitive Level**
CO1	Describe tools and techniques for genome assembly, annotation and cloning for production of recombinant protein.	1
CO2	Outline databases and advanced bioinformatics tools for analysis of whole genomes and proteomes.	2
CO3	Discuss the important steps and precautions necessary for isolation of the plasmid DNA and amplification of the desired gene.	3
CO4	Summarize the strategy for cloning and expression of recombinant products.	4
CO5	Design cloning, selection and expression of the desired gene into an appropriate vector.	5
CO6	Integrate *in silico* and wet lab practices for gene/protein studies.	6

Sr. No.	Content	Number of Practicals (15)
I	Databases and Software tools for Genome assembly and annotation.	**3**
II	Isolation of plasmid DNA, quantification, Primer designing and PCR of desired gene(s).	**3**
III	Designing a strategy for producing a recombinant product & expression of gene product with its analysis.	**1**
IV	Ligation, Preparation of competent cells and transformation. Selection and confirmation of transformants.	**3**
V	Induction studies for recombinant protein expression, its purification and confirmation by Western blotting.	**4**
VI	Visit to a facility for DNA sequencing and Microarray.	**1**

References:

1. Molecular cloning – a laboratory manual – (Vol. 1-3), 4rd edition, (2012), Green and Sambrook, Cold Spring Harbor Laboratory Press, USA
2. Reeves, Gabrielle A., et al. "Genome and Proteome Annotation: Organization, Interpretation and Integration." Journal of the Royal Society, Interface, vol. 6, no. 31, Feb. 2009, pp. 129–47. doi:10.1098/rsif.2008.0341.
3. Benito, M., Román, R., Ortiz, G. et al. Cloning, expression, and one-step purification/immobilization of two carbohydrate-binding module-tagged alcohol dehydrogenases. J Biol Eng 16, 16 (2022).
4. https://www.hsls.pitt.edu/obrc/

M.Sc. Semester -III		
BTH-621	**Practical-2** **Practicals in Plant and Animal Biotechnology**	**Credits:** 2 **Hours: 60**
	Course Outcomes (COs) **On completion of the course, the students will be able to:**	**Bloom's Cognitive Level**
CO1	Design a media for establishment of callus culture	1
CO2	Demonstrate how to isolate plant cell protoplast by enzymatic technique.	2
CO3	Describe in vitro production of secondary metabolites by using suitable techniques.	3
CO4	Recommend Anther culture technique to raise haploid plants.	4
CO5	Design the laboratory plan and describe the concept.	5
CO6	Illustrate the rationale behind different media compositions and reconstitute the media. Demonstrate in vitro cell culture and analyze the different growth properties like cell number, viability and morphology.	6

Unit. No	**Content**	**No. of Practicals (15P)**
	Plant Biotechnology	
I	Initiation of callus culture by using various explants.	**2**
II	Protoplast isolation.	**1**
III	*In vitro* production of secondary metabolites	**2**
IV	Initiation of hairy root culture/ anther culture	**2**
	Animal Biotechnology	
I	Initiation of Primary Culture	**2**

II	Subculture and maintenance of cell line established in laboratory	**3**
III	Effect of growth factors/ toxins on cell growth in culture	**3**

M.Sc. II Semester III		
BTH-621	**Practical-3** **Practicals in Stem Cell Biology and Regenerative Medicine**	**Credits: 2** **Hours:** 60
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's Cognitive Level**
CO1	Follow aseptic techniques and subculture avoiding contamination	1
CO2	Initiate and maintain primary culture from chick embryo	2
CO3	Analyse proteins by Western blotting	3
CO4	Perform cytotoxicity assay	4
CO5	Evaluate the Indian Scenario in Tissue Engineering	5
CO6	Visit a stem cell facility	6

Sr. No	**Topic**	**Number of Practicals (15)**
1	Initiation of primary cell culture from chick embryo	3
2	Subculture and observation of the cell line established from the chick embryo	3
3	Analysis of proteins by Western Blotting	3
3	Cytotoxicity analysis of various compound on cells in culture	3
4	Survey of current tissue engineering application in India	2
5	Visit to a stem cell facility	1

M.Sc-II Semester IV		
BTH-651	**Proteomics and Metabolomics**	**Credits:** 2 **Hours: 30**
	Course Outcomes (COs) **On completion of the course, the students will be able to:**	**Bloom's Cognitive Level**
CO1	State concepts related to proteome and metabolome.	1
CO2	Explain advantages and limitations of structural and functional proteomics and metabolomics.	2
CO3	Illustrate protein identification and separation strategies.	3
CO4	Explain applications of proteomics and metabolomics in various fields	4
CO5	Discuss the advantages and limitations of various metabolomics techniques.	5
CO6	Integrate proteomics and metabolomics strategies in variety of applications	6

Unit. No	Content	No. of hours (30)
I	**Proteomics:** Proteomics –Introduction, Difference between protein chemistry and proteomics, application. Advantages and limitations of Structural and Functional Proteomics.	**5**
II	**Techniques in Proteomics:** Protein separation techniques, Strategies in protein identification,2D Gel electrophoresis, Isoelectric Focusing (IEF). Mass spectrometry in proteomics –Principle, techniques, components and variations (HPLC, ESI, MALDITOF, FT-MS, MS/MS, Quadrupole) and analysis, applications.	**8**
III	**Protein- Protein interactions-** experimental and computational- two hybrid, Phage display; Protein Microarray- Preparation, working and analysis. Proteomics and Microarray databases and allied	**5**

	bioinformatics tools, Reading of current research publications	
IV	**Metabolomics:** Introduction, Concept, application. Advantages and limitations of Targeted and Non targeted metabolomics. Reading of current research publications	**5**
V	**Techniques in Metabolomics:** Sample Preparation techniques, Strategies in Metabolite identification, databases and analysis, applications.	**7**

References:

1. Graham, David R M et al. "Broad-based proteomic strategies: a practical guide to proteomics and functional screening." The Journal of physiology vol. 563, Pt 1 2005: 1-9. doi:10.1113/jphysiol.2004.080341
2. Malcoln Campbell, and Laurie J. Heyer, Discovering genomics, Proteomics and Bioinformatics.2nd ed. USA: Benjamin Cummings, 2006.
3. RichardTwyman. Principles of Proteomics. 1st ed. London: Taylor & Francis, 2004
4. Alonso A, Marsal S and Julià A (2015) Analytical methods in untargeted metabolomics: state of the art in 2015. *Front. Bioeng. Biotechnol.* **3**:23. doi: 10.3389/fbioe.2015.00023.
5. Zhan, X. (Ed.). (2021). Metabolomics - Methodology and Applications in Medical Sciences and Life Sciences. IntechOpen. doi: 10.5772/intechopen.90987
6. E resources:

   https://www.uniprot.org/

   https://www.expasy.org/

   https://www.matrixscience.com/

   https://www.metabolomicsworkbench.org/data/index.php

   http://www.metabolomexchange.org/site/

   https://www.ebi.ac.uk/metabolights/

M.Sc.- II Semester IV		
BTH-652	**Virology and Molecular Diagnostics**	**Credits:** 4 **Hours:60**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's Cognitive Level**
CO1	Outline the properties and classification of viruses	1
CO2	Discuss the epidemiology, replication strategies, pathogenesis, and host cell response to viral infections	2
CO3	Illustrate the role of biotechnology in detection and control of virus outbreaks	3

CO4	Explain various techniques in molecular diagnostics	4
CO5	Review molecular techniques for bacterial and viral diseases , ethical concerns and regulations	5
CO6	Specify role of molecular diagnostic in detection of genetic disorders,cancer	6

Unit	Content	Number of hours (60)
	VIROLOGY	30
I	**Introduction to viruses:** • General Properties of Viruses • Morphology, symmetry, and ultra structure of Viruses (Plant and animal viruses and Bacteriophages) • Sub viral particles: Viriods and Prions • Oncogenic Viruses **Classification and Nomenclature of viruses:** • ICTV and Baltimore classification **Replication of viruses:** • General Mechanism of replication: Adsorption. Entry. Replication and integration, Assembly, maturation and exit of progeny • **Emerging and re-emerging viruses** History, Epidemiology, replication strategy and pathogenesis of: Enteric, Respiratory, Hepatic and Retro virus (One example each type) • Case studies **Host cell response to viral infections:** • apoptosis, necrosis, stress response, types of cytopathic effects. • Immune response to viruses (cytotoxic T cells, interferons, antibodies) • General strategies of viruses to evade host immune system • Mechanisms of viral persistence and latency	20
II	**Role of Biotechnology in control of virus outbreaks:** • COVID-19 Vaccine strategies	5
	MOLECULAR DIAGNOSTICS	
III	• **Introduction and scope of Molecular Diagnostics** • **Techniques used for molecular diagnostics:** ❖ PCR based ❖ Hybridization based ❖ Pattern based ❖ Sequence based ❖ Microarray chips ❖ ELISA	10

	❖ Diagnostic genomics and proteomics ❖ Bioinformatics(data acquisition and analyses) ❖ Recent techniques	
IV	**Molecular Diagnostics in detection and identification of diseases** ● Types of genetic testing (diagnostic, predictive, carrier and prenatal etc.) ● Detection and Identification of bacterial (particularly for slow growing and/or unculturable bacteria) , viral diseases and parasitic infections **Molecular Diagnostics in inherited disorder detection** ● Detection of inherited disorders (chromosomal and single-gene) using molecular diagnostics (including prenatal testing and pre-implantation diagnosis) **Molecular Diagnostics in Cancer** ● Detection of recognized genetic aberrations in clinical samples from cancer patients ● Biomarkers and tumor profiling ● Ethical concerns, counselling, regulations and approved testing.	25

References:

1. Flint S. J., V. R. Racaniello, L. W. Enquist, V. R. Rancaniello, A. M. Skalka, (2015), Principles of Virology (Vol. 1-11) (4th Ed), ASM Press
2. Howley P. M., David M. Knipe , Jeffrey L. Cohen, Damania B, (2021) Fields Virology (Volume I and II) (7th edition), Wolters Kluwer N.V.
3. Dimock N. J.,A. J. EastonK. N. Leppar (2007), Introduction to Modern Virology (6th edition),Blackwell publishing
4. Campbell, A. M., & Heyer, L. J. (2006). Discovering Genomics, Proteomics, and Bioinformatics. San Francisco: Benjamin Cummings.
5. Brooker, R. J. (2009). Genetics: Analysis & Principles. New York, NY: McGraw-Hill. 20
6. Glick, B. R., Pasternak, J. J., & Patten, C. L. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, DC: ASM Press.
7. Coleman, W. B., & Tsongalis, G. J. (2010). Molecular Diagnostics: for the Clinical Laboratorian. Totowa, NJ: Humana Press
8. Elles Rob and Mountford, R(2004),Molecular Diagnosis of Genetic Diseases(Second Edition), Springer

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7106233/

https://pubmed.ncbi.nlm.nih.gov/8156276/

https://pubmed.ncbi.nlm.nih.gov/1507192/

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5634985/

M.Sc. II Semester IV		
BTH-653	**Nanotechnology**	**Credits: 4** **Hours: 60**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's Cognitive Level**
CO1	Define the common terms used in Nanotechnology and discuss types and properties of nanoparticles	1
CO2	Explain the physical, chemical and biological methods of synthesis of nanoparticles.	2
CO3	Outline and describe methods used for characterization of Nanomaterials	3
CO4	Review the applications of nanomaterials in different fields	4
CO5	Perform synthesis of nanoparticles by various methods	5
CO6	Demonstrate biological activity of synthesized nanoparticles	6

Unit. No.	Content	No. of Hours (60)
I	**Introduction to Nanoworld, Nanoscience and Nanotechnology:** ● Introduction to Nanobiotechnology, Concepts, historical perspective ● Types of nanoparticles and their Properties: Quantum dots, Polymeric nanoparticles, Metal nanoparticles, metal oxide nanoparticles, Dendrimers, Composites ● Nanofilms, Nanoparticles	**10**
II	**Synthesis of Nanoparticles:** ● Physical methods - mechanical methods, methods based on evaporation sputter deposition, chemical vapour deposition (CVD), electric arc deposition. ● Chemical methods - **S**ynthesis of nanoparticles by	**20**

	colloidal route, micro emulsion, sol-gel method, chemical precipitation, pyrolysis. ● Biological methods - Synthesis using microorganism, synthesis using plant extracts, use of proteins and template like DNA.	
III	**Properties and Characterization of Nanomaterials:** Optical (UV-Vis / Fluorescence), X-ray diffraction, Imaging and size (Electron microscopy TEM, SEM), Light scattering- DLS NTA, Zeta potential. Nanotoxicity studies.	**15**
IV	**Applications of Nanomaterials in/as**: ● Medicine: Drug Delivery, Nanomedicines, diagnostics and imaging ● Food Science:(Food Processing, Food Packaging, detection of pathogens) ● Nanosensors ● Water remediation and purification, ● Agriculture. ● Green Nanotechnology	**15**
Practicals [0.5C]		
Sr. No.	**Title**	**No. of Practicals**
I	**Synthesis of metal/metal oxide Nanoparticles by: (any 2)** a. Chemical b. Microbial **c.** Plant based method	**2**
II	**Biological activities of nanoparticles:** 1. Antimicrobial activities of synthesized nanoparticles (MIC/MBC determination) **2.** Cytotoxicity testing of nanoparticles using MTT/Tryphan blue assay	**2**

References:

1. Kulkarni, S. K. *Nanotechnology: Principals and Practices.* Revised ed., New Delhi:Capital Publishing company, 2009.

2. Michael Stroscio and Mitra Dutta. *Biological Nanostructures and Application of Nanostructures in Biology*.2nd ed., Springer, 2013.

3. Elizabeth Papazoglou, and Aravind Parthasarathy. *BioNanotechnology*, 1sted., Morgan & Claypool Publishers' series, 2007

4. David Goodsell. *Bionanotechnology*.1st ed., New Jersey: John Wiley & Sons, Inc, Publication, 2004.
5. C. N. R. Rao, Achim Müller, Anthony K. Cheetham (Eds). *The Chemistry of Nanomaterials: Synthesis, Properties and Applications*, 2 Volume Set. Wiley VCH, 2004.
6. Christof M. Niemeyer and Chad A. Mirkin (Eds). *Nanobiotechnology: Concepts, Applications and Perspectives*, Wiley Publishers, April 2004.

E -Resources:

1. https://www.nanowerk.com/nanotechnology-applications.php
2. https://www.frontiersin.org/articles/10.3389/fmicb.2017.01501/full
3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5766453/
4. https://www.nanotech-now.com/current-uses.html

MSc- II Semester IV		
BTH-654	**Bioentrepreneurship**	**Credits:** 4 **Hours:60**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's Cognitive Level**
CO1	Outline the concept of Bioentrepreneurship development	1
CO2	Discuss various types of entrepreneurships, various motivational theories of entrepreneurship and policies of government.	2
CO3	Define various steps for project proposal identification and selection of projects; project report: contents and formulation.	3
CO4	Explain the concept of enterprising management, HR concepts, basics of accounting and marketing, legal forms of business, how to manage capital and raise it.	4
CO5	Understand methods of evaluation of project proposal evaluation	5
CO6	Discuss the role of government agencies in entrepreneurship and various funding opportunities available through government and private investors.	6

Unit. No	**Title of Unit and Contents**	**No. of hours (60)**
I	**Basics of Entrepreneurship:** ● Importance of entrepreneurship; advantages of being entrepreneur - freedom to operate; introduction to bio entrepreneurship – biotechnology in a global scale. ● Scope in bio entrepreneurship; types of bio-industries	**10**

	biopharma, bioagri, bio services and bio industrial; innovation types, out of box thinking; skills for successful entrepreneur creativity, leadership, managerial, team building, decision making. ● Opportunities for bio entrepreneurship - Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Start-up & Make in India),Patent landscape, IP protection & commercialization strategies.	
II	**Accounting and Finance:** ● Business plan preparation; business feasibility analysis by SWOT, socio-economic costs benefit analysis; funds/support from Government agencies like MSME/banks and private agencies like venture capitalists:/angel investors for bio- entrepreneurship. ● Business plan proposal for „virtual startup company"; statutory and legal requirements for starting a company/venture; basics in accounting practices: concepts of balance sheet, profit and loss statement, double entry bookkeeping; ● Collaborations & partnerships; information technology for business administration and expansion.	**15**
III	**Business Strategy** ● Entry and exit strategy; pricing strategy; negotiations with financiers, bankers, government and law enforcement authorities; dispute resolution skills. ● External environment/ changes; avoiding/managing crisis; broader vision–global thinking; mergers & acquisitions.	**10**
IV	**Marketing** ● Market conditions, segments, prediction of market changes; ● Identifying needs of customers, Market linkages, branding issues, Developing distribution channels - franchising; policies, promotion, advertising, ● Branding and market linkages for virtual startup company	**10**
V	**Knowledge Centre and R&D:** ● Knowledge centers e.g., in universities, innovation centers, research institutions (public & private) and business incubators; R&D for technology development and upgradation; assessment of technology development. ● Managing technology transfer; industry visits to successful bio-enterprises, regulations for transfer of foreign technologies; ● Quality control; technology transfer agencies;	**15**

	Understanding of regulatory compliances and procedures (CDSCO, NBA)	

References:

1.Ram Chandran, 'Entrepreneurial Development', Tata McGraw Hill, New Delhi.
2.Saini, J. S., 'Entrepreneurial Development Programmes and Practices', Deep & Deep Publications (P), Ltd.
3.Khanka, S S. 'Entrepreneurial Development', S Chand & Company Ltd. New Delhi
4.Badhai, B 'Entrepreneurship for Engineers', Dhanpat Rai & co. (p) Ltd.
5.Desai, Vasant, 'Project Management and Entrepreneurship', Himalayan Publishing House, Mumbai, 2002.
6.Gupta and Srinivasan, 'Entrepreneurial Development', S Chand & Sons, New Delhi.
7.Adams, D. J., & Sparrow, J. C. , Enterprise for life scientists: Developing innovation and entrepreneurship in the biosciences 2008
8.Bloxham: Scion Shimasaki, C. D., Biotechnology entrepreneurship: Starting, managing, and leading biotech companies. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier 2014.
9.Onetti, A., & Zucchella, A. Routledge. Jordan, J. F. Business modelling for life science and biotech companies: Creating value and competitive advantage with the milestone bridge2014.
10.Desai, V. Innovation, Commercialization, and Start-Ups in Life Sciences. London: CRC Press (2009).
11.The Dynamics of Entrepreneurial Development and Management. New Delhi: Himalaya Pub. House.

E Resources:

1. https://library.stanford.edu/guides/entrepreneurship-resources
2. https://ocw.mit.edu/courses/entrepreneurship/
3. https://unimelb.libguides.com/c.php?g=849410&p=6079235
4. https://entrepreneurship.wharton.upenn.edu/

M.Sc. II Semester IV		
BTH-655	**Intellectual Property Rights and Bioethics**	**Credits: 4** **Hours: 60**
	Course Outcomes (COs) **On completion of the course, the students will be able to:**	**Bloom's Cognitive Level**
CO1	Understand the various form of IP and its protection	1

CO2	Describe various forms of IP in detail	2
CO3	Explain the importance of IPR in Biotechnology.	3
CO4	Describe the biosafety, bioethical and regulatory aspects related to Biotechnology.	4
CO5	Analyse the environmental risk and understand the importance of development plan	5
CO6	Review case studies related to the bioethics, biosafety and regulation concepts so as to gain a critical understanding of their contents.	6

Unit. No	**Title of Unit and Contents**	**No. of hours (60)**
IPR in Biotechnology		30
I	Intellectual Property Rights: Overview and Historical Perspectives; TRIPS (Trade Related Intellectual Property Rights) Agreement and International Treaties related to IPR	**3**
II	Patents: Criteria of Patentability; Procedure for Filing Patent Applications, Patent Granting Procedure; Revocation, Patent Infringement and Remedies; Plant, Animal, Microbial Patents: Indian and International Perspective; Patenting Biosimilars.	**12**

III	Copyright and Neighboring Rights - Conceptual Framework, Copyright works, Ownership, transfer and duration of Copyright, Renewal, Termination of Copyright, Neighboring Rights, Infringement of copyrights and remedies; Examples and Case study. Geographical Indications - Concept of Appellations of Origin, Indication of Source and Geographical Indication, Examples and case studies. Protection of Plant Varieties and Plant Breeders' Rights - Protection of Plant Varieties and Farmers Rights, Authority and Registry, Registration of Plant Varieties and Essentially derived variety, Duration, Effect of Registration and Benefit Sharing; Examples and Case study; Industrial Design - Need for Protection of Industrial Designs, Subject Matter of Protection and Requirements, Examples and Case Study.	**15**
Bioethics		**30**
IV	Biosafety, Bioethics and Regulations: <u>Biosafety:</u> Introduction; historical background; biosafety levels, introduction to biological safety cabinets; definition of GMOs, principles of safety assessment of transgenic plants, sequential steps in risk assessment; concepts of familiarity and substantial equivalence; risk – environmental risk assessment, risk characterization and development of analysis plan; risk assessment of transgenic crops. <u>Bioethics:</u> Introduction, ethical conflicts in biological sciences, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, Bioethics in research – cloning and stem cell research, Agricultural biotechnology - environmental risk, public opinion, Protection of environment and biodiversity, bio piracy <u>Regulations:</u> Regulatory affairs, role of regulatory professional, Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies; International regulatory bodies	**15**

V	Applications of bioethics, biosafety and bioregulation concepts: Understanding bioethical, biosafety and bio regulatory issues related to healthcare, medicine, genetic engineering, food & agriculture etc. through examples and case studies.	**15**

References:

1. Intellectual Property Law in India: Tamali Sen Gupta.
2. Kluwer Law International Intellectual Property and HumanDevelopment- Current Trends and Future Scenarios: Tzen Wong and Graham Dutefield Cambridge Industrial Property Law,Volume 1, Patent Law, by Prof. Nobuhiro Nakayama Koubundou Publishers 2000.
3. Intellectual Property Rights and the Law, Gogia Law Agency, by Dr. G.B. Reddy
4. Law relating to Intellectual Property, Universal Law Publishing Co, by Dr. B.L.Wadehra
5. IPR by P. Narayanan 4. Law of Intellectual Property, Asian Law House, Dr.S.R. Myneni.
6. https://www.ipindia.gov.in/

M.Sc.- II Semester IV		
BTH- 656	**Food Technology**	**Credits:** 4 **Hours: 60**
	Course Outcomes (COs) **On completion of the course, the students will be able to:**	**Bloom's Cognitive Level**
CO1	Classify food and outline the concept of Specialty foods, Nutraceuticals, health foods and functional foods	1
CO2	Discuss food adulterants and toxicants	2
CO3	Explain the factors affecting growth of microorganisms in food and food borne diseases.	3
CO4	Describe methods used for Food Processing and packaging	4
CO5	Design newer techniques used to detect microbial food spoilage and Review Food laws and legislations, HACCP	5
CO6	Perform analysis for food composition and detection of adulterants	6

Unit No.	**Content**	**No. of Hours**

		(60)
I	**Classification of food:** Health food, ethnic food, organic food functional food, nutraceuticals, fabricated foods, convenience foods, GM foods, space foods	2
II	**Compositional Analysis of Foods:** Physical, Chemical properties, Characteristics of foods, Sensory evaluation **Food adulterants, toxicants** Types and methods of detecting food adulterants and toxicants	8
III	**Food Microbiology:** Sources of microorganisms in foods; microbial growth, growth curve; factors affecting growth-intrinsic and extrinsic, factors controlling growth of microorganisms, microbiological criteria of foods and their significance **Foods microbiology and public health** GRAS foods, Food poisoning, types of food poisonings, important features etc; bacterial agents of food borne illness, food poisoning by *Clostridium, Salmonella, E. coli, Staphylococcus* etc.; non- bacterial agents of food borne illness, mycotoxins **Food spoilage** Methods of isolation and detection of microorganisms or their products in food; conventional methods; rapid methods (newer techniques) -immunological methods; fluorescent, antibody	10
IV	**Food processing and Packaging** Scope and importance of food processing- Preparation of foods before processing cleaning, sorting, grading, peeling.etc. Thermal. Low temperature and Dehydration methods **Canning,** **Introduction to Food Packaging:** definition, factors involved in the evolution and selection of a food package, functions of food packaging (containment, protection, convenience and communication). Paper and paper based packaging materials, Plastic packaging materials Metal packaging materials Glass packaging materials Aseptic packaging of foods Modern packaging techniques	10

V	**Specialty foods: Nutraceuticals, Functional foods, Nutrigenomics** Scope, importance and renewed emphasis on specialty foods, health foods, functional foods. Nutraceuticals, infant and baby foods, adolescent/ teen age foods, foods for pregnant ladies and nursing mothers, geriatric foods. Concept of nutrigenomics Food recommended and restricted in metabolic disorders and disturbances, gastrointestinal disorders; fever and infection; liver, gall, bladder and pancreatic disturbances; blood, circulatory and cardiac diseases; urinary and musculoskeletal diseases; allergies. Health benefits/ mode of action of PUFA/ gamma linoleic acids, antioxidants, dietary fiber, oligosaccharides, sugar alcohols, peptides and proteins, glycosides, alcohols, isoprenoids and vitamins, choline, LAB, phenolic, flavanols, minerals and other miner food constitutes Genetically modified foods: health claims and concerns	12
VI	**Food legislation:** Food Laws and Standards, National and International, FSSAI, Duties and responsibilities of Food Safety Authorities HACCP system and food safety used in controlling microbiological hazards Concept of QA, QC, ISO.	4

Practicals [0.5 C]		
Sr. No.	**Title**	**No. of Practicals**
I	Compositional Analysis of Foods (Physical, Chemical and Microbial)	**2**
II	Detection of Food Adulterants in various food samples	**2**
III	Visit to Food Industry/Food testing Laboratory	**2**

References:

1. De Sukumar., *Outlines of Dairy Technology*: Oxford University Press, 2007.
2. Coles R, McDowell D and Kirwan MJ, *Food Packaging Technology*: CRC Press, 2003.
3. Deman JM, *Principles of Food Chemistry*, 2nd ed.: Van Nostrand Reinhold, NY 1990
4. Frazier WC and Westhoff DC, *Food Microbiology*: TMH Publication, New Delhi, 2004.
5. Jenkins WA and Harrington JP, *Packaging Foods with Plastics*:Technomic Publishing Company Inc., USA, 1991.
6. Manay NS and Shadaksharaswamy M, *Food-Facts and Principles*, New Age: International (P) Ltd. Publishers, New Delhi, 1987
7. Ramaswamy H and Marcott M, *Food Processing Principles and Applications*:CRC Press, 2006
8. Ranganna S, *Handbook of Analysis and Quality Control for Fruits and Vegetable Products*,

2nd ed.: TMH Education Pvt. Ltd, 1986
9. Bamji MS, Krishnaswamy K, Brahmam GNV (2009). *Textbook of Human Nutrition*, 3rd ed.: Oxford and IBH Publishing Co. Pvt. Ltd.
10. Desrosier, Norman W. and Desrosier., James N., *The technology of food preservation*, 4th Ed., Westport, Conn.: AVI Pub. Co., 1977.
11. Whitehurst and Law, *Enzymes in Food Technology*: CRC Press, Canada, 2002
12. Fuller, Gordon W, *New Product Development from Concept to Marketplace*: CRC Press,2004
13. Ramesh C. Gupta, *Nutraceuticals: Efficacy, Safety and Toxicity* 1st ed., USA: Elsevier, 2016
14. Dhiraj A. Vattem , Vatsala Maitin , *Functional Foods, Nutraceuticals and Natural Products: Concepts and Applications*: DEStech Publications, Inc 2016.
15. Codex Guidelines on Nutrition Labelling (CAC/GL 2_1985) (Rev.1_1993). Rome, Food and Agriculture Organisation of the United Nations / World Health Organisation, 1993.
16. Food Safety and Standards Authority of India portal, Government of India

E -Resources

1. https://www.cdr.wisc.edu/
2. http://www.agr.gc.ca/eng/science-and-innovation/?id=1360882179814
3. https://www.centerforfoodsafety.org/
4. https://www.ifst.org/
5. https://www.who.int/health-topics/food-safety/
6. https://www.fda.gov/food/laboratory-methods-food/about-bacteriological-analytical-manual-bam

M.Sc.-II Semester IV		
BTH - 657	**Emerging Trends and Technologies**	**Credits:** 4 **Hours: 60**
	Course Outcomes (COs) **On completion of the course, the students will be able to:**	**Bloom's Cognitive Level**
CO1	Outline basics of latest technologies in area of biotechnology	1
CO2	Discuss principles of several new technologies employed by researchers	2
CO3	Explain the working of equipment/instrument used in current technologies	3
CO4	Review the applications of the technologies in different fields	4
CO5	Write and explain one application in depth	5
CO6	Apply the current day research tool kit as per requirement	6

Unit. No.	**Content**	**No. of. Hours (60)**

I	**Optical Microscopy Methods:** Confocal Microscopy, Scanning- Tunneling Microscopy, Atomic Force Microscopy, Interfacial-Force Microscopy. Fluorescence Lifetime, Fluorescence Resonant Energy Transfer (FRET), Fluorescence Correlation Spectroscopy (FCS), Evanescent Wave Microscopy; Near-Field and Evanescent Waves, Total Internal Reflection Microscopy; Near-Field Microscopy; Beyond the Diffraction Limit: Stimulated Emission Depletion (STED), Super-Resolution Summary, Super-Resolution Imaging with Stochastic Optical Reconstruction Microscopy (STORM) and Photoactivated Localization Microscopy (PALM)	**20**
II	**Mass Spectroscopy Ionization techniques:** Mass analyzers/overview MS; FT-ICR and Orbitrap, fragmentation of peptides; proteomics, nano LC-MS; Phospho- proteomics; interaction proteomics, mass spectroscopy in structural biology; imaging mass spectrometry.	**15**

III	**CRISPR-CAS**: History of its discovery, elucidation of the mechanism including introduction to all the molecular players, development of applications for in vivo genome engineering for genetic studies, promise of the technology as a next generation therapeutic method.	**15**
IV	**Systems Biology:** High throughput screens in cellular systems, target identification, validation of experimental methods to generate the omics data, bioinformatics analyses, mathematical modeling and designing testable predictions.	**10**

References:

1. Keith Wilson and John Walker. *Principles and Techniques of Biochemistry and Molecular Biology*. 7th ed. Cambridge, UK: Cambridge University Press, 2010.
2. Rodney Boyer. *Modern Experimental Biochemistry*. 3rd ed. San Francisco, USA: Benjamin Cummings, 2000.
3. Iain Campbell. *Biophysical techniques*. 1st ed. Oxford, UK: Oxford University Press, 2012.
4. V. Pattabhi and N. Gautham. *Biophysics*. 1st ed. New Delhi, India: Kluwer Academic Publishers and Narosa Publishing House, 2002.
5. Avinash Upadhyay, Kakoli Upadhyay and Nirmalendu Nath. *Biophysical Chemistry (Principles and Techniques)*. 4th ed. New Delhi, India: Himalaya Publishing House, 2016.

E-resource:

1. https://crispr.i2bc.paris-saclay.fr/
2. http://systems-biology.org/resources