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

Program: M.Sc. Biotechnology

M.Sc. Part-I

(Semester I & II)

Choice Based Credit & Grading System (60:40)

Total Credits: 96

(To be implemented from Academic Year 2022-2023)

(Approved in the academic council meeting held on _____)

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-I and II) 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.

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.

Programme Outcomes for M.Sc. Degree

Sr. No.	OUTCOME FOR M.Sc. PROGRAMME	GRADUATE ATTRIBUTE
After completion of M.Sc. programme students will acquire		
PO-1	The ability to identify and describe broadly accepted methodologies of science, and different modes of reasoning.	Disciplinary knowledge
PO-2	An ability to demonstrate proficiency in various instrumentation, modern tools, and advanced techniques to meet industrial expectations and research outputs.	Disciplinary knowledge
PO-3	Ability to identify problems, formulate, and prove hypotheses by applying theoretical knowledge and skills relevant to the discipline.	Problem-solving
PO-4	The ability to articulate thoughts, research ideas, information, scientific outcomes in oral and in written presentation to range of audience.	Communication skills
PO-5	A capacity for independent, conceptual, and creative thinking, and critical analysis through the existing methods of enquiry.	Critical thinking
PO-6	Acquisition of skills required for cutting edge research, investigations, field study, documentation, networking, and ability to build logical arguments using scholarly evidence.	Research skills
PO-7	An ability to portray good interpersonal skills with the ability to work collaboratively as part of a team undertaking a range of different team roles	Teamwork
PO-8	The ability to understand ethical responsibilities and impact of scientific solutions in global, societal, and environmental context and contribute to sustainable development.	Moral and ethical awareness/ multicultural competence
PO-9	An openness to and interest in, life-long learning through directed and self-directed study.	self-directed learning
PO-10	The ability to translate the knowledge and demonstrate the skills required to be employed and successful professional development.	Life-long learning

Programme Specific Outcomes for M.Sc. Biotechnology

Name of the Programme:	M.Sc. Biotechnology
Upon completion of M.Sc. Biotechnology programme students will be able to:	
PSO-1	Demonstrate comprehensive knowledge and interdisciplinary skills in the core and allied courses in biotechnology along with other emerging trends.
PSO-2	Apply modern Bio-analytical tools, techniques, software and equipment to analyze and solve problems in different areas of biotechnology.
PSO-3	Design research problems, test hypothesis, prepare scientific report and use biostatical and bioinformatics tools for data interpretation and draw conclusions.
PSO-4	Apply entrepreneurial skills and appraise bioethics, biosafety, research ethics, and plagiarism and intellectual property rights.

M.Sc. Biotechnology Course Structure

Semester I

Course	Course Type	Course code	Marks	Credits	Nos of Lectures / week
1.1. Advanced Biological Chemistry	Core Course	PBT1ABC	100	4	4
1.2. Immunology	Core Course	PBT1IMM	100	4	4
1.3. Molecular Biology	Core Course	PBT1MOB	100	4	4
1.4. Emerging Techniques in Biological Sciences	Core Course	PBT1ETB	100	4	4
1.5. Practical-I Practical's of PBT1ABC & PBT1IMM	Core Course	PBT1PR1	100	4	8
1.6. Practical-II Practical's of PBT1MOB & PBT1ETB	Core Course	PBT1PR2	100	4	8
		Total	**600**	**24**	**32**

Semester II

Course	Course Type	Course code	Marks	Credits	Nos of Lectures / week
2.1. Metabolism	Core Course	PBT2MET	100	4	4
2.2. Cellular Processes and Developmental Biology	Core Course	PBT2CPD	100	4	4
2.3. Bioprocess Technology	Core Course	PBT2BPT	100	4	4
2.4. Research Methodology and Scientific Communication Skills	Core Course	PBT2RMS	100	4	4
2.5. Practical-I Practical's of PBT2MET & PBT2CPD	Core Course	PBT2PR1	100	4	8
2.6. Practical-II Practical's of PBT2BPT & PBT2RMS	Core Course	PBT2PR2	100	4	8
		Total	**600**	**24**	**32**

Examination Scheme

Choice Based Credit System (CBCS)

Revised 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 Examination are as shown below:

A) INTERNAL ASSESSMENT : 40% **40 Marks**

Sr. No	Particular	Marks
1	One periodical class test/ online examination to be conducted in the given semester.	20 Marks
2	Any two tools out of these (10 Marks each)	20 Marks
	Group/Individual Project	
	Presentation and write-up on the selected topics of the subjects / Case studies	
	Test on Practical Skills	
	Open Book Test	
	Quiz	

Question Paper Pattern

(Periodical Class Test for the courses at Post-Graduate Programmes)

Maximum Marks: 20
Duration 30 Minutes

Particular	Marks
Match the column / Fill in the Blanks / Multiple Choice Questions / True/False / Answer in One or Two Lines (Concept based Questions) (1 Mark each)	20 Marks

B) Semester End Examination :60% **60 Marks**

Duration: The examination shall be of 2 ½ hours duration.

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. Questions 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 to pass a course 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 Advanced Biological Chemistry (PBT1ABC)

Course Objectives:	• To build upon the advanced concepts of protein structure and functions. • To emphasize upon the role of enzymes and lipid aggregates. • To introduce the students to recent trends in the bio-molecular structures and interactions.		
Course Outcomes:	After completing the course, Student will able to: • Discuss protein structure, folding pathways and diseases within the context. • Understand the enzyme catalysis, kinetics and relevance of enzymes. • Apply methodologies of Biomolecular interactions and DNA topology. • Elaborate on significance of Membrane architecture and lipid aggregates.		
Units	**Topics**	**Credit**	**Lectures**
Unit-I Protein Structure and Folding	Primary structure of proteins and their determination – end group analysis; cleavage of disulfide bond; separation, characterization of polypeptide chain; specific peptide cleavage reactions. Secondary structure: Alpha-Helix, Beta sheets, Turns and loops. Super-secondary structures: Domains and motifs. Ramachandran plot. Tertiary structure- fibrous (Collagen) and globular (Myoglobin) structure, Protein stability. Quaternary structure: Subunit Interactions, Symmetry in Proteins and Determination of Subunit Composition (Hemoglobin). Protein folding: Denaturation, Anfinsen's classical experiment mechanisms and Pathways of Protein folding. Molecular chaperons, Protein misfolding and diseases.	**4**	**15**

Unit- II **Enzymes and their Applications**	General characteristics of enzymes. Enzyme catalysis – general principles of catalysis. Enzyme Activity, Various factors influencing enzyme activity and Enzyme inhibition. Enzyme kinetics: Significance; Rapid Equilibrium and Steady State approach, Michaelis-Menten's and Haldane equations, Significance of Km, Catalytic efficiency and turnover number and Kinetic perfection. Order of kinetics. Methods of plotting enzyme kinetics data: Lineweaver-Burk, Hanes-Woolf, Woolf, Augustinsson-Hofstee, Eadie-Scatchard; Direct linear plot; Advantages and disadvantages. Relevance of enzymes in metabolic regulation, activation, inhibition and covalent modification. Clinical Enzymology- Enzymes as therapeutic agents and diagnostic tools.		**15**
Unit- III **Biochemistry of Nucleic acids**	Different forms of DNA, Super-helix topology- linking number, Twist and writhing number, measurement of supercoiling and Topoisomerases. Genome organization - bacterial genome; Structure of eukaryotic chromosomes; Heterochromatin and Euchromatin; DNA re-association kinetics (Cot curve analysis); DNA melting and buoyant density; DNA methylation & Imprinting. Nucleic acid binding protein – Leucine Zipper, Zinc fingers OB fold, Beta Barrel, Helix-turn-helix, and Helix-loop-helix. DNA – protein interaction, Methodologies for detection: Protein – Protein and DNA – Protein interactions.		**15**

Unit- IV **Membrane Architecture** **&** **Lipid Aggregates**	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 Lipid aggregates: micelles, bilayers and liposomes.		**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.	Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2002). MolecularBiology of the Cell. New York: Garland Science.
8.	Laouini et.al. Preparation, Characterization and Applications of Liposomes: State of the Art. journal of Colloid Science and Biotechnology Vol. 1, 147–168, 2012
9.	Lesk, A. M. (2004) Introduction to Protein Science: Architecture, Function, andGenomics. Oxford University Press, UK.
10.	Sheehan, D. (2009) Physical Biochemistry: Principles and Applications. John Wiley &Sons Ltd., UK.
11.	Uversky, V. N. and Fink, A.L. (2006) Protein Misfolding, Aggregation andConformational Diseases: Part A: Protein Aggregation and Conformational Diseases (Protein Reviews). Springer, USA.
12.	Enzymes: Biochemistry, Biotechnology & Clinical chemistry, (2001) Palmer Trevor, Publisher: Horwood Pub. Co., England.
13.	Metabolic Engineering: Principles and Methodologies. (1998). Gregory N Stephanopoulos, Aristos A Aristidou, Jens Nielsen. Publisher: Academic Press, San Diego, US.
14.	An Introduction to Practical Biochemistry.3rd Edition, (2001), David Plummer, Tata McGraw Hill Edu.Pvt.Ltd. India.
15.	Biochemical Methods.1st, (1995), S. Sadashivam, A. Manickam, New Age International Publishers, India.

M.Sc. Biotechnology
Semester –I
Paper-II Immunology (PBT1IMM)

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.		
Course Outcomes:	On completion of this course, students should be able to: • Discuss structural features of components of immune system as well as their function. • Explain the concept of cytokines, hypersensitivity reactions and Autoimmunity. • Elaborate tumour immunology, immunodeficiency and Transplantation. • Evaluate useful animal models in Immunology. • Apply their knowledge and design immunological experiments to demonstrate and figure out kind of immune responses.		
Units	**Topics**	**Credit**	**Lectures**
Unit -I Overview of The Immune System	Overview of the Immune System Components of innate and acquired immunity; Phagocytosis; complement and inflammatory responses; pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP); innate immune response; mucosal immunity. Antigens: Immunogens, Hapten. Humoral Immunology Immunoglobulin: fine structure and superfamily Multigene organization of Ig gene, Variable region gene rearrangement and generation of antibody diversity, Class switching among the constant region Synthesis, assembly, and secretion of Immunoglobulins, B-cell development, activation, differentiation and memory.	**4**	**15**

	Cellular Immunology T-cell development (Early thymocyte development, Positive and negative selection, Apoptosis), T-cell development, activation, differentiation and memory (XA, JH).		
Unit -II Immune effector Mechanism	Cytokines: Properties, receptor, cytokine related diseases and cytokine based therapies. Hypersensitivity Reactions: Type I –IV. Autoimmunity: types of autoimmune diseases; mechanism for Induction of Autoimmunity; treatment of autoimmune diseases.		**15**
Unit -III Clinical Immunology	Immunodeficiency: Primary immunodeficiency, acquired or secondary immunodeficiency. Tumor immunology: tumor antigens; immune response to tumors and tumor evasion of the immune system, cancer immunotherapy. Transplantation: immunological basis of graft rejection; clinical transplantation and: clinical transplantation and immunosuppressive therapy		**15**
Unit- IV Immunodiagnostics and Animal Models	Immunodiagnostics: Haem-agglutination and Blood typing; Phage Display libraries; Microscopy and Imaging; TUNEL Assay; Assay for cytotoxic T Cell. Detection of Immunity in Vivo: Tuberculin Test, Testing of allergic responses, Arthur Reaction and adaptive transfer of Lymphocyte and Haemotopoietic Stem Cell. Animal models: Inbred-strain, Adoptive transfer technique, Congenic-strain, 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). Kuby Immunology. 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's Immunobiology. New York: Garland Science.
4.	Elgert, Klaus D.: Immunology: Understanding the immune system. (2nd edition) Hoboken. John Wiley & Sons, Inc., 2009. 978-0-470-08157-0--(616.079Elg).
5.	Paul, W. E. (2012). Fundamental Immunology. New York: Raven Press.
6.	Goding, J. W. (1996). Monoclonal Antibodies: Principles and Practice: Production and Application of Monoclonal Antibodies in Cell Biology, Biochemistry, and Immunology. London: Academic Press.
7.	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.
8.	Praful Godkar: Textbook of Medical Biochemistry, Bahalani Publishers
9.	Medical Microbiology by Anantnarayan.
10.	Ian R Tizard: Immunology, An introduction, fourth edition, Thomson.
11.	Abbas, A.K., Lichtman, A.H. and Pillai, S. (2007) Cellular and Molecular Immunology. Saunders Elsevier, USA.

M.Sc. Biotechnology
Semester –I
Paper-III Molecular Biology (PBT1MOB)

Course Objectives:	The objectives of this course are to provide knowledge related to different mechanisms of transcription, translation, Gene Expression and Regulation in Prokaryotes & Eukaryotes. Thus providing them an insight to the basis of molecular biology.		
Course Outcomes:	After completing the course, Student will able to: • Compare the mechanism of replication in prokaryotes and eukaryotes • Elaborate on transcription in Prokaryotes & Eukaryotes • Explain the different DNA damage and repair systems • Discuss the mechanism of translation, gene expression and transposition		
Unit	**Topics**	**Credits**	**Lectures**
Unit- I Replication, Repair and Recombination	Replication mechanism in prokaryotes and eukaryotes; Enzymes and accessory proteins; Fidelity; Replication of single stranded circular DNA; Gene stability. DNA repair- enzymes; Photo-reactivation; Excision repair; Mismatch correction; SOS repair. Recombination: Homologous and non-homologous; Site specific recombination.	**4**	**15**
Unit- II Prokaryotic transcription and regulation	Prokaryotic Transcription: Transcription unit; Promoters, Operators, Regulatory elements, Initiation; Attenuation; Termination-Rho-dependent and independent; Anti-termination Transcriptional regulation-Positive and negative; Operon concept-*lac, trp and ara* operons Transcriptional control in lambda phage.		**15**

Unit-III Eukaryotic Transcription and Post Transcriptional Modifications	Eukaryotic transcription and regulation; RNA polymerase- structure and types; Eukaryotic promoters and enhancers; General Transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF); Transcriptional and post-transcriptional gene silencing. Post Transcriptional Modifications- Processing of hnRNA, tRNA, rRNA; capping and polyadenylation; Splicing; RNA editing; Nuclear export of mRNA; mRNA stability; Catalytic RNA. Regulatory RNA and RNA interference mechanisms.		**15**
Unit-IV Translation and Transposition	Translation machinery; Ribosomes; Composition and assembly; Universal genetic code; Degeneracy of codons; Termination codons; Wobble hypothesis; Mechanism of translation ; Co- and post-translational modifications. Protein degradation: Ubiquitin-Proteasome pathway and lysosomal proteolysis. Transposition- Transposable genetic elements in prokaryotes and eukaryotes; Mechanisms of transposition; Role of transposons in mutation.		**15**

References:

1.	Genes XI, 11th edition (2012), Benjamin Lewin, Publisher - Jones and Barlett Inc. USA
2.	J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levin, R. Losick. (2013). Molecular Biology of the Gene (7th edition). Benjamin Cummings, San Francisco, USA.
3.	R.F. Weaver (2007). Molecular Biology. (4th edition). McGraw Hill. New York. USA.
4.	Genome 3 T.A Brown
5.	iGenetics A Molecular Approach Third Edition, Peter J. Russell
6.	Molecular Biology, 5th Edition (2011), Weaver R., McGrew Hill Science. USA
7.	Lewin's GENES XII 2017 Jocelyn E. Krebs , Elliott S. Goldstein , Stephen T. Kilpatrick Jones and Bartlett Publishers

M.Sc. Biotechnology
Semester –I
Paper-IV- Emerging Techniques in Biological Sciences (PBT1ETB)

Course Objectives:	The objectives of this course are to provide introductory knowledge concerning genomics, proteomics and their applications. The students will be given exposure to advanced analytical tools to study biological system.		
Course Outcomes:	After completing the course, Student will able to: • Illustrate the principle underlying various advance microscopy & spectroscopy and proteomics techniques • Elaborate on emerging techniques in Genomics & Transcriptomics • Discuss the advanced techniques used in molecular cytogenetics • Understand the principle & application of the CRISPR-CAS system		
Unit	**Topics**	**Credits**	**Lectures**
Unit-I Advanced Microscopic and Spectroscopic Techniques	Microscopy: Scanning and Transmission microscopes: different fixation and staining techniques for EM, Freeze-etch and freeze- fracture methods for EM, Image processing methods in microscopy. Confocal microscopy, Atomic Force Microscopy, Super-Resolution Imaging with Stochastic Optical Reconstruction Microscopy (STORM) and Photo-activated Localization Microscopy (PALM). Spectroscopy- Principle and applications of UV Visible, ORD, CD, NMR, FTIR, ESR and X-ray diffraction.	**4**	**15**
Unit-II Protein Purification & its Characterization	Protein purification and characterization Techniques: Dialysis, Salting in and Salting out, Chromatography: Size exclusion, Affinity, Ion-exchange and FPLC. 2D-PAGE, isoelectric focusing, Mass spectrometry and its versions. Protein Expression Profiling: Protein Microarrays/ Protein chips: Types and applications. Gel-based quantitative proteomics: DIGE (Difference in Gel Electrophoresis). Gel-free based quantitative proteomic: Surface plasmon resonance. In vivo and In-vitro labelling- SILAC and ICAT		**15**

Unit-III **Functional & Comparative genomics and Transcriptomics**	Genomics: Gene expression by SAGE and Microarrays: Construction of microarrays – genomic arrays, cDNA arrays and oligo arrays and its applications. Next Generations Sequencing (NGS): Principles and Instrumentation. Assigning Gene Function Experimentally: Gene Knockouts in Yeast, Mouse & *Mycoplasma genitalium,* Metagenomic Analysis. Transcriptomics: Northern blotting, DDRT PCR, gel free assays like biolayer interference		**15**
Unit-IV **Molecular Cytogenetics**	Advanced fluorescence techniques: Fluorescence Lifetime (FLIM), Fluorescence Resonant Energy Transfer (FRET), Fluorescence Correlation Spectroscopy (FCS) Advanced Cytogenetic techniques and applications - FISH, M-FISH, SKY, CGH, Marker Chromosomes, and Prenatal Diagnosis of Common Aneuploidies. CRISPR CAS: History, principle and Applications. Identification and classification of organisms using Molecular markers- 16S rRNA typing/sequencing.		**15**

References:

1.	Principles and Techniques of Biochemistry and Molecular Biology,7th edition, (2010), Wilson K.M., Walker J.M., Cambridge University Press, U
2.	Biophysical chemistry by Upadhyay, Upadhyay and Nath, Himalaya publication house.
3.	Biophysics. 1st edition (2002), Pattabhi V and Gautham N. Kluwer Academic Publisher, USA.
4.	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
5.	Molecular Cytogenetics: Protocols and Applications, Edited by: Y. S. Fan © Humana Press Inc., Totowa, NJ 2001.
6.	Lander, E. (2016). The Heroes of CRISPR. Cell, 164(1-2), 18-28. Doi: 10.1016/j. cell.2015.12.041.
7.	Genomics. Seventh Edition. Blackwell Publishing, USA
8.	Microarray and Microplates: Applications in biomedical sciences Shu Ye, Ian Day, 2003, Bios Scientific Ltd, oxford.
9.	iGenetics A Molecular Approach Third Edition, Peter J. Russell

M.Sc. Biotechnology
Semester –I
PRACTICAL- I (PBT1PR1) 8- Credits
(Practicals of PBT1ABC and PBT1IMM)

1.	Preparation of buffers and Reagents
2.	Viscosity study of protein.
3.	Titration of amino acids and calculation of pK value
4.	Protein Estimation using the following methods: Bradford and Folin Lowry method
5.	Experimental verification that absorption at OD260 for denatured DNA as compared to native double stranded DNA
6.	Isolation partial purification and Characterization of any one enzyme • Preparation of cell-free lysates • Ammonium Sulfate precipitation • Dialysis of the purified protein solution • Enzyme assay • Generating a Purification Table Enzyme Kinetic Parameters: Km, V_{max} and K_{cat}
7.	LDH Zymography
8.	Video demonstration of membrane dynamics
9.	Cell permeability testing- osmotic fragility
10.	Preparation of TAB and sterility testing
11.	Perform serum electrophoresis (horizontal)
12.	To perform the Dot blot assays
13.	To check antibody titer by Tube precipitation test
14.	In-vitro demonstration of phagocytosis and calculating phagocytic index
15.	Latex bead agglutination / precipitation test for detection of rheumatoid factor (RF).
16.	Separation of lymphocytes on Ficoll Histopaque and viability count
17.	Demonstration/Video of tuberculin test, hypersensitivity reaction Arthur reaction.
18.	Complement fixation test

M.Sc. Biotechnology
Semester –I
PRACTICAL- II (PBT1PR2)
(Practicals of PBT1MOB & PBT1ETB) 08 Credits

1.	Diauxic growth curve of *E.coli*
2.	Extraction of Genomic DNA Extraction from Bacteria and separation by Agarose gel electrophoresis
3.	Extraction of Genomic DNA Extraction from human samples (Cheek cells, Blood) and separation by Agarose gel electrophoresis
4.	Restriction Enzyme digestion of plasmid DNA
5.	Ligation Reaction
6.	Conjugation in bacteria
7.	Demonstration/ video of 2D PAGE
8.	Demonstration of affinity & gel filtration chromatography techniques
9.	Microscopy types Confocal, Fluorescence, STORM – videos and pictures – Write up
10.	To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law
11.	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
12.	Overview of MALDI-TOF-MS Virtual
13.	Recovery of DNA from low-melting temperature agarose gel
14.	To resolve soluble proteins by Native PAGE followed by staining with Coomassie Brilliant Blue R-250
15.	To resolve soluble proteins by discontinuous, SDS-gel electrophoresis under denaturing conditions followed by staining with Coomassie Brilliant Blue R-250 and silver stain
16.	Identification of protein using analytical technique Mass spectroscopy (demonstration)
17.	FTIR/NMR spectrum based theory questions

Semester –II

M.Sc. Biotechnology
Semester –II
Paper-I Metabolism (PBT2MET)

Course Objectives:	The objectives of this course are to build upon 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.		
Course Outcomes:	After completing the course, Student will able to: • Illustrate major metabolic pathways with Principles of Metabolic regulations. • Justify role of metabolic pathways in various disease pathology. • Correlate different adaptations in plants with respect to carbon assimilation. • Discuss role of phytochemicals.		
Units	**Topics**	**Credit**	**Lectures**
Unit –I **Bioenergetics, Carbohydrate & Lipid Metabolism**	Bioenergetics and Thermodynamics-basic principles; equilibria and concept of free energy; coupled interconnecting reactions in metabolism and common Biochemical reactions. Carbohydrate Metabolism- Overview of major pathways of carbohydrate metabolism. HMP and Uronic acid pathways with their significance, Metabolism of other important sugars – fructose. Coordinated regulation of glycogen breakdown and synthesis. Inborn errors of carbohydrate metabolism. Synthesis of essential fatty acids- Overview.	**4**	**15**
Unit -II **Amino-acid and Nucleic acid Metabolism**	Biosynthesis of essential amino acids. Metabolic breakdown of amino acids leading to Krebs cycle intermediate. Disorders of amino acid metabolism.		**15**

	Nucleic acid metabolism Biosynthesis and degradation of purines and pyrimidines with regulation, disorders of Nucleic acid metabolism.		
Unit –III **Plant metabolism**	C-3 cycle and C-4 cycles, CAM, glyoxalate pathway, photosynthetic formation of hydrogen. Integration of carbohydrate metabolism in plants. Nitrogen fixation and role of nitrogenase, Annamox reactions. Plant secondary metabolism – Introduction, Pathways for secondary Metabolite 1. Mevalonate pathways 2.Shikimate Pathway 3.Isoprene Unit Pathways Major Secondary metabolites with their functions (alkaloid, terpenoids, phenolics).		**15**
Unit- IV **Principles of Metabolic regulations and Metabolic Engineering**	Principles of Metabolic regulations-Regulations of Metabolic pathways and analysis of Metabolic control. Integration of Metabolic pathways. Synthetic Biology-Introduction and applications. Metabolic Engineering- Historical perspective and introduction. Importance of metabolic engineering, Plant and microbial metabolic engineering-examples Metabolic flux analysis. future of metabolic engineering		**15**

References:

1.	Lehninger, Principles of Biochemistry. 7th Edition (2008), David Nelson& Michael Cox, W.H. Freeman and company, NY
2.	Phytochemical Method, 3rd edition (1998), A.J. Harborne, Springer, UK.
3.	Pharmacognosy, 14th edition, (2008), Dr. C. K. Kokate, A. P. Purohit, S. B. Gokhale, NiraliPrakashan, India
4.	Biochemistry: 7th Edition, (2012), Jeremy Berg, Lubert Stryer, W.H. Freeman and company, NY
5.	Voet, D., & Voet, J. G. (2016). Biochemistry (5th ed.). Hoboken, NJ: J. Wiley & Sons
6.	Harper's Biochemistry- 27th edition
7.	Devlin, Thomas M.: Textbook of biochemistry with clinical correlations. [ed. by] (7th ed.) Hoboken. John Wiley & Sons, Inc., 2011. 978-0-470-28173-4--(612.015Dev
8.	Buchanan B; Gruissem W et al (2nd Ed.) Biochemistry and Molecular Biology of Plants John Wiley & Sons 2015.

M.Sc. Biotechnology
Semester –II
Paper-II- Cellular Processes and Developmental Biology (PBT2CPD)

Course Objectives	The objectives of this course are to provide an understanding of the functions of cells at molecular level and give a thorough knowledge about protein trafficking, biomolecules, cellular development and Human Embryonic development.		
Course Outcomes	Students should be able to: • Outline the concept of cell cycle regulation, cellular signaling, transport and trafficking. • Determine the role of Cell ECM and cell -cell interactions in maintenance of cellular integrity and functions; • Analyze genes and genetic changes affecting cycle regulation and mechanisms that lead to apoptosis. • Understand Human Embryonic development and Post fertilization events		
Unit	**Topics**	**Credits**	**Lectures**
Unit -I Cellular processes	Cell cycle and its regulation; Cell division: mitosis, meiosis and cytokinesis; Checkpoints in cell cycle regulation. Cell differentiation: stem cells, their differentiation into different cell types and organization into specialized tissues; cell-ECM and cell-cell interactions; Cell Signalling: Principles of signalling, Signalling molecules, receptors and their functions. Intercellular communications: nerve impulses, Neuro-transmitters; agonist & antagonist Reactions. Cell death: different modes of cell death and their regulation.	**4**	**15**
Unit -II Cellular transport, Membrane trafficking	Molecular mechanisms of membrane transport, nuclear transport Protein Transport: Translocation of Secretory Proteins across the ER Membrane, Insertion, Protein Modifications,		**15**

	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.		
Unit -III Genome instability and cell transformation	Mutations, proto-oncogenes, oncogenes and tumour suppressor genes, physical, chemical and biological mutagens; types of mutations; intra-genic and inter-genic suppression; role of transposons in genome; 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**
Unit- IV Human Embryonic Development and Model Organism	Human Embryonic development: Events during fertilization, in-vitro fertilization, Zona Pellucida, glycoprotein, Oelemma protein and their role in fertilization, sperm antigens and their functional significance. Molecular and biochemical events during sperm function. Post fertilization events Major Model Organism in Developmental Biology: Xenopus, Zebra fish, Chick, Mouse, *C. elegans*, Drosophila		**15**

References:

1.	Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008). Molecular Biology of the Cell (5th Ed.). New York: Garland Science.
2.	Lodish, H. F. (2016). Molecular Cell Biology (8th Ed.). 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. (2013). The Cell: a Molecular Approach (6th Ed.). Washington: ASM; Sunderland.
5.	Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W. M. (2012). Becker's World of the Cell. Boston (8th Ed.). Benjamin Cummings.
6.	Watson, J. D. (2008). Molecular Biology of the Gene (5th ed.). Menlo Park, CA: Benjamin/Cummings.

M.Sc. Biotechnology
Semester –II
Paper-III-Bioprocess Technology (PBT2BPT)

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 the biotechnology industry.		
Course Outcomes	Students should be able to: • Appreciate relevance of microorganisms from industrial context • Give an account of design and operations of various fermenters • Calculate yield and production rates in a biological production process, interpret data and need for oxygen and oxygen transfer; • Understand important microbial/enzymatic industrial processes in the food and fuel industry.		
Unit	**Topics**	**Credits**	**Lectures**
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- Batch and continuous fermenters; modifying batch and continuous reactors: chemostat with recycle, multistage chemostat systems, fed-batch operations; conventional fermentation v/s biotransformation; immobilized cell systems; large scale animal and plant cell cultivation; 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 **Downstream processing, Industrial Production and Recovery processes**	Downstream processing and product recovery Separation of insoluble products - filtration, centrifugation, sedimentation, flocculation; Cell disruption; separation of soluble products: liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and microfiltration, electrophoresis; final purification: drying; crystallization; storage and packaging. Industrial Production and Recovery process of following (with one example each): Vitamins, Amino acids, Enzymes (Extra and Intra cellular), Antibiotics, Organic acids, Production of recombinant pharmaceuticals, Human growth hormone, Interferon vaccines. Biotransformation product (Steroids)		**15**
Unit- III **Applications of enzyme technology**	Rationale for immobilizing enzymes, Methods for enzyme immobilization, Properties of immobilized enzymes, applications of immobilized enzymes. Industrial applications of enzymes in pharmaceuticals, food industries, Detergents, paper and leather processing. Enzyme Engineering and its applications.		**15**
Unit- IV **Applications of microbial technology in food process operations 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 – production and applications e.g., Nisin Microbial production of colours and flavours. Polyhydric alcohols: low -calorie sweetener particularly useful for sweetening food products for diabetics		**15**

	Microbial exo-polysaccharides - 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.	Blanch, H. W., & Clark, D. S. (1997). Biochemical Engineering. New York: M. Dekker.
4.	Bailey, J. E., & Ollis, D. F. (1986). Biochemical Engineering Fundamentals. New York: McGraw-Hill.
5.	El-Mansi, M., & Bryce, C. F. (2007). Fermentation Microbiology and Biotechnology. Boca Raton: CRC/Taylor & Francis.
6.	Alexander N. Glazer and Hiroshi Nikaido -Microbial Biotechnology: Fundamentals ofApplied Microbiology, 2ndEdition
7.	Michael Waites and Morgan , Rockney and Highton -Industrial microbiology : An Introduction
8.	Nduka Okafor Modern industrial microbiology and biotechnology Science Publishers, Enfield,
9.	Robert Whitehurst and Maarten Van Oort - Enzymes in food technology 2nded
10.	Lee, Y. K. (2013). Microbial Biotechnology: Principles and Applications. Hackensack,NJ: World Scientific.

M.Sc. Biotechnology
Semester –II
Paper-IV-Research Methodology and Scientific Communication Skills (PBT2RMS)

Course Objectives	The objectives of this course are to acquire the ability to articulate thoughts, research ideas, information, and scientific outcomes in oral and in written presentation to a range of audience. The course mainly emphasizing methodologies used to do research, use framework of these methodologies for understanding effective lab practices and scientific communication and appreciate scientific ethics.		
Course Outcomes	**After completing the course, Student will able to:** • Design research problems, formulating the objectives, test hypotheses and prepare scientific reports using appropriate research processes. • Appraise Research writing, Research ethics, Data fudging and Plagiarism with the help of statistical and referencing software. • Develop the concept of effective communication, presentation skills and computing skills for scientific research. • Critically analyze the classical papers in biotechnology through the existing methods of enquiry.		
Unit	**Topics**	**Credits**	**Lectures**
Unit-I Scientific Research and Research Methodology	Scientific Research: Meaning of Scientific Research, Definition, Characteristics, Types of Research, and Need of research. Identification of the problem: assessing the status of the problem, formulating the objectives, Hypotheses, Research Methods and Methodology: Selecting & defining Research problem Research Process Research Design/Plan: Preparing Research design (experimental or otherwise), Actual investigation, Surveys - Case Study - Field Studies & others.	**4**	**15**
Unit-II Research Ethics	Research in Practice: Literature review, Journals, Conference Proceedings, Journal Impact factor, Citation Index, h, g, h-g index, Referencing software: Mendeley, Endnote.		**15**

	Research Ethics: Social implications of research, biosafety issues Animal experimentation ethics, wild-life ethics and human experimentation ethics Data fudging and Plagiarism: Definition, Common types of plagiarism, Intentional and Unintentional plagiarism, Detection of plagiarism by anti-plagiarism tools (Turnitin, Duplichecker, Viper, Copyleaks), Use of URKUND, Turnitin and iThenticate software, Penalties for Plagiarism, Avoiding plagiarism.		
Unit-III **Process of communication**	Concept of effective communication- setting clear goals for communication; determining outcomes and results; initiating communication; avoiding breakdowns while communicating; creating value in conversation; barriers to effective communication; Presentation skills - formal presentation skills; preparing and presenting using overhead projector, PowerPoint; defending interrogation; scientific poster preparation & presentation; participating in group discussions; Computing skills for scientific research - web browsing for information search; search engines and their mechanism of searching; hidden Web and its importance in scientific research; internet as a medium of interaction between scientists; effective email strategy using the right tone and conciseness.		**15**
Unit-IV **Scientific communication**	Scientific Communication: Importance of scientific communication, Types of scientific communications, Logical organization of scientific data and documentation Different modes of scientific communication: Scientific Writing: What are Scientific Writing Skills, Good Scientific Writing Skills Research Proposal writing: Format and layout Research Paper writing: Format and layout Report Writing: Format and layout Thesis writing : (Introduction, Literature review, Materials and Methods, Results, Discussion, Conclusion and Implications, conflict of interest)		**15**

	Legal forms of communication in science: Plagiarism and scientific misconduct, Ethics in scientific communication, Patent submissions.		

References:

1.	Research methodology Techniques and Methods by C. R. Kothari, New age International publishers.
2.	Valiela, I. (2001). Doing Science: Design, Analysis, and Communication of Scientific Research. Oxford: Oxford University Press.
3.	On Being a Scientist: a Guide to Responsible Conduct in Research. (2009). Washington, D.C.: National Academies Press.
4.	Gopen, G. D., & Smith, J. A. The Science of Scientific Writing. American Scientist, 78 (Nov-Dec 1990), 550-558.
5.	Mohan, K., & Singh, N. P. (2010). Speaking English Effectively. Delhi: Macmillan India.
6.	Movie: Naturally Obsessed, The Making of a Scientist.
7.	Michael Alley, The Craft of Scientific Writing, fourth edition, Springer, 2018.
8.	Stephen B. Heard, The Scientists Guide To Writing, Princeton University Press, 2018.
9.	Fisher R A, The Design of Scientific Experiment (1971) 9th edition, Collier Macmillan Publishers, London
10.	Martha Davis, Scientific Papers And Presentations 2nd edition (2004), Academic Press
11.	H. Hofmann, Scientific Writing and Communication Papers, Proposals, and Presentations. New York: Oxford University Press, 2010, pp. xv–xvi
12.	John D'Angelo, Ethics in Science: Ethical Misconduct in Scientific Research (2012),CRC Press, USA
13.	David B. Resnik, The Ethics of Science: An Introduction (1998), Routledge Publication, UK5.

M.Sc. Biotechnology
Semester –II
PRACTICAL- I (PBT2PR1) 08 Credits
Practicals of (PBT2MET+ PBT2CPD)

1.	Isolation of starch from potato and its estimation by anthrone method
2.	The isolation and assay of glycogen from liver and skeletal muscles of bird/mammal
3.	Isolate chloroplasts from the given plant material, quantitate and resolve the proteins by SDS-PAGE to identify major chloroplast proteins
4.	TLC for amino acid separation
5.	Detection of saponification and Iodine value of lipids
6.	Estimation of urate/creatinine ratio to diagnose Lesch Nyhan syndrome
7.	Detection of phenylalanine for PKU
8.	Secondary metabolite study-Extraction and Qualitative estimation of phyto-constituents
9.	Determination of total Nitrogen content by Kjeldahl method
10.	Programmed cell death during limb development in Chick
11.	Karyotyping and Ideogram construction in onion roots using Colchicine treatment
12.	Candling, Observing chick embryo- stages of development: prepared slides/ preserved specimens
13.	Developmental Biology- Visit to laboratory/ video lectures for latest Developments in the field
14.	Cell death /apoptosis studies using flow-cytometry demonstration
15.	Isolation of cell organelle by differential centrifugation techniques from plant / animal sources

M.Sc. Biotechnology
Semester –II
PRACTICAL- I (PBT2PR1) 08 Credits
Practicals of (PBT2BPT+ PBT2RMS)

1.	Maintenance of the isolated production organism (Agar slants/ glycerol stocks /soil culture/ lyophilization) at least two methods
2.	Demonstration of media optimization by Placket Burman test
3.	Study of Working of lab bench fermenter (with production of enzyme or antibiotic using screened organism)
4.	Immobilize an organism / enzyme and detect the conversion of substrate to product
5.	Physico-chemical characterization of an industrial effluents
6.	Pigment production and isolation from a microbial source (yeast, fungi or bacteria) Spirulina
7.	Recovery and Assay of product formed (Bioassay or Enzyme assay)
8.	Detection of different food enzymes by simple tests (amylase, catalase, invertase, papain, pectinase, pepsin)
9.	Study of the pickling process (sauerkraut / pickled cucumbers) with respect to physical, chemical / biochemical and biological changes occurring during the pickling process
10.	Visit to industry and Report writing
11.	Research Methodology: Review writing/ Report writing/Research paper writing (Following proper Research methods/Methodology)
12.	Scientific presentation of research paper from a reputed journal.
13.	Research Data collection and analysis from different Sources • Research Data collection and analysis from Primary Sources • Research Data collection and analysis from Secondary Sources • Research Data collection and analysis for Survey based Research • Different Sampling methods for Research
14.	Scientific communication: • Gathering scientific data from various sources. • Written communication: Guide to clear writing, forms and styles of writing • Scientific publication writing • Oral communication variants • Concept of Plagiarism

15.	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)
16.	To study a patent and to develop a patent application for a hypothetical product or process.
17.	Critical Analysis of Classical Papers: How does the Course Module work? Students may be divided in groups and each group may be responsible for one classical paper. Each week there may be a 1.5 hour presentation cum discussion for each of the papers. At the end of the semester each student will be asked to write a mini-review (2-3 pages long) on any one classical paper, other than the one he/she presented/discussed.

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