Janardan Bhagat Shikshan Prasarak Sanstha's

CHANGU KANA THAKUR
ARTS, COMMERCE & SCIENCE COLLEGE, NEW PANVEL
(AUTONOMOUS)

Re-accredited 'A+' Grade by NAAC
'College with Potential for Excellence' Status Awarded by UGC
'Best College Award' by University of Mumbai

Affiliated to University of Mumbai with an autonomous Status

Revised Syllabus of

Program: M.Sc. Biotechnology

M.Sc. Part-I
(Semester I & II)
Choice Based Credit & Grading System (60:40)

(To be implemented from Academic Year 2019-2020)

Preamble:

Master of Science (M.Sc.) Programme in Biotechnology is a P.G. Programme of Department of Biotechnology, Changu Kana Thakur Arts, Commerce & Science College, New Panvel, affiliated to University of Mumbai with an Autonomous status. Biotechnology is technology based on biology. Biotechnology harnesses cellular and bio-molecular processes to develop technologies and products that help to improve our lives and the health. Modern biotechnology provides breakthrough products and technologies to combat debilitating and rare diseases, reduce our environmental footprint, feed the hungry, cleaner energy, and have safer, cleaner, and more efficient industrial manufacturing processes.

The Choice Based Credit and Grading System (CBCGS) to be implemented through this curriculum would allow students to develop a strong footing in the fundamentals and specialize in the disciplines of his/her liking and abilities. The proposed credit-based curriculum and grading system will even add much more to the existing interdisciplinary nature of biotechnology.

Under the 'autonomy' we have made an attempt to design Master's in Biotechnology course syllabus to cater to the needs of credit based- semester and grading system. The changing scenario of higher education in India and abroad is taken into consideration to make this syllabus more oriented towards current need of modern research and industrial sectors. The syllabus encompasses the fundamental academics at one end and latest technologies in life science at the other. Theory courses will help students develop their knowledge sets on various topics of biotechnology, to which, they are introduced at the undergraduate level. Extensive practical courses are designed to supplement the theory courses with hands on experimentation in wet-lab and on fields.

At the post graduate level they will be exposed to the advanced principles of biochemistry, molecular and cell biology, bioinformatics, Biostatic, Nanotechnology etc. along with technological advances and applications of basic principles to successfully carry out research and industrial developments. A research project/ industrial training modules are incorporated to provide a buffer zone for budding biotechnologists eager to enter the life science sector.

M.Sc. Biotechnology Course Structure

Semester I

Course code PSBT	Title	Theory /Practical	Marks	Credits	Nos of Lectures/ week
PBT1BC1	Biochemistry	Theory	100	4	4
PBT1IM2	Immunology	Theory	100	4	4
PBT1CB3	Cell Biology	Theory	100	4	4
PBT1GE4	Genomics and Emerging Technologies	Theory	100	4	4
PBT1PR-1	Practical- I (Paper-I &IV)	Practical	100	4	8
PBT1PR-2	Practical –II (Paper-II &III)	Practical	100	4	8
		TOTAL	**600**	**24**	**32**

Semester II

Course code PSBT	Title	Theory /Practical	Marks	Credits	Nos of Lectures/ week
PBT2BB1	Bioinformatics and Biostatistics	Theory	100	4	4
PBT2PA2	Plant and Animal Biotechnology	Theory	100	4	4
PBT2BE3	Bioprocess Engineering and Technology	Theory	100	4	4
PBT2IP4	Intellectual property rights and Bioethics	Theory	100	4	4
PBT2PR-1	Practical- I (Paper-I &III)	Practical	100	4	8
PBT2PR-2	Practical –II (Paper-II &IV)	Practical	100	4	8
		TOTAL	**600**	**24**	**32**

Eligibility: As per University of Mumbai Rules

Scheme of Examination: The performance of the learners shall be evaluated into two parts. The learner's performance shall be assessed by Internal Assessment with 40% marks in the first part and by conducting the Semester End Examinations with 60% marks in the second part. The allocation of marks for the Internal Assessment and Semester End Examinations are as shown below-

A) Internal Assessment: 40 % **40 Marks**

Sr. No.	Particular		Marks
01	One periodical class test / online examination to be conducted in the given semester		20 Marks
02	One case study /review / project with presentation based on curriculum to be assessed by the teacher concerned		15 Marks
	Presentation	10 Marks	
	Written Document	05 Marks	
03	Active participation in routine class instructional deliveries and overall conduct as a responsible learner, mannerism and articulation and exhibit of leadership qualities in organizing related academic activities		05 Marks

Question Paper Pattern

(Periodical Class Test for the Courses at Under Graduate Programmes)

Maximum Marks: 20 Duration: 40 Minutes

Questions to be set: 02

All Questions are Compulsory

Question No.	Particular	Marks
Q-1	Match the Column / Fill in the Blanks / Multiple Choice Questions/ Answer in One or Two Lines (Concept based Questions) (1 Marks / 2 Marks each)	10 Marks
Q-2	Answer in Brief (Attempt any Two of the Three) (5 Marks each)	10 Marks

B) Semester End Examination: 60 %

60 Marks Duration: $2\frac{1}{2}$ hours

Question Paper Pattern

Theory question paper pattern
1. There shall be five questions each of 12 marks. 2. All questions shall be compulsory with internal options. 3. Question may be subdivided into sub-questions a, b, c… and the allocation of marks depends on the weightage of the unit.

Passing Standard:

The learners shall have to obtain a minimum of 40% marks in aggregate for each course where the course consists of Internal Assessment and Semester End Examination. The learners shall obtain minimum of 40% marks (i.e. 16 out of 40) in the Internal Assessment and 40% marks in Semester End Examination (i.e. 24 Out of 60) separately, to pass the course and minimum of grade D in each project wherever applicable to pass a particular semester.

Semester-I

M.Sc. Biotechnology
Semester –I
Paper-I Biochemistry (PBT1BC1)

Units	Topics	Credit	No of lectures
Course Objectives: The objectives of this course are to build upon undergraduate level knowledge of biochemical principles with specific emphasis on different metabolic pathways. The course shall make the students aware of various disease pathologies within the context of each topic.			
Student Learning Outcomes: On completion of this course, students should be able to Gain fundamental knowledge in biochemistry. Understand the molecular basis of various pathological conditions from the perspective of biochemical reactions.			
Unit-I Glycobiology & Protein Folding	**Glycobiology:** Structure and role of Proteoglycans, Glycolipids and Lectins. Glycosylation of Biomolecules – Structure, Synthesis and role of N-linked, O-linked, and GPI linked glycoproteins. **Protein Folding:** Denaturation and Renaturation of proteins; Denaturants and their mode of action; Anfinsen's classical experiment; Folding curves and transitions; Types of protein folding and intermediates; Models of protein folding; Assisted protein folding (Chaperones); Misfolding and diseases.	4	15
Unit- II Protein Transport & Membrane Trafficking	**Protein Transport:**Translocation of Secretory Proteins across the ER Membrane, Insertion, Protein Modifications, Folding, and Quality, Control in the ER, Protein sorting and export from Golgi Apparatus. **Sorting of Proteins**:to Mitochondria and Chloroplasts. Molecular Mechanisms of Vesicular Traffic, early and later Stages of the Secretory Pathway, Receptor-Mediated Endocytosis. **Protein degradation:** Ubiquitin-Proteasome pathway and lysosomal proteolysis.		15

Unit- III Biochemistry of Nucleic acids	Forces stabilizing nucleic acid structures, triple helix. **Super-helix topology-** linking number, Twist and writhing number, measurement of supercoiling and Topoisomerases. **Nucleic acid binding protein** – Leucine Zipper, Zinc fingers OB fold, Beta Barrel, Helix-turn-helix, Helix-loop-helix. Biosynthesis of nucleic acids and inborn errors of nucleic acid Metabolism. **Methodologies for detection: Protein –Protein and DNA –Protein interactions:** Gel retardation assay, DNA foot printing, Yeast 2 Hybrid Method advantages and limitations, yeast split-hybrid and reverse two-hybrid systems, Co-Immunoprecipitation (Co-IP) and Far-Western Blot Analysis.		15
Unit- IV Bioenergetics and regulation of metabolism	**Biosynthesis of Amino acids;** phenylalanine, tyrosine, threonine and methionine. **Bioenergetics-** coupled interconnecting reactions in metabolism; oxidation of carbon fuels; recurring motifs in metabolism. **Elucidation of metabolic pathways:** Experimental approaches to the study of Metabolism. Entry/ exit of various biomolecules from central pathways, Principles of metabolic regulation. **Strategies of energy Metabolism:** organ specialization- Brain, Muscle, Adipose Tissue, Liver, Kidney. Metabolic Homeostasis: Regulation of Appetite, Energy Expenditure, and Body Weight; Metabolic Adaptation: Starve–Feed Cycles, insulin signaling and Diabetes Mellitus, target of Rapamycin (TOR).		15

References:

1. Stryer, L. (2015). *Biochemistry*. (8th edition) New York: Freeman.
2. Lehninger, A. L. (2017). *Principles of Biochemistry* (7th edition). New York, NY: Worth.
3. Voet, D., &Voet, J. G. (2018). *Biochemistry* (5th edition). Hoboken, NJ: J. Wiley & Sons.
4. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008).
5. Lodish, H. F. (2016). *Molecular Cell Biology* (8th Ed.). New York: W.H. Freeman.
6. Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2014).
7. *Lewin's Genes XI*. Burlington, MA: Jones & Bartlett Learning.
8. Cooper, G. M., &Hausman, R. E. (2013). *The Cell: a Molecular Approach* (6th Ed.). Washington: ASM; Sunderland.
9. Laouini et.al. Preparation, Characterization and Applications of Liposomes: State of the Art. journal of Colloid Science and Biotechnology Vol. 1, 147–168, 2012
10. Watson, James D., Baker, Tania A., Bell, Stephen P. & Gann, Alexander: Molecular biology of the gene. (6th ed.) New York. Pearson Education Inc., 2008. 0-321-50781.
11. Sheehan, D. (2009) Physical Biochemistry: Principles and Applications. John Wiley &Sons Ltd., UK.
12. Lesk, A. M. (2004) Introduction to Protein Science: Architecture, Function, andGenomics. Oxford University Press, UK.
13. Uversky, V. N. and Fink, A.L. (2006) Protein Misfolding, Aggregation andConformational Diseases: Part A: Protein Aggregation and Conformational Diseases(Protein Reviews). Springer, USA.

M.Sc. Biotechnology
Semester –I
Paper-II -Immunology (PBT1IM2)

Units	Topics	Credit	No of lectures
Course Objectives: The objectives of this course are to learn about structural features of components of immune system as well as their function. The major emphasis of this course will be on development of immune system and mechanisms by which our body elicits immune response. This will be imperative for students as it will help them to predict about nature of immune response that develops against bacterial, viral or parasitic infection, and prove it by designing new experiments.			
Student Learning Outcomes : On completion of this course, students should be able to • Evaluate usefulness of immunology in different pharmaceutical company. • Identify proper research lab working in area of their interests.			
Unit -I Vaccinology	Active and passive immunization; live, killed, attenuated, subunit vaccines. **Vaccine technology:** role and properties of adjuvants, recombinant DNA, plant-based vaccines, reverse vaccinology; peptide vaccines and conjugate vaccines. **Antibody genes and antibody engineering:** chimeric, generation of monoclonal antibodies, hybrid monoclonal antibodies; catalytic antibodies and generation of immunoglobulin gene libraries. **Disease specific vaccine design:** Tuberculosis Vaccine; Malaria Vaccine; Cancer vaccine, HIV/AIDS vaccine, idiotypic vaccines; New emerging diseases and vaccine needs (Ebola, Zika).		15
Unit -II Clinical Immunology	**Immunity to infection:** bacteria, viral, fungal, and parasitic infections (with examples from each group).		

	Allergy and hypersensitivity: Type I-IV **Autoimmunity:** types of autoimmune diseases; mechanism and role of $CD4^+$ T cells; MHC and TCR in autoimmunity; treatment of autoimmune diseases-rheumatoid arthritis, systemic lupus erythematosus and multiple sclerosis. **Transplantation:** immunological basis of graft rejection; clinical transplantationand: clinical transplantation and immunosuppressive therapy.		
Unit -III Tumor Immunology, Immunodeficiency & Cytokines	**Tumor immunology:** tumor antigens; immune response to tumors and tumor evasion of the immune system, cancer immunotherapy. **Immunodeficiency:** Primary immunodeficiency, acquired or secondary immunodeficiency. Immune exhaustion in chronic viral infection, immune tolerance, NK cells in chronic viral infection and malignancy. **Cytokines:** Properties, receptor, cytokine related diseases and cytokine based therapies.		
Unit- IV Immunological techniques and Animal Models	**Immunological techniques:** Isolation of pure antibodies, Assay of complement, Assays for circulating immune complexes, Magnetic Activated Cell Sorting, Cell CycleAnalysis, Assays of Cell Death, Biochemical Approaches Used to Elucidate Signal, Transduction Pathways. **Nanobodies:** Introduction and applications **CMI techniques**: lympho-proliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays. **Animal models:** Inbredstrain, Adoptive transfer technique, Congenicstrain, Transgenic animals, and their use in immunological studies, Knockout Mice.		15

References:

1. Kindt, T. J., Goldsby, R. A., Osborne, B. A., &Kuby, J. (2006). KubyImmunology.New York: W.H. Freeman.
2. Brostoff, J., Seaddin, J. K., Male, D., &Roitt, I. M. (2002). Clinical Immunology. London: Gower Medical Pub.
3. Murphy, K., Travers, P., Walport, M., &Janeway, C. (2012). Janeway'sImmunobiology. New York: Garland Science.
4. Paul, W. E. (2012). Fundamental Immunology. New York: Raven Press.
5. Goding, J. W. (1996). Monoclonal Antibodies: Principles and Practice: Production and Application of Monoclonal Antibodies in Cell Biology, Biochemistry, and Immunology. London: Academic Press.
6. Parham, P. (2005). The Immune System. New York: Garland Science
7. C V Rao : An introduction to Immunology Narosa Publishing house
8. S. Pathak& U Palan: Immunology essential and fundamental, Second edition Parveen Publishing House
9. PrafulGodkar: Text Book of Medical Biochemistry,Bahalani Publishers
10. Ian R Tizard:Immunology, An introduction, fourth edition, Thomson.
11. Immunology, sixth Ed Roitt, Brostoff, Male Mosby, An imprint of Elsevier science Ltd
12. Medical Microbiology by Anantnarayan.
13. Abbas, A.K., Lichtman, A.H. and Pillai, S. (2007) Cellular and MolecularImmunology. Saunders Elsevier, USA.
14. Janeway, C.A., Travers, P., Walport, M. and Shlomchik, M.J. (2005)Immunobiology: The immune system in health and disease. Garland Science Publishing,USA.

M.Sc. Biotechnology
Semester –I
Paper-III-Cell Biology (PBT1CB3)

Unit	Topics	Credits	Number of lectures
Course Objectives: The objectives of this course are to sensitize the students to the fact that as we go down the scale of magnitude from cells to organelles to molecules, the understanding of various biological processes becomes deeper and inclusive.			
Student Learning Outcomes: Student should be equipped to understand three fundamental aspects in biological phenomenon: a) what to seek; b) how to seek; c) why to seek?			
Unit- I **Organization of Biological Membranes**	Cell theory; Lipid aggregates: micelles, bilayers and liposomes- structure, types, preparation, characterization, and therapeutic applications of liposomes. Composition and Architecture of membrane: structural lipids in membranes, membrane bound proteins- structure, properties, and function. Membrane Dynamics: lipid movements, flippase, FRAP, Lipid raft, Membrane fusion. Solubilization of the membrane by using different detergents.	4	15
Unit- II **Membrane transport & Cell Signaling**	Molecular mechanisms of membrane transport, nuclear transport. Cell Signaling: Principles of signaling, signaling through G-protein-coupled receptors ,signaling through enzyme-coupled receptors,alternative signaling routes in gene regulation,signaling in plants. Intercellular communications: nerve impulses, neurotransmitters; agonist and antagonist reactions.		15

Unit- III **Cellular processes – Manipulations**	Cell cycle and its regulation; cell divisions and related machineries. **Celldifferentiation:** stem cells, their differentiation into different cell types and organization into specialized tissues. **Cell death:** different modes of cell death and their regulation. Apoptosis (Programmed Cell Death) The Human Perspective. **Visualizing cells :** Isolation of cells; Light microscopy**,** phase contrast microscopy. EM: Localisation of specific macromolecule by immunogold EM**,** Images of surfaces by SEM Metal shadowing for surface exam of features at high resolution by TEM, Negative staining and cryo-electron microscopy.		15
Unit- IV **Genome Instability and cell Transformation**	Mutations, proto-oncogenes, oncogenes and tumor suppressor genes, physical, chemical and biological mutagens; types of mutations; Epigenetic mutations intra-genic and inter-genic suppression; viral and cellular oncogenes; tumor suppressor genes; structure, function and mechanism of action; activation and suppression of tumor suppressor genes; oncogenes as transcriptional activators.		15

References:

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2002). MolecularBiology of the Cell. New York: Garland Science.
2. Lodish, H. F. (2000). Molecular Cell Biology. New York: W.H. Freeman.
3. Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2014). Lewin's Genes XI. Burlington, MA: Jones & Bartlett Learning.
4. Cooper, G. M., &Hausman, R. E. (2009). The Cell: a Molecular Approach. Washington: ASM; Sunderland.
5. Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W. M. (2012). Becker's World of the Cell. Boston: Benjamin Cummings.
6. Watson, J. D. (1987). Molecular Biology of the Gene (7th ed.). Menlo Park, CA: Benjamin/Cummings.
7. Ernst J M Helmreich: The Biochemistry cell signaling. Oxford UniversityPress.
8. Karp, J.G.(2007). Cell and Molecular Biology. John Wiley & Sons, USA.

M.Sc. Biotechnology
Semester –I
Paper-IV- Genomics and Emerging Technologies (PBT1GE4)

Unit	Topics	Credits	Number of lectures
Course Objectives The objectives of this course are to provide introductory knowledge concerning genomics, proteomics and their applications.The objectives of this course are to teach basics of the new principles to students so as to appreciate current-day research tool-kit better.			
Student Learning Outcomes : Students should be able to acquire knowledge and understanding of fundamentals of genomics and proteomics, transcriptomics and metabolomics and their applications in various applied areas of biology. Students should be to learn history, theoretical basis, and basic understanding of latest technologies in area of biotechnology with applications of these technologies.			
Unit-I Regulation of Genome Activities	Transient changes in genome activity, permanent and semi-permanent changes. Regulation of genome activity during development: sporulation in *Bacillus*, Vulva development in *C.elegance* and development in *Drosophila melanogaster.*	4	15
Unit-II Genome Editing Technologies	Principles for maximizing gene expression: Expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag *etc.*; Intein-based vectors; Baculovirus and *Pichia*vectors system. Principle and application of gene silencing. Introduction to methods of genetic manipulation in different model systems *e.g.* fruit flies (*Drosophila*), worms (*C. elegans*), frogs (*Xenopus*), fish (zebra fish) and chick. Transgenics- gene replacement; gene targeting; creation of transgenic and knock-out mice; disease model.		15

Unit-III Functional genomics and proteomics	**Genomics:** Gene expression by SAGE and Microarrays: Construction of microarrays – genomic arrays, cDNA arrays and oligo arrays and its applications. NGS platforms, high and low read sequences. **Proteomics:** Separation and Identification of Proteins: Edman reaction, Protein tryptic digestion and peptide mass fingerprinting mass spectrometry, MALDI-TOF. Protein Expression Profiling: Protein Microarrays/ Protein chips: Types and applications. Gel-based quantitative proteomics: DIGE (Difference in Gel Electrophoresis). Gel-free based quantitative proteomic:Surfaceplasmon resonance,MS based used with stable-isotope tagging . In vivo and Invitro labelling- SILAC and ICATIntroduction to metabolomics, lipidomics, metagenomics and systems biology.		15
Unit-IV Molecular Cytogenetics	Advanced fluorescence techniques: FLIM, FRET, and FCS, Fluorescence Lifetime, Fluorescence Resonant Energy Transfer (FRET), Fluorescence Correlation Spectroscopy (FCS), Evanescent Wave Microscopy. Super-Resolution Imaging with Stochastic Optical Reconstruction Microscopy (STORM) and Photoactivated Localization Microscopy (PALM). **CRISPER CAS**: History, principle and Applications. Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing.		**15**

References:

1. Campbell, I. D. (2012). *Biophysical Techniques*. Oxford: Oxford University Press. Serdyuk, I. N., Zaccai, N. R., &Zaccai, G. (2007). *Methods in Molecular Biophysics: Structure, Dynamics, Function*. Cambridge: Cambridge University Press.
2. Phillips, R., Kondev, J., &Theriot, J. (2009). P*hysical Biology of the Cell*. New York: Garland Science.

3. Huang, B., Bates, M., &Zhuang, X. (2009). *Super-Resolution Fluorescence Microscopy.*Annual Review of Biochemistry, 78(1), 993-1016.doi:10.1146/annurev.biochem.77.061906.092014.
4. Mohanraju, P., Makarova, K. S., Zetsche, B., Zhang, F., Koonin, E. V., &Oost, J. V. (2016). *Diverse Evolutionary Roots and Mechanistic Variations of the CRISPR-Cas Systems.* Science, 353(6299). doi:10.1126/science.aad5147.
5. Lander, E. (2016). *The Heroes of CRISPR.* Cell, 164(1-2), 18-28. doi:10.1016/j. cell.2015.12.041.
6. Ledford, H. (2016). *The Unsung Heroes of CRISPR*. Nature, 535(7612), 342-344. doi:10.1038/535342a.
7. *Molecular Imaging* Theranostics, 4(4), 386-398. doi:10.7150/thno.8006 Coleman, W. B., &Tsongalis, G. J. (2010). *Molecular Diagnostics: for the Clinical Laboratorian*. Totowa, NJ: Humana Press.
8. Molecular biology of the cell by Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Rafi, Keith Roberts, and Peter Walter. 5th ed. 2008
9. Molecular Microbiology Diagnostic Principles and practice third edition, David H. Persing and Fred C. TenoverCopyright _ 2016 by ASM Press
10. Methods in Molecular Biology, Vol. 204: Molecular Cytogenetics: Protocols and Applications, Edited by: Y. S. Fan © Humana Press Inc., Totowa, NJ 2001
11. Molecular Biotechnology – Principles and applications of recombinant technology, Glick 4th edition 2010
12. Microarray and Microplates: Applications in biomedical sciences Shu Ye, Ian Day, 2003, Bios Scientific Ltd, oxford.
13. Human Molecular Genetics. Tom Strachan and Andrew Read, 2004, 3rd Edition, Garland Science.
14. Introduction to human molecular genetics. Jack Pasternak, 2005, 2nd Edition, Wiley publication.
15. Microarray bioinformatics by DovSketel , Cambridge university press 2003.
16. Brown, T.A. (2007) Genomes 3. Garland Science Publishing, USA.
17. Metzler, D.E. (2000) Biochemistry. Academic Press, USA.
18. Primrose, S.B. and Twyman, R.M. (2006) Principles of Genetic Manipulation and
19. Genomics. Seventh Edition. Blackwell Publishing, USA.

M.Sc. Biotechnology
Semester –I
PRACTICAL- I (PBT1PR1)
(PAPER I + PAPER IV)

4 Credits

1. To prepare an Acetate and phosphate buffers using the Henderson-Hassel Bach equation. (m)
2. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law. (m)
3. Protein gel staining techniques: silver staining, Activity staining: LDH, glycoprotein staining (M)
4. Viscosity studies of proteins (m)
5. Identification of sugars in fruit juices using thin layer chromatography. (M)
6. Isolation of starch from potato and its estimation by anthrone method. (M)
7. The isolation and assay of glycogen from liver and skeletal muscles of bird/mammal. (M)
8. Antimicrobial sensitivity test and demonstration of drug resistance. (M)
9. Microscopy types Confocal, Fluorescence, STORM – videos and pictures – Write up
10. Photo album of chromosomal abnormalities in normal and disease condition:
    - Numerical Detected By Using Different Probes – Centromeric, Locus Specific, Telomeric Structural -Translocations And Fusion Genes
    - Detection Of Inversions And Interstitial Deletions By SKY
    - CGH For a disease or cancer
11. Over-expression of proteins and analysis by SDS-PAGE
12. Preparation of competent cells and determination of transformation efficiency.
13. Recovery of DNA from low-melting temperature agarose gel.
14. Overview of MALDI-TOF-MS Virtual.

References:

1. Principles and techniques of Biochemistry and molecular biology (7th Ed, 2010) Keith Wilson and John Walker, Cambridge university Press.
2. Biochemistry Laboratory (2nd Ed, 2012) Rodney Boyer, Pearson's Publication.
3. Biochemical Methods, Sadasivam and Manikam(3rd Ed, 2008)New age international publishers,2008.
4. An Introduction to Practical Biochemistry (3rd Edition), David T Plummer, Tata McGraw Hill Publishing Company Limited, 1992.
5. Proteins and proteomics: A laboratory manual by Simpson.

M.Sc. Biotechnology
Semester –I
PRACTICAL II (PBT1PR2)
(PAPER II + PAPER III)

4 Credits

1. Preparation of TAB and sterility testing.(M)
2. Demonstration of Western blotting.
3. Perform serum electrophoresis (horizontal). (M)
4. To perform the Dot blot assays. (m)
5. To check antibody titer by Tube precipitation test.
6. Partial purification of IgG by ammonium sulphate fractionation and Dialysis
7. In-vitro demonstration of phagocytosis and calculating phagocytic index.
8. Latex bead agglutination / precipitation test for detection of rheumatoid factor. (m)
9. Separation of lymphocytes on Ficoll Histopaque and viability count. (M)
10. Isolation of cell organelle by differential centrifugation techniques from plant/ animal sources. (M)
11. Isolation of mitochondrial DNAand determination of succinate dehydrogenase activity. (M)
12. Isolation of chloroplast DNA. (M)
13. Isolation and identification of mutagens of plant origin (demonstration/ video)
14. To study the effect of detergents on membrane solubilization of cell.
15. Visit to a blood bank and preparation of report

References:

1. A Handbook of Practical Immunology – G P Talkwar
2. Practical immunology, Frank Hay, 4th Edition , Blackwell Science
3. Laboratory Manual of Microbiology, Biochemistry and Molecular Biology, Jyoti Saxena Mamta Baunthiyal, Indu Ravi , Scientific Publishers (India) 5 A, New Pali Road, P.O. Box 91 Jodhpur 342 001 (India)
4. Medical Laboratory Technology 2nd edition Authors Kanai, L Mukherjee and Swarajit Ghosh .McGraw Hill publications, 2010.
5. Practical Immunology, Frank Hay,4thEdition,BlackwellScience
6. Nigam and Ayyagari. (2007). Lab Manual in Biochemistry, Immunology and Biotechnology. TATA McGraw Hill.
7. Cell Biology Lab Manual-http: /www. ihcworld.com /_protocols/ lab_protocols/ cell biology- lab- manual-heidcamp.htm
8. Text Book of Medical Biochemistry, Praful Godkar. Bahalani.

Semester-II

M.Sc. Biotechnology
Semester –II
Bioinformatics and Biostatistics (PBT2BB1)

Unit	Topic	Credits	Number of lectures
Course Objectives: The objective of this course is to give conceptual exposure of essential contents of statistics to students and to provide theory and practical experience of the use of common computational tools and databases which facilitate investigation of molecular biology and evolution-related concepts.			
Student Learning Outcomes : Student should be able to : To Gain broad understanding in statisticsand approach to problem solving, on a diverse variety of disciplines. To Gain working knowledge of these computational tools and methods.			
Unit -I **Basics of Bioinformatics and DNA sequence analysis**	Bioinformatics basics: Computers in biology and medicine. Introduction to Unix and Linux systems and basic commands; Database concepts; Protein and nucleic acid databases; Structural databases; Biological XML DTD's; pattern matching algorithm basics; Databases and search tools: biological background for sequence analysis; Identification of protein sequence from DNA sequence; searching of databases similar sequence; NCBI; publicly available tools; resources at EBI; resources on web; database mining tools. DNA sequence analysis: gene bank sequence database; submitting DNA sequences to databases and database searching; sequence alignment; pairwise alignment techniques; motif discovery and gene prediction; local structural variants of DNA, their relevance in molecular level processes, and their identification; assembly of data from genome sequencing.	**4**	**15**

Unit -II Multiple sequence alignments and protein modelling	Multiple sequence analysis; multiple sequence alignment; flexible sequence similarity searching with the FASTA3 program package; use of CLUSTALW and CLUSTALX for multiple sequence alignment; submitting DNA protein sequence to databases: where and how to submit, SEQUIN, genome centres; submitting aligned sets of sequences, updating submitted sequences, methods of phylogenetic analysis. Protein modelling: introduction; force field methods; energy, buried and exposed residues; side chains and neighbors; fixed regions; hydrogen bonds; mapping properties onto surfaces; fitting monomers; RMS fit of conformers; assigning secondary structures; sequence alignment- methods, evaluation, scoring; protein completion: backbone construction and side chain addition; small peptide methodology; protein displays; substructure manipulations, annealing.		**15**
Unit -III Biostatistics	Introduction and Scope of statistics in biological studies and basic concepts. Collection of data, by different sampling methods: Simple random sampling stratifies random sampling and systemic sampling. Measures of central tendency; Mean, Median and Mode. Measures of Dispersion: Variance/ standard deviation, coefficient of variation. Confidence limits for mean and proportion. Probability and Basic concepts: Normal and binomial distribution. Correlation and regression analysis for a bivariate data: Scatter diagram.		**15**

Unit -IV Biostatistics	Test of Hypothesis: Null hypothesis, alternate hypothesis, test statistics,Type I and Type II errors, Level of significance and critical region. Z test: for a single sample, two samples, and two sample proportion. t-test a single sample, two samples and testing the significance of the correlation. Coefficient: t paired test. x^2 test: As a goodness of fit and in 2x2 contingency test		**15**

References:

1. Lesk, A. M. (2002):Introduction to Bioinformatics. Oxford: Oxford University Press.
2. Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. Baxevanis, A. D. & Ouellette, B. F. (2001). Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins. New York: Wiley-Interscience.
4. Pevsner J. (2015); Bioinformatics and Functional Genomics. Hoboken, NJ: Wiley-Blackwell.
5. Bourne, P. E., &Gu, J. (2009). Structural Bioinformatics, Hoboken, NJ: Wiley-Liss.
6. Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press.
7. N. Gurumani: A Introduction to Biostatistics (Second Edition-2005) M J P Publishers
8. Wayne W. Daniel Biostatistics: A foundation For Analysis In Health Sciences (7th Edition 1999) John Wiley & Sons Inc.
9. Veer BalaRastogi: Fundamentals of Biostatistics (2006) Ane Books India
10. NosmanStreiner, Biostatistics- the Bare Essentials (Second Edition 2000), B. C. Decker Inc.
11. E. A. Shortifile: Computer Based Decision Making in Medicine American Elsevier.
12. David W. Mount Bioinformatics: Sequence and Genome Analysis (Second Edition 2004). Coldspring Harbor Laboratory Press

M.Sc. Biotechnology
Semester –II
Plant and Animal Biotechnology (PBT2PA2)

Unit	Topic	Credit	Number of lectures
Course Objectives: The objectives of this course are to provide hands-on training in basic experiments of plant and animal biotechnology.			
Student Learning Outcomes: On completion of course, students should be able to gain basic skills in plant and animal biotechnology			
Unit-I Plant Tissue Culture	Plant tissue culture: historical perspective; organogenesis; Somatic embryogenesis; establishment of cultures –Micropropagation; soma -clonal variation; androgenesis and its applications in genetics and plant breeding; Germplasm conservation and cryopreservation; synthetic seed production. Protoplast culture and somatic hybridization - protoplast isolation; culture and usage; somatic hybridization - methods and applications; cybrids and somatic cell genetics. Plant cell cultures for secondary metabolite production. Hairy root culture.	**4**	**15**
Unit-II Animal Cell Culture	Animal cell culture: brief history of animal cell culture; culture of mammalian cells, tissues and organs; primary culture, secondary culture, continuous cell lines, suspension cultures; application of animal cell culture for virus isolation and *in vitro* testing of drugs, testing of toxicity of environmental pollutants in cell culture. Application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins.		**15**

Unit-III Animal Reproductive Biotechnology	Animal reproductive biotechnology: structure of sperms and ovum; cryopreservation of sperms and ova of livestock; artificial insemination; super ovulation, embryo recovery and *in vitro* fertilization; culture of embryos; cryopreservation of embryos; embryo transfer technology; transgenic manipulation of animal embryos. Applications of transgenic animal technology; animal cloning - basic concept, cloning for conservation for conservation endangered species.		**15**
Unit-IV Molecular Mapping And Marker Assisted Selection Plant Genetic Manipulations	Molecular Mapping: Molecular polymorphism, RFLP, RAPD, STS, AFLP, SNPmarkers; Construction of genetic and physical map; Gene mapping and cloning; QTL mapping and cloning. Marker Assisted Selection (MAS): Quantitative and qualitative traits; MAS for genesof agronomic importance, e.g. insect resistance, grain quality and grain yield. Strategies for Introducing Biotic and Abiotic Stress Resistance/Tolerance: Viral resistance; Fungal resistance; Insects and pathogens resistance; Drought, salinity, thermal stress, flooding and submergence tolerance. Chloroplast transformation;Molecular pharming: concept of plants as biofactories, production of industrial enzymes and pharmaceutically important compounds.		**15**

References

1. Biology of plant metabolomics, Robert Hall, Annual Plant Reviews, 43,Chichester, West Sussex; Ames, Iowa : Wiley-Blackwell, 2011
2. Plant Biotechnology. Umesha, S. (2013).
3. Glick, B. R., & Pasternak, J. J. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, D.C.: ASM Press.

4. Brown, T. A. (2006). Gene Cloning and DNA Analysis: An Introduction. Oxford: Blackwell Publishers.
5. Primrose, S. B., &Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics. Malden, MA: Blackwell Pub.
6. Slater, A., Scott, N. W., & Fowler, M. R. (2003). Plant Biotechnology: The Genetic Manipulation of Plants. Oxford: Oxford University Press.
7. Gordon, I. (2005). Reproductive Techniques in Farm Animals. Oxford: CAB International.
8. Levine, M. M. (2004). New Generation Vaccines. New York: M. Dekker.
9. Pörtner, R. (2007). Animal Cell Biotechnology: Methods and Protocols. Totowa, NJ: Humana Press.
10. Chawla, H. S. (2000). Introduction to Plant Biotechnology. Enfield, NH: Science.
11. Razdan, M. K. (2003). Introduction to Plant Tissue Culture. Enfield, NH: Science.
12. Slater, A., Scott, N. W., & Fowler, M. R. (2008). Plant Biotechnology: n Introduction to Genetic Engineering. Oxford: Oxford University Press.
13. Buchanan, B. B., Gruissem, W., & Jones, R. L. (2015). Biochemistry & Molecular Biology of Plants, Wiley 2002.
14. Primrose, S. B., &Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics. Malden, MA: Blackwell Pub.
15. Newbury, H.J. -Ed. (2003) Plant Molecular Breeding, CRC Press, Blackwell Publication, UK.
16. Paterson, A.H. (1996) Genome Mapping in Plants, Academic Press, USA.
17. de Vienne, D.Ed. (2003) Molecular markers in Plant Genetics, INRA Publications, France.

M.Sc. Biotechnology
Semester –II
Bioprocess Engineering and Technology (PBT2BE3)

Unit	Topics	Credit	Number of lectures
Course Objectives: The objectives of this course are to educate students about the fundamental concepts of bioprocess technology and its related applications, thus preparing them to meet the challenges of the new and emerging areas of biotechnology industry.			
Student Learning Outcomes: Students should be able to: Appreciate relevance of microorganisms from industrial context. Give an account of design and operations of various fermenters. Give an account of important microbial/enzymatic industrial processes in food and fuel industry.			
Unit-I **Basic Principles of Biochemical Engineering**	Sources of Microorganisms used in Biotechnology:Literature search and culture collection supply, Isolation de novo of organisms producing metabolites of economic importance. Strain Improvement: Selection from naturally occurring variants, Manipulation of the genome of industrial organisms in strain improvement Bioreactor design and analysis:upstream processing: media formulation and optimization; sterilization; aeration, agitation and heat transfer in bioprocess; scale up and scale down; measurement and control of bioprocess parameters, fermentation economics.	**4**	**15**

Unit II **Pharmaceutical Applications of Microbial Technology**	Production of Ergot alkaloids, Steroid biotransformation, bacterial vaccines. Antibiotic production: Cloning antibiotic biosynthesis Genes Modulating Gene Expression in Streptomyces Production of proteins from cloned genesin *E.coli* and mammalian cells. Production of recombinant pharmaceuticals –insulin, Human growth hormone (somatotrophin), Interferon vaccines.		**15**
Unit III **Applications of Enzymes in Food Processing**	Rationale for immobilizing enzymes, Methods for enzyme immobilization, Properties of immobilized enzymes, Industrial applications of immobilized enzymes.we Applications ofenzymes in food processing: Starch-processing enzymes. Enzymatic bioconversions. Lipases for the production of food components. inter-esterified fat Enzymes in protein modification Enzymes in bread making Enzymes in fruit and vegetable processing and juice extraction Enzymes in fish and meat processing		
Unit-IV **Applications of Microbial Technology in Food Process Production and Biofuels**	Microbial biomass production: mushrooms, SCP. Fermented foods and beverages - Sauerkraut production, soya bean fermentations, coffee, cocoa and tea fermentations *Food additives and supplements* • Lipids Nucleosides, nucleotides and related compounds Vitamins • Natural food preservatives- bacteriocins from lactic acid bacteria –		15

	production and applications in food preservation Nisin • Microbial production of colors and flavors. • Polyhydric alcohols low-calorie sweetener and is particularly useful for sweetening food products for diabetics • Microbial exopolysaccharides productionof Xanthan gum • Process Food wastes- for bioconversion to useful products (Compost, biofuels, biomass cheap source of raw material in fermentation etc).		

References:

1. Shuler, M. L., &Kargi, F. (2002). Bioprocess Engineering: Basic Concepts. Upper Saddle River, NJ: Prentice Hall.
2. Stanbury, P. F., & Whitaker, A. (2010). Principles of Fermentation Technology. Oxford: Pergamon Press.
3. Bailey, J. E., &Ollis, D. F. (1986). Biochemical Engineering Fundamentals. New York: McGraw-Hill.
4. El-Mansi, M., & Bryce, C. F. (2007). Fermentation Microbiology and Biotechnology. Boca Raton: CRC/Taylor & Francis.
5. Lee, Y. K. (2013). Microbial Biotechnology: Principles and Applications. Hackensack, NJ: World Scientific.
6. Alexander N. Glazer and Hiroshi Nikaido -Microbial Biotechnology: Fundamentals of Applied Microbiology, 2nd Edition.
7. Michael Waites and Morgan ,Rockney and Highton -Industrial microbiology : An Introduction.
8. Robert Whitehurst and Maarten Van Oort - Enzymes in food technology 2nded
9. NdukaOkafor Modern industrial microbiology and biotechnology Science Publishers, Enfield, NH, USA**(**2007).
10. Immobilized enzymes- An introduction and application in biotechnology- Michael Trevan, John Wiley sons (1980).
11. Fundamentals of enzymology-NC Price and L Stevens.
12. Methods in Enzymology Ed by K.MosbachVol 44 (1976),Vol 135,135a (1987).

M.Sc. Biotechnology
Semester –II
Intellectual Property Rights and Bioethics (PBT2IP4)

<table>
<tr><th>Unit</th><th>Topic</th><th>Credits</th><th>Number of lectures</th></tr>
<tr><td colspan="4">Course Objectives: The objectives of this course are:
• To provide basic knowledge on intellectual property rights and their implications in biological research and product development
• To become familiar with India’s IPR Policy
• To learn biosafety and risk assessment of products derived from biotechnology and regulation of such products;-
• To become familiar with ethical issues in biological research.
• This course will focus on consequences of biomedical research technologies such as cloning of whole organisms, genetic modifications, DNA testing.</td></tr>
<tr><td colspan="4">Student Learning Outcomes: On completion of this course, students should be able to:
• Understand the rationale for and against IPR and especially patents;
• Understand why India has adopted an IPR Policy and be familiar with broad outline ofpatent regulations;
• Gain knowledge of biosafety and risk assessment of products derived from recombinant DNA research and environmental release of genetically modified organisms, national and international regulations.</td></tr>
<tr><td>Unit- 1 Introduction to IPR</td><td>Introduction to intellectual property; types of IP: patents, trademarks, trade secrets, copyright & related rights, industrial design, geographical indications, Biodiversity importance and legislation, International convention and treaties; plant variety protection and farmer’s rights act. , traditional knowledge.</td><td rowspan="2">4</td><td>15</td></tr>
<tr><td>Unit -2 Patents</td><td>Basics of patents: eligibility criteria, classification of patents, categories, special patents, and patenting biological products.

Patentable and Non-patentable inventions in India and abroad. Process of Patenting, Patent Search, and Inventor’s homework, drafting patent applications, patenting systems.

Rights of the patent holder, assignment and licensing of patents and patent Infringement, case studies. Patent Agent.</td><td>15</td></tr>
</table>

Unit -3 Patentability of Biotechnology Inventions	Patentability of Biotechnology Inventions in India, Statutory Provisions Regarding Biotechnological Inventions Under the Current Patent Act 1970 (as Amended 2005). Biotechnological Inventions as Patentable Subject Matter, Territorial Nature of Patents,: From Territorial to Global Patent Regime, Interpreting TRIPS in the Light of Biotechnology Inventions, Feasibility of a Uniform Global Patent System, Merits and Demerits of Uniform Patent Law, Relevance of the Existing International Patent, Tentative Harmonisation Efforts, Implications of Setting up a Uniform World Patent System. This is purely hypothetical and only of academic interest.		**15**
Unit- 4 Bioethics	Introduction, bioethics in health care- euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, organ transplantation. Ethics of clinical research, Bioethics in research – cloning and stem cell research, Human, and animal experimentation, Agricultural biotechnology - Genetically engineered food, environmental risk, labelling and public opinion. Bioterrorism.		**15**

References:

1. Ganguli, P. (2001). *Intellectual Property Rights: Unleashing the Knowledge Economy*. Tata McGraw-Hill Publishing Company.
2. Karen F. Greif, Jon F. Merz - Current Controversies in the Biological Sciences_ Case Studies of Policy Challenges from New Technologies (Basic Bioethics)-The MIT Press (2007)
3. V. Sreekrishna - Bioethics and Biosafety in Biotechnology-to New Age International Pvt Ltd Publishers (2007)
4. Padma Nambisan (Auth.) - An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology- Academic Press (2017)
5. Kshitij Kumar Singh (auth.) - Biotechnology and Intellectual Property Rights_ Legal and Social Implications-Springer India (2015)

6. David Castle - The Role of Intellectual Property Rights in Biotechnology Innovation (2011)
7. Goel, D., &Parashar, S. (2013). *IPR, Biosafety and Bioethics*. Pearson Education India.
8. Singh, S. S. (2004). The Law of Intellectual Property Rights. *Deep and Deep Publications, New Delhi*, 96.
9. TalwarShabana; *Intellectual Property Rights in WTO and Developing Countries*, Edition 2010, Serials Publications, New Delhi.
10. Helga Kuhse_ UdoSchüklenk_ Peter Singer_ (eds.) - Bioethics_ An Anthology-Wiley-Blackwell (2016)
11. National Guidelines for Biomedical and Health Research on Human Participants (ICMR – 2017)
12. ICMR-DBT National Guidelines for Stem Cell Research - 2017

M.Sc. Biotechnology
Semester –II
PRACTICAL I (PBT2PR1)
(PAPER I + PAPER III)

4 Credits

1. Using NCBI and Uniprot web resources.
2. Introduction and use of various genome databases.
3. Similarity searches using tools like BLAST and interpretation of results.
4. Multiple sequence alignment using ClustalW.
5. Phylogenetic analysis of protein and nucleotide sequences.
6. Use of various primer designing and restriction site prediction tools.
7. Use of different protein structure prediction databases (PDB, SCOP, CATH).
8. Introduction to MS-EXCEL- Use of worksheet to enter data, edit data, copy data, move data.
9. Use of in-built statistical functions for computations of mean, S.D., correlation, regression coefficient etc.
10. Use of Bar diagram, histogram, scatter diagram.
11. Basics of SPSS .
12. Handling of biological data using statistical tools
13. Immobilize an organism / enzyme and detect the conversion of substrate to product.
14. Pigment isolation from Spirulina.
15. Demonstration of media optimization by Placket Burman test.
16. Methods for measurement of cell mass:

- Direct physical measurement of dry weight, wet weight, or volume of cells after centrifugation.
- Direct chemical measurement of some chemical component of the cells such as total N, total protein, or total DNA content.
- Turbidity measurements employ a variety of instruments to determine the amount of light scattered by a suspension of cells.

17. Evaluation of compost – physical and chemical parameters.
18. Preparation of compost of good quality compost from degradable wastes.
19. Production and analysis of Single cell protein.

M.Sc. Biotechnology
Semester –II
PRACTICAL II (PBT2PR2)
(PAPER II + PAPER IV) 4 Credits

1. Prepare culture media with various supplements for plant tissue culture.
2. Micropropagation using a suitable plant species.
3. Preparation of synthetic seeds.
4. Generate a RAPD profile of plant.
5. Prepare karyotypes and study the morphology of somatic chromosomes of any plant species.
6. To study the marker enzymes under abiotic stress
7. Demonstration of Secondary metabolite production from Beetroot
8. Count cells of an animal tissue and check their viability.
9. Prepare culture media with various supplements for animal tissue culture.
10. Monitor and measure doubling time of animal cells.
11. Chromosome preparations from cultured animal cells.
12. Isolate DNA from animal tissue by SDS method.
13. To study a patent and to develop a patent application for a hypothetical product or process.
14. To write SOPs of 4 laboratory equipment or instruments.
15. Use of Microsoft PowerPoint /coral draw to prepare poster (on a paper from peer reviewed journal not more than 5 years old or if possible on their own work presented before at a conference)
16. Compilation of information on recommended biosafety practices in a Biotechnology/ Biology laboratory. (demonstration by field visit or video)

References:

1. Experiments in Plant tissue culture, third edition, John H. Dodds, Lorin W, Roberts
2. In Vitro Cultivation of Animal Cells, Butterworth-Heinemann, An Imprint of Elsevier
3. Plant Biotechnology and its application in Tissue Culture, Ashwini Kumar and ShikhaRoi, IK International pv. ltd.
4. Sambrook and Russell (3rd Edition,2001) CSHL Press
5. Practical Immunology by Hudson & Hay (Blackwell Publishing) 4th edition 2002
6. Baxevanis, A.D. and Ouellette, B.F.F.(2005) Bioinformatics: A Practical Guide to the
7. Analysis of Genes and Proteins. John Wiley and Son Inc., USA.
8. Purifying Proteins for Proteomics Richard J. Simpson , 2004(CSHL Press)Molecular Cloning (A Laboratory Manual)
9. Mahajan's Methods in Biostatistics for Medical Students and Research Workers

Janardan Bhagat Shikshan Prasarak Sanstha's

CHANGU KANA THAKUR
ARTS, COMMERCE & SCIENCE COLLEGE, NEW PANVEL
(AUTONOMOUS)

Re-accredited 'A+' Grade by NAAC
'College with Potential for Excellence' Status Awarded by UGC
'Best College Award' by University of Mumbai

Affiliated to University of Mumbai with an autonomous Status

Revised Syllabus of

Program: M.Sc. Biotechnology

M.Sc. Part-II
(Semester III & IV)
Choice Based Credit & Grading System (60:40)

(To be implemented from Academic Year 2020-2021)

Preamble:

Master of Science (M.Sc.) Programme in Biotechnology is a P.G. Programme of Department of Biotechnology, Changu Kana Thakur Arts, Commerce & Science College, New Panvel, affiliated to University of Mumbai with an Autonomous status. Biotechnology is technology based on biology. Biotechnology harnesses cellular and bio-molecular processes to develop technologies and products that help to improve our lives and the health. Modern biotechnology provides breakthrough products and technologies to combat debilitating and rare diseases, reduce our environmental footprint, feed the hungry, cleaner energy, and have safer, cleaner, and more efficient industrial manufacturing processes.

The Choice Based Credit and Grading System (CBCGS) to be implemented through this curriculum would allow students to develop a strong footing in the fundamentals and specialize in the disciplines of his/her liking and abilities. The proposed credit-based curriculum and grading system will even add much more to the existing interdisciplinary nature of biotechnology.

Under the 'autonomy' we have made an attempt to design Master's in Biotechnology course syllabus to cater to the needs of credit based- semester and grading system. The changing scenario of higher education in India and abroad is taken into consideration to make this syllabus more oriented towards current need of modern research and industrial sectors.

The present M.Sc. Biotechnology Second Year (Semester III and IV) syllabus is based on the remodeled M.Sc. Biotechnology Curriculum, May 2017, Department of Biotechnology, Ministry of Science and Technology, Government of India and revised syllabus of University of Mumbai. Syllabus is robust and well-designed to enable students to pursue high quality research or increase employability of the students. Online course component has been introduced in the curriculum in keeping with the digital initiatives of MHRD to provide good quality self-learning content through MOOCs under SWAYAM and allied platforms. It is hoped that the revised syllabus shall serve its objective of promoting outcome-based learning to meet the changing needs of the biotechnology sector.

M.Sc. Biotechnology Course Structure

Semester III

Course code PSBT	Title	Theory /Practical	Marks	Credits	Nos of Lectures / week
PBT3AVM	Applied Virology and Microbiology	Theory	100	4	4
PBT3EBT	Environmental Biotechnology	Theory	100	4	4
PBT3BRA	Biologics and Regulatory Affairs	Theory	100	4	4
PBT3MET	Molecular Enzymology and Enzyme Technology	Theory	100	4	4
PBT3PR1	Practical- I (Paper-I &IV)	Practical	100	4	8
PBT3PR2	Practical –II (Paper-II &III)	Practical	100	4	8
		TOTAL	**600**	**24**	**32**

Semester IV

Course code PSBT	Title	Theory /Practical	Marks	Credits	Nos of Lectures / week
PBT4NBT	Nanobiotechnology	Theory	100	4	4
PBT4OSB	OMICS & Systems Biology	Theory	100	4	4
PBT4DDC	Drug Discovery & Clinical Study	Theory	100	4	4
PBT4SWF	Scientific Writing & Food Biotechnology	Theory	100	4	4
PBT4PR1	Practical- I (Paper-I &II)	Practical	100	4	8
PBT4PR2	Practical –II (Paper-III &IV)	Practical	100	4	8
		TOTAL	**600**	**24**	**32**

Teaching pattern: One (01) Credit would be of thirty-forty (30-40) learning hours; of this, more than fifty per cent of the time will be spent on classroom instructions including practical as prescribed by the University. Rest of the time would be invested for assignments, projects, journal writing, case studies, library work, industrial visits, attending seminars/workshops, preparations for examinations etc. would be considered as notional hours. The present syllabus considers (60L as classroom teaching and 15 lectures as Notional hours/ paper). Each lecture duration would be for 60 min. The names of the reference books provided in the syllabus are for guidance purpose only. Students and faculty are encouraged to explore additional reference books, online lectures, videos, science journals for latest/ additional information.

Eligibility: As per University of Mumbai Rules

Scheme of Examinations: (a) Internal assessment of 40 marks per course per semester should be conducted. (b) External assessment of 60 marks per course per semester at the end of every semester (c) Practical examination of 200 marks should be conducted at the end of every semester.

A) Internal Assessment: 40 % **40 Marks**

<table>
<tr><th>Sr. No.</th><th colspan="2">Particular</th><th>Marks</th></tr>
<tr><td>01</td><td colspan="2">One periodical class test / online examination to be conducted in the given semester</td><td>20 Marks</td></tr>
<tr><td rowspan="3">02</td><td colspan="2">One case study (clinical case/trial study report for paper III) /review / project with presentation based on curriculum to be assessed by the teacher concerned</td><td rowspan="3">15 Marks</td></tr>
<tr><td>Presentation</td><td>10 Marks</td></tr>
<tr><td>Written Document</td><td>05 Marks</td></tr>
<tr><td>03</td><td colspan="2">Active participation in routine class instructional deliveries and overall conduct as a responsible learner, mannerism and articulation and exhibit of leadership qualities in organizing related academic activities</td><td>05 Marks</td></tr>
</table>

	Semester -IV	
	a. **FOR PAPER 4:** The internal assessment will comprise of the following: Online course: The student is expected to complete at least one online course relevant for the subject from any of the appropriate reputed online platforms. A proof of successful completion of the online course must be provided for the award of marks. /TEST	20 Marks
	b. Research Proposal: The student is expected to submit a research proposal relevant to the subject	20 Marks

Question Paper Pattern
(Periodical Class Test for the Courses at Under Graduate Programs)

Maximum Marks: 20 Duration: 40 Minutes
Questions to be set: 02
All Questions are Compulsory

Question No.	Particular	Marks
Q-1	Match the Column / Fill in the Blanks / Multiple Choice Questions/ Answer in One or Two Lines (Concept based Questions) (1 Marks / 2 Marks each)	10 Marks
Q-2	Answer in Brief (Attempt any Two of the Three) (5 Marks each)	10 Marks

B) Semester End Examination: 60 % 60 Marks Duration: $2\frac{1}{2}$ hours

Question Paper Pattern

Theory question paper pattern
1. There shall be five questions each of 12 marks. 2. All questions shall be compulsory with internal options. 3. Question may be subdivided into sub-questions a, b, c… and the allocation of marks depends on the weightage of the unit.

Passing Standard:

The learners shall have to obtain a minimum of 40% marks in aggregate for each course where the course consists of Internal Assessment and Semester End Examination. The learners shall obtain minimum of 40% marks (i.e. 16 out of 40) in the Internal Assessment and 40% marks in Semester End Examination (i.e. 24 Out of 60) separately, to pass the course and minimum of grade D in each project wherever applicable to pass a particular

Practical Examination Evaluation scheme (50 marks per paper)

SL. No.	Questions	MARKS
1.	Practical Question 1	**25**
2.	Practical Question 2	**15**
3.	Journal	**05**
4.	Viva Voce	**05**
OR		
1.	Practical Question	**40**
2.	Journal	**05**
3.	Viva Voce	**05**
	Semester IV- Project Dissertation	**100**

- For semester IV it is mandatory for students to undergo Hands-on Project training in an established research laboratory or college laboratory for 4-6 months; This should involve one or more relevant instrumentation technique.
- Thesis on the same to be evaluated by the guide alternatively by an internal examiner for 50M based on the student's performance, written matter and experimentation.
- A certificate must be appended with the thesis. The external examiner will assess for 50M as a Presentation during practical exams. Marks allotted by Internal examiner would be scaled down if required as per university guidelines

The practical examinations at a center would be evaluated by one external examiner assigned by the University and one internal examiner assigned by the college/department.

Semester-III

M.Sc. Biotechnology
Semester –III
Paper-I Applied Virology & Microbiology (PBT3AVM)

Course Objectives:	• Students will be exposed to pandemic diseases, significance of epidemiology in studying various diseases and societal & economic issues related to such diseases. • Students will also learn details about emerging viral, bacterial, parasitic pathogens. Students will learn advanced, automated methods for determining antimicrobial susceptibility, drug resistance and various aspects of biofilms		
Course Outcomes:	• Students will understand epidemiological principles in prevention, control and management of pandemic disease. They will acquire understanding of antimicrobial resistance for management of drug resistance in population. • Students will understand the different aspects of biofilm and their management. They will also get insights into latest development of diagnostics & therapeutics for such diseases.		
Units	**Topics**	**Credit**	**Lectures**
Unit-I **Pandemic Diseases, Pathogenesis, Diagnosis and Treatment**	• Introduction to Pandemic diseases and causative agent like H1N1, MERS, SARS, Swine flu, COVID-19, Nipah virus, Ebola virus. • Structure of these virus-coat and envelope protein, genome composition. • Pathogenesis (Mechanism of infection) and Acute Clinical manifestations (Signs and symptoms) of H1N1, MERS, SARS, Swine flu, COVID-19, Nipah virus, Ebola virus. • Diagnosis, and Treatment for H1N1, MERS, SARS, Swine flu, COVID-19, Nipah virus, Ebola virus. • Economic and Social loss due to t Viruses.	**4**	**15**

Unit- II **Epidemiology of Infectious Diseases**	• Concept of Host, Reservoir, Source of infection, Carrier, Epidemic, Endemic, Pandemic, Outbreak • History, Definition scope, importance of epidemiology • Epidemiology, Health & Public Health • Epidemiological principles in prevention & control of disease • Measures of disease frequency – Concept of incidence, prevalence, Incidence rate, cumulative incidence, case fatality • Epidemiological studies Organizations in disease control & Research – WHO, CDC, UNICEF, NACO, ICMR, NARI, NIV & NGOs		**15**
Unit- III **Medical Microbiology**	• Emerging Pathogens / Infections: Diseases caused by Bacteria / parasites/ viruses- Name of causative agent, Name of disease caused, History, Antigenic structure, virulence factors, source of infection, Transmission, Pathogenesis, Clinical manifestations, Laboratory diagnosis, Treatment, Prophylaxis, vaccines, Current research and developments • Bacteria as emerging pathogens / Diseases caused by bacteria: MOTT, Legionella, Conditions caused by *Helicobacter pylori* • Viruses as emerging pathogens / Diseases caused by viruses: HIV (AIDS), Chikungunya, Dengue, • Parasites as emerging pathogens / Diseases caused by parasites: Malaria, *Entamoeba histolytica* (Amoebic dysentery)		**15**
Unit- IV **Biofilms** **&** **Antimicrobial Activity**	• Structure of Biofilm – Extracellular polymeric substances, Biofilm architecture. • Stages in formation of Biofilm. • Microbial interactions in Biofilms (Quorum sensing) Need for formation of Biofilms by microorganisms. • Microorganisms commonly associated with biofilms on indwelling medical devices		**15**

	Response of biofilms to host defense mechanisms & antimicrobial agents • Recent advances in biofilm management. • Conventional methods of drug susceptibility testing (Kirby-Bauer disc diffusion, Stoke's method, E test) • Advanced methods- Macro & Micro broth dilution methods, Time kill curves, serum killing curves and checker-board assays. • Detection of drug resistance in Staphylococci, Streptococci, Enterococci. Automated methods of sensitivity testing. Concept of CLSI standards.		

References:

1.	Microbiology An introduction 10th edition Gerald Tortora, Burdell Funke, Christine Case, Pearson Education Inc. Publication 2010.
2.	Basic Epidemiology R. Bonita, Bealglehole, T. Kjellstrom, 2nd Edition, 2006, WHO.
3.	Principles of Epidemiology in Public Health Practice, Third edition, US Department of Health & Human Services, CDC, 2012.
4.	Martin Rusnák, Viera Rusnáková, Georges Kamtoh,: Relations Between Epidemiology and Public Health, 2018 https://www.researchgate.net/publication/323964710
5.	Evaluation and use of Epidemiological evidence for environmental health risk assessment guideline document World Health Organization 2000 eur/00/5020369
6.	Ananthanarayan and Paniker's Textbook of Microbiology, by Reba Kanungo, 10thedUniversities Press; Tenth edition, 2017
7.	Koneman's Colour Atlas & Textbook of Diagnostic microbiology, 7th edition, 2017, Lippincott, Williams & Wilkins.
8.	Mackie & McCartney Medical Microbiology, J. G. Collee, J. P.Duguid, A. G. Fraser, B. P. Marmion, Thirteenth edition, Churchill Liviingston
9.	Bailey and Scotts Diagnostic Microbiology Forbes, Sahem et al 12th ed, Moshby

M.Sc. Biotechnology
Semester –III
Paper-II - Environmental Biotechnology (PBT3EBT)

Course Objectives	• This course aims to introduce learners to latest concepts in environmental biotechnology, various types of pollutions, monitoring, latest mitigation strategies and management of the same. Health hazards of pollution and waste, solid waste management, biodiversity concepts and data management and environmental monitoring.		
Course Outcomes	• At the end of the course, students will be able to understand various concepts of environmental biotechnology, latest development in the area and use of microbiological, molecular and analytical methods in environmental biotechnology.		
Units	**Topics**	**Credit**	**Lectures**
Unit -I **Air pollution and Management**	• Air pollution & air Quality Monitoring, Sampling, and Source Apportionment. • Air Pollution Management in Urban Settlement & Rural Areas, Integrated Air Pollution Management, Green Belt. Bio scrubber. Catalytic Systems. Green Technology. • Ozone Layer Depletion Atmospheric Brown Cloud Impact on Flora and Fauna Impact on Crop Yield, concept of carbon credit, footprint.	**4**	**15**
Unit -II **Soil pollution And Solid waste Management**	• Causes of soil salinity; Chemical and metallic pollution of agricultural soil; Mining and soil pollution. • Bioleaching of metals, bioaugmentation & biomagnifcation for soil remediation. • Phytostabilization - Contaminant removal, Soil cover, Rhizosphere modification, Geotextile capping solid waste; Industrial solid waste; Domestic solid waste; Agricultural solid waste; Municipal solid waste; Major sources of solid wastes; Effects of solid waste generation on quality of air, water and public health;		**15**

	• Solid waste management, Disposal of organic and medical waste; Recovery and recycling of metallic waste; Disposal of plastic waste and hazardous wastes.		
Unit -III Water Pollution and Management	• Biofilms in treatment of waste water; Biofilm development and biofilm Kinetics; Aerobic Biofilms. • Marine pollution-major pollutants (heavy metal, pesticide, oil, thermal, radioactive, plastics, litter and microbial, microplastics); • Biological indicators (Marine microbes, algae and crustaceans) and accumulators: Biotechnological application of hazardous waste management of water; Use of microbial systems, Phytoremediation strategies in constructed wetlands, Designing constructed wetlands, Substrate, Hydraulic loading rate, Hydraulic retention time, The selection of plant species, Surface area of wetland, Mechanisms to remove pollutants from constructed wetlands		**15**
Unit- IV Biodiversity & Environment Monitoring	• Introducing biodiversity informatics, Global patterns of distribution of biodiversity, biomes, Composition and distribution of biodiversity in India, Taxonomic Database Working Group (TDWG) standards, compatibility and interoperatability, taxonomically intelligent systems, Global biodiversity information system-Overview of the UNEP/GEF biodiversity data management project (BDM) • Biosensors in Environmental Monitoring – Working & its application for monitoring environment pollutants, Application of protein biomarkers; Biosensors and biochips. IOT for water quality monitoring – General working, Application, water Parameters.		**15**

References:

1.	Chandrappa, R., & Kulshrestha, U. C. (2015). *Sustainable air pollution management: theory and practice*. Springer. 7
2.	Karl B. Schnelle & Charles A. Brown, (2002) Air pollution control technology Handbook. CRC Press
3.	Singh, R. L. (Ed.). (2017). *Principles and applications of environmental biotechnology for a sustainable future*. Springer Singapore.
4.	Enger, E. D., Smith, B. F., & Bockarie, A. T. (2000). *Environmental science: A study of interrelationships* (p. 434). Boston, MA: McGraw-Hill
5.	Rittmann, B. E., & McCarty, P. L. (2012). *Environmental biotechnology: principles and applications*. Tata McGraw-Hill Education.
6.	Wainwright, M. (2012). *An introduction to environmental biotechnology*. Springer Science & Business Media.
7.	Bolan, N. S., Park, J. H., Robinson, B., Naidu, R., & Huh, K. Y. (2011). Phytostabilization: a green approach to contaminant containment. In *Advances in agronomy* (Vol. 112, pp. 145-204). Academic Press.
8.	Pradhan, A. K., & Pradhan, N. (2015). Microbial biosurfactant for hydrocarbons and Revised Syllabus for M.Sc. (Biotechnology) Semester III and IV Page 14 of 35 heavy metals bioremediation. In *Environmental Microbial Biotechnology* (pp. 91-104). Springer.
9.	Rittmann, B. E., & McCarty, P. L. (2012). *Environmental biotechnology: principles and applications*. Tata McGraw-Hill Education.
10.	Foin, T. C. (1976). *Ecological systems and the environment*. Houghton Mifflin.
11.	Wise, D. L. (1988). Biotreatment systems: Volume II, Springer.
12.	Sheng, Y., Qu, Y., Ding, C., Sun, Q., & Mortimer, R. J. (2013). A combined application of different engineering and biological techniques to remediate a heavily polluted river. *Ecological engineering*, *57*, 1-7.
13.	Maier, R. M., Pepper, I. L., & Gerba, C. P. (2009). *Environmental microbiology* (Vol. 397). Academic press.
14.	Olguni, E.J. et al. (2000) Environmental Biotechnology and Cleaner Bioprocess, Taylor & Francis.
15.	Gareth M. Evams et al., (2003) Environmental Biotechnology: Therory & Applications, Wiley.
16.	Milton fingerman et al. (1999) Recent Advances in Marine Biotechnology Volume 3, AbeBooks Inc
17.	Upadhyay, L. S., & Verma, N. (2015). Role of Biosensors in Environmental Monitoring. In *Environmental Microbial Biotechnology* (pp. 77-90). Springer.

18.	Geetha, S., & Gouthami, S. (2016). Internet of things enabled real time water quality monitoring system. *Smart*
19.	Gibas, C., Jambeck, P., & Fenton, J. M. (2001). *Developing bioinformatics computer skills*. "O'Reilly Media, Inc.". *Water*, *2*(1), 1.
20.	Attwood, T.K. & Parry-Smith D.J. (2003). Introduction to Bioinformatics. Pearson Education.
21.	Rastogi, S. C., Rastogi, S. C., Mendriratta, N., & Rastogi, P. (2006). *Bioinformatics: Concepts, Skills & Applications*. CBS Publishers & Distributors Pvt. Limited.
22.	Sensen, C. W. (2005). *Handbook of genome research: genomics, proteomics, metabolomics, bioinformatics, ethics and legal issues; Vol. 1 und 2*. Wiley-VCH Verlag GmbH & Co. KGaA.

M.Sc. Biotechnology
Semester –III
Paper-III- Biologics and Regulatory Affairs (PBT3BRA)

Course Objectives:	• To introduce learner to the basic concept of Biologics and Biosimilars, and its therapeutic uses • To expose learner to the methodologies/steps involved in the production of Biologics/Biosimilars. • To educate learner with the nuances of characterization of Biosimilars with emphasis on Reference Biologic. • To familiarize learner with the regulatory aspects of approval of a Biologic/Biosimilar.		
Course Outcomes	At the end of the course, the learner will be: • Familiar with the basic concepts and significance of Biologics/Biosimilar in addition to having knowledge about its therapeutic applications Knowledgeable in the steps involved in the production of Biologics/Biosimilars • Aware of the protocols/techniques required for characterization of the Biosimilars relative to the Reference Biologic • Acquainted with the regulatory aspects of approval of a Biosimilars.		
Unit	**Topics**	**Credits**	**Lectures**
Unit- I **Introduction to Biologics and Biosimilars**	• Definition: Drugs, Small molecules, Large molecules/Biologics; Categories of Biologics: protein-based hormones, enzymes, monoclonal antibodies, vaccines, blood products, and gene/ cellular therapies. • Similarities and Differences: Small molecules versus generics, Biologics versus Biosimilars. • USFDA Approved Small Molecules and USFDA Approved Generics USFDA Approved Biologics and USFDA Approved Biosimilars. • Indian Regulatory Scenario in relation to Small Molecules and Biologics. • Therapeutic uses of some of the Biologics/Biosimilars Acceptable quality differences between approved Biosimilar and innovator's product.	**4**	**15**

Unit- II **Production of Biologics and Biosimilar s**	• Reference Biologic and its significance, Choice of expression system/s and stability of cell lines Development of upstream and downstream processes and scale up to manufacturing. • Major factors contributing to the maintenance of product quality: raw materials and manufacturing conditions, virus filtration, mycoplasma removal, ultrafiltration. • Example: Production of Monoclonal antibody, downstream processing of Mab Introduction to the concept of Biobetters vs Biosimilars.		**15**
Unit- III **Characterization of Biologics and Biosimilars**	• Appearance, particulates, pH, osmolality, particle size Molecular Weight, Protein Sequence and/or amino acid composition Glycosylation, Sialylation, Phosphorylation, Acetylation, and Myristoylation, if any Sulfhydryl groups(s) and di-sulphide bridges. • Size and Purity on HPLC/ MALDI Isoform pattern, Gel electrophoresis (IEF, SDS PAGE and Native PAGE), Western blot Fluorescence spectrum FTIR spectrum and NMR spectrum Bioassays, characterization using Monoclonal Antibody as an example.		**15**
Unit- IV **Quality Assurance** **&** **Regulatory Affairs of Biologics and Biosimilars**	• Introduction to Regulatory Affairs and approvals of Biosimilars, Products approved under the FD&C. • PHS/BCPI Act 2009: Innovator Biologics Approval, Biosimilar Pathway, Totality of Evidence, Information required to demonstrate biosimilarity, Inter changeability, Product Switching, Product Naming Global regulatory framework.		**15**

References:

1.	**Biosimilars:** Regulatory, Clinical and Biopharmaceutical Development, Editors: Hiten J. Gutka, Harry Yang, Shefali Kakar, AAPS Advances in the Pharmaceutical, Sciences Series, Volume 34.
2.	https://www.fda.gov/drugs/drug-approvals-and-databases/approved-drug-products-therapeutic-equivalence- evaluations-orange-book.
3.	https://www.fda.gov/drugs/therapeutic-biologics-applications-bla/purple-book-lists-licensed-biological- products-reference-product-exclusivity-and-biosimilarity.
4.	http://nib.gov.in/ NIB-DBT2016.pdf.
5.	Biosimilars of Monoclonal Antibodies, A Practical Guide to Manufacturing, Preclinical, and Clinical Development. *Edited by Cheng Liu, Ph.D.,K. John Morrow, Jr., Ph.D.,* Copyright c 2017 by John Wiley & Sons, Inc. All rights reserved. Published by John Wiley & Sons, Inc., Hoboken, New Jersey.
6.	Introduction to Biologic and Biosimilar Product Development and Analysis, Karen M. Nagel, AAPS Introductions in the Pharmaceutical Sciences, Editor-in-Chief: Robin M. Zavod, Midwestern University, Downers Grove, IL, USA
7.	International Journal of Drug Regulatory Affairs; 2017, 5(1), 20-24.
8.	Introduction to Biosimilars and Regulatory Requirements. Fact Sheet 3. International Federation of Pharmaceutical Manufacturers & Association (Geneva) & International Alliance of Patients Organization (UK).

M.Sc. Biotechnology
Semester –III
Paper-IV-Molecular Enzymology and Enzyme Technology (PBT3MET)

Course Objectives	• To get familiarity with the basic concepts of enzymes like enzyme kinetics, catalytic power of enzymes, active site and transition sate, regulatory and allosteric enzymes, on protein enzymes. • Techniques of enzyme purification and its importance. Need for enzyme engineering and its benefits and applications. • Role of enzymes as a diagnostic tool and for industrial applications. Use of enzymes as Biosensors.		
Course Outcomes	• Enzyme deficiencies and use of enzymes as therapeutics. At the end of the course the student will be aware of the enzyme kinetics, the catalytic power of an enzyme, changes in the active site, and the importance of the transition state. The importance of obtaining enzymes in their pure form and the ways it can be achieved. The need for and methods for enzyme engineering to enhance its activity or half-life. • The significance of enzymes as diagnostic tools, in therapy, industrial application and as biosensors; and the outcome of enzyme deficiencies.		
Unit	**Topics**	**Credits**	**Lectures**
Unit-I Basic concepts of Enzymology	• Brief history and introduction; chemical nature and properties of enzymes; • **how enzymes work**-mechanism of action; **catalytic power** and specificity of enzymes; types of catalysis; **active site**; **transition state** and evidence for enzyme transition state complementarity; enzyme kinetics – **factors affecting enzyme activity**; enzyme inhibition; enzyme specificity; • **Regulatory enzymes**, regulation of enzyme activity; **allosteric enzymes** and their kinetic properties; units of enzymes; non protein enzymes.	**4**	**15**
Unit-II Techniques of Enzyme Purification and Studies /Enzyme Engineering	Purification and Characterization: • Based on molecular size (Dialysis/ ultrafiltration, density gradient centrifugation, size exclusion chromatography); • based on solubility of proteins (Isoelectric precipitation, salting out); Based on electric charge		**15**

	(Ion exchange chromatography, Electrophoresis-capillary electrophoresis, 2D electrophoresis); • Based on adsorption properties (Adsorption and Affinity chromatography). • Other techniques: Immobilized metal ion affinity chromatography, Hydrophobic interaction chromatography, Reversed-phase chromate-graphy and Chromato-focusing. Enzyme engineering – Introduction, Objectives, Principles, Examples and Steps involved in enzymes engineering. Random mutagenesis and molecular breeding of DNA. Recent advances in rational approaches for Enzyme engineering. Applications of enzyme engineering.		
Unit-III Industrial & Medical Application Of Enzymes	• Textile Industry, Detergent Industry, Pulp and Paper Industry, Animal Feed Industry: Enzyme Technology for Detoxification of Mycotoxins in Animal Feed, Phytases for Feed Applications and Leather Industry. Enzyme Applications for Human and Animal Nutrition. • Biosensors – Introduction, instrumentation, Types and examples. • Enzymes based sensors as diagnostic tools-Biosensors for Blood Glucose, Biosensors for Urea in Blood and Urine, Biosensors for Uric Acid, Biosensors for Arginine, Biosensors for Asparagine, Biosensors for Creatinine, Biosensors for Cholesterol, Allosteric enzyme-based biosensors.		**15**
Unit-IV Enzyme Deficiencies/ Diagnostic Enzymes/ Therapeutics	• Disorders of amino acid metabolism-Phenylketonuria, Alkaptonuria, Homocystinuria. • Disorders of carbohydrate metabolism – Galactosemia, Hereditary fructose intolerance, hereditary lactose intolerance. • Disorder of lipid metabolism - Gaucher disease, Fabry disease. • Enzymes in diagnosis of diseases- Liver disorders, Cancer, Cardiac disorders. • Role of Other enzymes- Lysozyme, Butyryl choline esterase and Lipases.		**15**

	• Therapeutic uses of enzymes - enzymes in replacement therapy enzymes in cancer treatment, enzymes for fibrinolysis, enzymes used for various treatments and enzyme gene therapy. • Iso-enzymes; enzyme pattern in diseases.		

References:

1.	Lehninger Principles of Biochemistry (4th Ed. Nelson, D., and Cox, M.; W.H. Freeman and Company, New York, 2005
2.	Satyanarayan and Chakrapani, Biochemistry. New Delhi, Elsevier Health Sciences APAC, 2013.
3.	Berg JM, Tymoczko JL, Stryer L (2002): Biochemistry, 5th ed., Freeman WH and Co., New York.
4.	https://shodhganga.inflibnet.ac.in/bitstream/10603/100595/7/07_chapter%201.pdf General Introduction to enzymes
5.	https://iopscience.iop.org/ book/978-0-7503-1302-5/chapter/bk978-0-7503-1302-5ch1 Introduction to enzymes and their applications.
6.	Biochemistry by Lehninger, 2nd Ed, Kalyani publication 2008.
7.	Understanding enzymes (3rd edition). Edited by Trevor Palmer, Ellis Horwood, Chichester, 1991.
8.	Protein purification principles, High Resolution Methods, and Applications, 3rd Edition, Jan-Christer Janson, John Wiley & Sons, Inc., Hoboken, New Jersey.
9.	https://www.biotecharticles.com/ Applications-Article/Methods-of-Purification-of Enzymes-583.html
10.	https://www.creative-enzymes.com/service/enzyme-purification_307.html Enzyme Purification
11.	http://web.sungshin.ac.kr/~spark/class/enzchem/EnzChem_ch02pdf Chapter 2 - purification of enzymes
12.	https://www.labome.com/method/Protein-Purification.html
13.	http://www1.lsbu.ac.uk/water/enztech/index.html Chapter 6 Enzyme preparation and use Revised Syllabus for M.Sc. (Biotechnology) Semester III and IV Page 21 of 35
14.	https://docplayer.net/20937505- Protein-purification-nison-sattayasai-khon-kaen-universitythailand-1-introduction-2-extraction-of-protein.html
15.	http://www.processdevelopmentforum.com/ppts/posters/ Protein_purification_methods _overview,_29155460.pdf
16.	https://www.researchgate.net/publication/281102215_ How_to_purify_proteins.
17.	Fundamentals of Enzyme Engineering, Young Je Yoo, Yan Feng, Yong-Hwan Kim, Camila Flor J. Yagonia, : Springer Netherlands 2017

M.Sc. Biotechnology
Semester –III
PRACTICAL- I (PBT3PR1) 4 Credits

Paper-I

1.	Viral Titering – Plaque Assay, Tissue Culture Infectious Dose (TCID), Chicken Embryo Infectious Dose (CEID)
2.	Immunoassays: For detection of the virus antigens by ELISA / RIA
3.	Detection techniques for COVID like RT- PCR and various RAPID tests
4.	Diagnosis of dengue (kit method).
5.	Diagnosis of Chikungunya (kit method)
6.	Antibiotics susceptibility testing by broth Macro dilution method & Micro broth dilution method
7.	Study of microbial biofilm formation on various surfaces & Biofilm visualization by staining
8.	Demonstration of minimum biofilm inhibition concentration of antibiotics/disinfectants

Paper-II

1.	Soil and water quality assessment (temp, pH, salinity, water holding capacity of soil etc.
2.	Study of metal tolerance of microorganisms isolated from soil/water.
3.	Soil ecosystem analysis/ analysis of microorganisms of soil.
4.	Analysis of compost.
5.	Detection of heavy metals concentration in soil/ water.
6.	Study and comparison of different air samplers.
7.	Growth curve of metal tolerant organism isolated from soil/ water.

M.Sc. Biotechnology
Semester –III
PRACTICAL- I (PBT3PR2) 4 Credits

Paper-III

1.	Electrophoresis {PAGE (native, SDS, reducing, non- reducing)} to characterize the protein with regard to its molecular weight, structure/subunits/SS bonds etc., or for detection of impurities in the product.
2.	Concentration of protein with Folin Lowry
3.	Western blot/dot blot for purity of product demonstration/ dummy sandwich preparation of semi-dry or wet western blot sandwich.
4.	HPLC /FTIR/NMR spectrum based theory questions may be asked for interpretation
5.	Visit to a facility manufacturing Biosimilar

Paper-IV

1.	Microbial Enzyme production: a. Partial purification using ammonium sulphate precipitation. b. Dialysis of the salt-precipitated protein. c. Assessing the enzyme activity and the protein content.
2.	Effect of inhibitors/ chemicals on enzyme activity.
3.	Extraction of enzymes from any plant sources.
4.	Measurement of Enzymatic Activity by Using a Colorimetric Assay.
5.	Purification of Acid Phosphatase from Wheat Germ.
6.	Enzyme Immunoassays. a. Methods for Enzyme Immunoassays. b. Non-competitive Solid-phase Enzyme Immunoassay. c. Competitive, Solid-phase Enzyme Immunoassay.
7.	Determining of Alkaline Phosphatase (ALP) Concentration in Blood Plasma.
8.	Measuring Lactase Enzymatic Activity.
9.	Screening of new microbial strains for production of enzymes and perform its activity staining (zymogram).
10.	To determine Specific activity of α Amylase from different sources.

Semester-IV

M.Sc. Biotechnology
Semester –IV
Nanobiotechnology (PBT4NBT)

Course Objectives	• The course aims at providing a general and broad introduction to multi-disciplinary field of nanotechnology. • It will familiarize students with the synthesis and applications of nanomaterials in the field of medicine. • The course will also give an insight into complete systems where nanotechnology can be used to improve our everyday life.		
Course Outcomes	• Students should be able to understand the basic science behind the properties of nanomaterials and the principles behind advanced experimental techniques for studying nanomaterials. Also understand the different aspects and applications of nanomaterials.		
Unit	**Topic**	**Credits**	**Lectures**
Unit -I Introduction to Nanotechnology and Nanomaterials	• Introduction: Nanotechnology, Nature's biological pathway, Examples of nanomaterials and nanostructures found in nature. • Nanometer-scale materials: Nanometer-Scale Metals Nano Metal Oxides, Nanopolymers, Quantum Dots, Carbon nanostructures. • Nanorobotiocs devices of nature ATP synthase, the kinesin, myosin, dynein, flagella modulated motion.	**4**	**15**
Unit -II Synthesis of Nanomaterials	• Synthesis of nanometer-scale materials- Top down and Bottom up approaches. • Self-Assembly of nanoparticles and its mechanism. • Bio-directed synthesis and assembly of nanomaterials Synthesis and Assembly of Nanoparticles and Nanostructures Using Bio-Derived Templates		
Unit -III Nanotechnology in Drug Delivery	• Biological Barriers to Nanocarrier- Mediated Delivery of Therapeutic and Imaging Agents, Nano-Sized Carriers for Drug Delivery, nano enabled drug delivery system, nanorobotics in medicine, • Nanomedicine: biopharmaceutics, implantable materials, implantable chemicals, surgical aids.		

Unit –IV Applications of nanotechnology and Nanotoxicology	• Applications of Nanomaterials. • Nanotoxicology: Unique Properties, Toxicity of Nanomaterials, Factors Responsible for the Nanomaterial Toxicity, Routes of Exposure, Mechanisms of Nanoparticle Toxicity, • In Vitro Testing Methods for Nanomaterials, Ecotoxicity Analyses of Nanomaterials		

References:

1.	Poinern, Gerrard Eddy Jai. A laboratory course in nanoscience and nanotechnology. CRC Press, 2014.
2.	Guozhong, Cao. Nanostructures and nanomaterials: synthesis, properties and applications. World scientific, 2004.
3.	Sulabha K. Kulkarni (auth.) - Nanotechnology_ Principles and Practices-Springer International Publishing (2015)
4.	Crookes-Goodson, W. J., Slocik, J. M., & Naik, R. R. (2008). Bio-directed synthesis and assembly of nanomaterials. Chemical Society Reviews, 37(11), 2403-2412
5.	Chad A. Mirkin, Christof M. Niemeyer - Nanobiotechnology II_ More Concepts and Applications-Wiley-VCH (2007)
6.	Christof M. Niemeyer, Chad A. Mirkin (Editors) - Nanobiotechnology_ Concepts, Applications and Perspectives-Wiley-VCH (2004)
7.	Chad A. Mirkin, Christof M. Niemeyer - Nanobiotechnology II_ More Concepts and Applications-Wiley-VCH (2007)
8.	Oded Shoseyov, Ilan Levy NanoBioTechnology_ BioInspired Devices and Materials of the Future (2008, Humana Press)
9.	Textbook of Nanoscience and Nanotechnology by B.S. Murty, P. Shankar, Baldev Raj, B B Rath, James Murday
10.	Arun Kumar - Nanomedicine in drug delivery-CRC Press _ Taylor & Francis (2013).
11.	Yuliang Zhao, Zhiyong Zhang, and Weiyue Feng - Toxicology of Nanomaterials-Wiley- VCH (2016)
12.	Diwan, Parag, and Ashish Bharadwaj, eds. The Nanoscope: Encyclopedia of Nanoscience and Nanotechnology. Pentagon Press, 2005. (Vol 1-6)

M.Sc. Biotechnology
Semester –IV
OMICS & Systems Biology (PBT4OSB)

Course objective:	• Bring awareness of the emerging fields of OMICS and Systems Biology, biological systems as a whole and how parts of a systems interact with each other To introduce the techniques involved in Genomics, Proteomics, transcriptomics, Lipidomics and Metabolomics. • To describe the key features of human genome project • To understand the applications of the different OMICS technology to screening, testing and treatment of human diseases. • Perturbation of biological systems to study various responses in the biological systems using high throughput techniques. • Introduction to the modeling systems, databases, computational tools used in systems biology Data mining: The unit aims at introducing the concept of knowledge discovery process, data mining methods and various scientific application of data mining. The unit also explores application of systems biology in different field of health care.
Course outcome:	**At the end of the course learners will be able to** • Understand how the data is generated by OMICS technologies to contribute to different databases. • Understand, compare and contrast the techniques involved in Genomics, Proteomics, transcriptomics, Lipidomics and Metabolomics. • Will be able to apply the different technologies of OMICS to the screening, testing and treatment of human diseases. • Understand the structure and dynamics of a systems as a whole. Apply the different approaches to study systems biology by top down and bottom up approach. • Introduction to concepts of knowledge discovery process and data mining methods. Understand the application of data mining in genomics, proteomics and development of tools in bioinformatics. Have the knowledge of applications of systems biology in development of personalized medicine, drug development.

Unit	Topic	Credit	Lectures
Unit-I OMICS- The OMICS Technology, A Broad Outlook	• Tools of Omics-Introduction to Epigenomics Human genome project- goals, conclusions and application. • Structural and functional proteomics- protein- protein interaction and identification of interactions by various methods. • Application of Proteomics and Genomics in human diseases –screening, testing and treatment of diseases. • Metagenomics: concept, strategies, and applications in environmental biotechnology, agriculture and health	**4**	**15**
Unit-II Transcriptomics, Lipidomics and Metabolomics	• Introduction to Transcriptomics, Lipidomics And Metabolomics, Glycomics, • Pharmacogenomics Techniques used in Lipidomics- Mass Spectroscopy, TLC, HPLC, GC and Capillary electrophoresis, MALDI. • Technique used in Metabolomics- Mass Spectroscopy, Electrophoresis, chromate-graphy- GC, LC & NMR. • Technique used in Transcriptomics- next generation sequencing, northern blotting, DDRT-PCR, microarrays, gel free assays like biolayer interference, SPR. • Applications of transcriptomics metabolomics and lipidomics in human diseases –screening, testing and treatment of diseases. (in clinical applications, personalized medicine, infectious diseases)		**15**
Unit-III Introduction to Systems Biology	• Systems biology towards systems level understanding of biological systems • Systems structure, systems dynamics, systems design and control, systems project Models and Modelling systems in systems biology • What is a model? Key properties of models, Basic of computational models, networks,		**15**

	data integration, standards, and model organism • Perturbation of biological systems and 'Omics' as Quantitative high throughput experimental tools for systems biology Standards and formats for systems biology. • Computational Databases and software tools in systems biology. • Biological networks: metabolic networks, gene regulatory networks, PPI networks, genetic interaction (GI) networks, and signaling networks.		
Unit-IV **Data mining and Application of Systems Biology**	• Introduction to Knowledge of discovery in databases (KDD) What is knowledge, need for KDD, KDD process outline, concept and goals. • Data Mining methods: Statistics – classification, correlation, association analysis, regression, and clustering Machine learning –Symbolic and statistical approaches. • Text mining, and Pattern evaluation. • Data mining in scientific application • Application of systems biology: 1. Systems biology to systems medicine. 2. Application of systems biology in drug discovery and development 3. Systems biology and synthetic biology.		**15**

References

1.	Bioinformatics and functional genomics (2003). Jonathan Pevsner John wiley & sons Publications.
2.	Integration of omics approaches and systems biology for clinical applications. Antonia Vlahou, Harald Mischak, Jerome Zoidakis, Fulvio Magni. Wiley publications.
3.	Omic technologies: genomics, transcriptomics, proteomics and metabolomics. Richard P. Horgan And Louise C. Kenny Scientific advisory committee (sac), the obstetrician and gynaecologist.
4.	Bioinformatics and functional Jonathan Pevsner. Wiley blackwell genomics, *third edition* publications.

5.	Concepts and techniques in genomics and proteomics- Nachimuthu Saraswathy And Ponnusamy Ramalingam. Biohealthcare publishing (oxford) limited.
6.	Introduction to proteomics-*tools for the new biology- by* Daniel C. Liebler, Humana press totowa, nj.
7.	Introduction to proteomics principles and applications By Nawin Mishra John Wiley & sons, inc., publication.
8.	Multi-omics approaches to disease Hasin et.,Al; Genome biology (2017).
9.	The new science of metagenomics Committee on Metagenomics: Challenges and Functional Applications, National Research Council, Board on Life Sciences The national academies press. www.nap.edu.
10.	Human molecular genetics 4th edition. Tom Strachan and Andrew Read Garland science.
11.	Lipidomics-technologies and applications (2012) Dr. Kim Ekroos Wiley wch publications.
12.	Topics in current genetics-metabolomics- a powerful tool in systems biology Jens Nielsen · Michael C. Jewett (Eds) Springer publications.
13.	Foundations of systems biology. First edition Hiraokikitano(2001) MIT press, Cambridge
14.	Systems biology Karthik Raman and Nagasuma Chandra, Resonance February 2010.
15.	Systems biology a textbook, second edition Edda Klipp, Wolfram Liebermeister, Christoph Wierling Axel Kowald Wiley-vch publication.
16.	A new approach to decoding life: systems biology Trey Ideker Article *in* annual review of genomics and human genetics · February 2001.
17.	systems biology and synthetic biology (2009) Pengcheng Fu, Sven Panke Wiley publication.
18.	Analysis of biological networks (2008) Bjorn. Junker, Falk Schreiber Wiley Inter-science.
19.	Knowledge discovery and data mining in biological databases Vladimir Brus I C The knowledge engineering review, vol. 14:3, 1999.
20.	Computational systems biology Andrieskreite, Roland Eils Elsevier academic press.
21.	introduction To Biological Networks Alpan Ravaland Animesh Ray CRC press (2013).
22.	Advanced systems biology methods in drug discovery and translational biomedicine Jun Zou Biomed research international volume 2013.

M.Sc. Biotechnology
Semester –IV
Drug Discovery & Clinical Study (PBT4DDC)

Course Objectives:	• The objective of this course is to have a firm foundation in Drug Discovery and Clinical Studies. • To provide students' knowledge about Clinical Trial Design and Indian Regulations, Pharmacovigilance and Clinical Data Science.		
Course Outcomes:	By the end of the course the student will: • Able to learn about drug discovery-design pathway using some in-silico tools. Able to understand the clinical trial design set up as well as they will gain information on rules-regulation and responsibilities in clinical studies.		
Unit	**Topics**	**Credit**	**Lectures**
Unit-I **Clinical Research Informatics in Drug Discovery**	**Introduction to the drug discovery & development** • Source of drugs • Structural effects on drug action • Drugs derived from natural products • General principles of pharmacology • Drug development and testing process **Approaches to new drug discovery** • Computer-aided drug design • Identification of novel drug candidates and drug targets • Construction the signaling network of a drug using integer linear programming • Identification for druggable targets of a disease	**4**	**15**
Unit II **Clinical Trial Design And Indian Regulations**	**Clinical Trial Design** • Basic framework of clinical trial • Randomized clinical trials and different phases • Adaptive randomization methods • Seamless design • Internal pilot design • Design selection factors		**15**

	Regulations • The national regulatory body • Key documents in clinical research • Regulatory requirements for the conduct of clinical trials in India **The Roles and Responsibilities of Stakeholders in the Sharing of Clinical Trial Data** • Participants in clinical trials, Investigators, • Research institutions and universities • Journals and Professional societies		
Unit III **Pharmaco-vigilance**	**Scope and purposes of pharmacovigilance** • Adverse Drug Reactions (ADR) • ADR classification • Nature and mechanism of ADR • Concept of safety • Phases and types of DATA **The process of Pharmacovigilance** • Signal detection, evaluation and investigation, • Communication **Methods of evaluating effectiveness of action** **International regulatory collaboration** • WHO, CIOMS, ICH, ISoP, ISPE		**15**
Unit-IV **Clinical Data Science**	**Data management in clinical research: An overview** • Data Sources and Data Types • Standards in Healthcare Data • Research Data Stewardship for Healthcare Professionals • Preparing Data for Prediction Model Development • Prediction Modeling Methodology • Clinical Decision Support System		**15**

References:

1.	Introduction to Basics of Pharmacology and Toxicology, Volume 1: General and Molecular Pharmacology: Principles of Drug Action, Chapter 3 Gerard Marshall Raj Ramasamy Raveendran, Editors ISBN 978-981-32-9778-4 ISBN 978-981-32- 9779-1 (eBook) https: oi.org/10.1007/978-981-32-9779-1

2.	Basic & Clinical Pharmacology, 2017, Fourteenth Edition, Section I, Chapter 1. Bertram G. Katzung, Editor ISBN 978-1-259-64115-2 MHID 1-259-64115-5 ISSN 0891-2033
3.	Software based approaches for drug designing and development: A systematic review on commonly used software and its applications, Bulletin of Faculty of Pharmacy, Cairo University 55 (2017) 203–210 Prasad G. Jamkhande, Mahavir H. Ghante, Balaji R. Ajgunde http://dx.doi.org/10.1016/j.bfopcu.2017.10.001
4.	Bioinformatics and Drug Discovery, Third Edition, (A Computational Platform and Guide for Acceleration of Novel Medicines and Personalized Medicine, Chapter 10) Richard S. Larson, Tudor I. Oprea https://doi.org/10.1007/978-1-4939-9089-4
5.	Molecular docking studies, Chapter 5, Shodhganga
6.	Clinical Trial Designs, Indian Dermatol Online J. 2019 Mar-Apr; 10(2): 193–201. Brijesh Nair doi: 10.4103/idoj.IDOJ_475_18 PMCID: PMC6434767 PMID: 30984604
7.	Experimental designs for small randomised clinical trials: an algorithm for choice, Catherine Cornu et. al., doi: 10.1186/1750-1172-8-48 PMCID: PMC3635911 PMID: 23531234
8.	Regulatory requirements for clinical trials in India: What academicians need to know, Indian J Anaesth 2017;61:192-9 Nithya J Gogtay, Renju Ravi, Urmila M Thatte DOI: 10.4103/ija.IJA_143_17
9.	Regulatory environment for clinical research: Recent past and expected future, Perspect Clin Res 2017;8:11-6. Bhave A, Menon S DOI: 10.4103/2229-3485.198551
10.	National Academy Press, Committee on Strategies for Responsible Sharing of Clinical Trial Data; (Chapter 3, The Roles and Responsibilities of Stakeholders in the Sharing of Clinical Trial) Data, Board on Health Sciences Policy; Institute of Medicine. Washington (DC): National Academies Press (US); 2015 Apr 20. The National Academies Press International Standard Book Number-13: 978- 0-309-31629-3
11.	An Introduction to Pharmacovigilance, Second Edition Patrick Waller and Mira Harrison- Woolrych ISBN 9781119289753 (Adobe PDF)
12.	Data management in clinical research: An overview, Indian J Pharmacol. 2012 Mar-Apr; 44(2): 168–172. Binny Krishnankutty, Shantala Bellary, and Latha S. Moodahadu doi: 10.4103/0253-7613.93842 PMCID: PMC3326906 PMID: 2252946
13.	Fundamentals of Clinical Data Science Pieter Kubben, Michel Dumontier Andre Dekker ISBN 978-3-319-99712-4 ISBN 978-3-319- 99713-1 (eBook) https://doi.org/10.1007/978-3-319-99713-1

M.Sc. Biotechnology
Semester –IV
Scientific Writing & Food Biotechnology (PBT4SWF)

Course Objectives:	• To develop skills for the processing and analysis of scientific data. • To enable students to present their research results in the format of oral or poster presentations at conferences, to write scientific publications (theses, articles) and to prepare applications for scientific grants (research proposals). • To inculcate good scientific writing practices.		
Course Outcomes:	• Think critically, organize and analyze scientific data. • Develop advanced scientific writing skills to write research articles, reviews, thesis, and proposals and to make oral, poster or power point presentations. Understand the best practices of scientific writing by adhering to research ethics and by avoiding plagiarism.		
Unit	**Topics**	**Credit**	**Lectures**
Unit-I **Basic Scientific Writing and Plagiarism**	**Introduction to scientific writing.** • Basic scientific writing skills: style and language, spelling, grammar, syntax, jargon and sentence structure. • Elements of a scientific paper: abstract, introduction, materials & methods, results, discussion, references and drafting titles. • Scientific writing process: thinking, planning, rough draft, revision of content. • Processing data & application of statistics Displaying data: text, table, graph and defining terms and abbreviations. • Statistical analysis and tools for experimental data. • Referencing software: Mendeley, Endnote. Plagiarism: Definition, Common types of plagiarism, Intentional and Unintentional plagiarism, Detection of plagiarism by anti-plagiarism tools (Turnitin, Duplichecker, Viper, Copyleaks), Penalties for plagiarism, Avoiding plagiarism.	**04**	**15**

Unit II **Advanced Scientific Writing**	**Guidelines for Medical writing.** **Scientific writing skills:** • Writing a research paper for biomedical journal, • Writing science research papers and articles, Writing a research proposal, • Writing a research report, writing popular reports, writing thesis and dissertation, Writing clinical study reports. • Presentation skills: Oral presentation, Poster Preparation & presentation, PowerPoint presentations. • Research ethics, Scientific misconduct.		**15**
Unit III **Food Biotechnology-Nutraceuticals**	• Nutraceuticals and functional foods Definition, characteristic features, and classification, phytonutraceuticals, • Prebiotics and Probiotics, Sources (with examples e.g. microbes, plants, algae, animals), Blue biotechnology, Food security, Food preservation, Chemopreservation Food processing (animal and sea food), Food packaging		**15**
Unit-IV **Food biotechnology in management of health and disease**	• Applications of nutraceuticals in human health and nutrition- health effects of commonly used nutraceuticals and functional foods (case studies), Safety and Regulatory guidelines • Nutraceuitcals in management of health and disease • Development of designer foods for specific chronic diseases • Nutraceutical adjuvants		**15**

References:

1.	Thomas, C George. (2019). Research Methodology and Scientific Writing 2nd edition.
2.	Kumar, Ranjeet. (2011). Research methodology: a step-by-step guide for beginners 3rd edition.
3.	Jennifer Peat, Elizabeth Elliott, Louise Baur, and Victoria Keena. (2002). Scientific Writing (BMJ Books).
4.	J.R. Mathews & R.W.Mathews (2008) Successful Scientific Writing, 3rd Ed. Cambridge University Press.
5.	https://www.ema.europa.eu/en/documents/scientific-guideline/ich-e-3-structure-content-clinicalstudy-reports-step-5_en.pdf
6.	htps://www.emwa.org/documents/about_us/EMWAguidelines.pdf
7.	https://www.otago.ac.nz/hedc/otago615367.pdf
8.	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3510958/
9.	http://medind.nic.in/iad/t02/i1/iadt02i1p21.pdf
10.	https://intranet.birmingham.ac.uk/as/registry/policy/conduct/plagiarism/interactive-course. aspx
11.	https://www.bowdoin.edu/dean-of-students/judicial-board/academic-honesty-and-plagiarism/ common-types-of-plagiarism.html
12.	https://www.ox.ac.uk/students/academic/guidance/skills/plagiarism?wssl=1
13.	https://holyfamily.libguides.com/c.php?g=610218&p=4236572
14.	https://plagiarismdetector.net
15.	https://www.duplichecker.com

M.Sc. Biotechnology
Semester –IV
PRACTICAL- I (PBT4PR1) 4 Credits
Paper-I

1.	Biosynthesis and characterization of eco-friendly silver nanoparticles by using plant/leaf extracts/green tea
2.	Synthesis and characterization of zinc sulfide nanoparticles by A reverse micelle method
3.	Synthesis and characterization of Fluorescent Carbon Nanoparticles from Candle Soot and its separation of using the Thin-Layer Chromatographic Method
4.	Synthesis of alginate beads and investigation of citric acid release from a nano shell coating of polymer
5.	Antimicrobial activity testing of Nanoparticles/nanocomposites

Paper-II

1.	Gel electrophoresis of lipids (lipoproteins exrtacted from various sources) to separate and identify the lipid fraction
2.	Preparation of report based on -Databases and data repositories used in systems Biology
3.	Detection assay for gene expression using micro array and qRT –PCR (demonstration)
4.	Identification of protein using analytical technique Mass spectroscopy (demonstration)

M.Sc. Biotechnology
Semester –IV
PRACTICAL- I (PBT4PR2) 4 Credits

Paper-III

1.	Exploration of various learning platforms in online courses listed below :
	Online courses in fundamentals of Neuroscience from Harvard University https://online-learning. harvard.edu/course/fundamentals-neuroscience-part-1-electrical-properties-neuron? delta=0
	Molecular Biology from MIT https://ocw.mit.edu/courses/biology/7-28-molecular-biology-spring- 2005/
	Introduction to Bioethics from Georgetown https://bioethicsarchive.georgetown.edu/phlx101-2/course.html#units/introduction
2.	Write a research proposal on any topic of your interest from the MSc syllabus. For research proposal contents and format refer to NSF guidelines. https://www.nsf.gov/pubs/policydocs/pappg19_1/nsf19_1.pdf For reference work use Mendeley Desktop. https://www.mendeley.com/guides/desktop
3.	Complete an online course (Minimum 1 week) on the topic related to the biotechnology. Write a comprehensive report on the studied course contents.
	Swayam https://swayam.gov.in/
	NPTEL https://nptel.ac.in/noc/
	MOOC https://www.it.iitb.ac.in/frg/wiki/images/7/7b/Demo-PPT.pdf
	E-learning https://www.bellevuecollege.edu/elearning/start/intro/

Paper-IV

1.	Estimation of total sugars from food products (dairy, fruit juices, bakery)
2.	Determination of acid value of natural fats and oils.
3.	Determination of iodine number of fats and oils.
4.	Estimation of vitamin B by HPLC (demonstration)
5.	Study of nutraceuticals important plants like Zinziber, Curcuma, Alovera, Asparagus, Ocimum etc.
6.	Estimation of antioxidant property of phytochemical by DPPH.
7.	Qualitative test for tannins, phenols, isoflavones, alkaloids using TLC.
8.	Estimation of food preservatives/additives (Parabens) from food sample by HPLC (demonstration).
9.	Estimate Cholesterol contents in given sample by Zak's methods
10.	Estimation of bio-burden by viable counts.
11.	Estimation of gluten from food sample.
12.	To study nutritional components (protein, carbohydrate, secondary metabolites, lipids, vitamin C) of following: Bee honey, Mushrooms, Lentils, Soya, Dairy product, Amla, Papaya, Spinach

Practical References:

1. Cappuccino, J. G., & Welsh, C. (2016). Microbiology: a Laboratory Manual.Benjamin-Cummings Publishing Company.2. Collins, C. H., Lyne, P. M., Grange, J. M., & Falkinham III, J. (2004). Collins andLyne's Microbiological Methods (8th ed.). Arnolds.3. Tille, P. M., & Forbes, B. A. Bailey & Scott's Diagnostic Microbiology,
2. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: A Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. Wilson K and Walker J. (2000). Principles and Techniques of Practical Biochemistry, 5th Edition, Cambridge University Press.2. Holme D and Peck H. (1998). Analytical Biochemistry, 3rd Edition, Longma
4. Plummer DT (1971). An Introduction to Practical Biochemistry. McGraw-Hill, NY.

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