AC –07/07/2023
Item No. – 6.20 (N)

As Per NEP 2020

University of Mumbai

Title of the program

A- P.G. Diploma in Biotechnology
B- M.Sc. (Biotechnology) (Two Year) } 2023-24
C- M.Sc. (Biotechnology) (One Year) - 2027-28

Syllabus for

Semester- Sem. I & II

Ref: GR dated 16th May, 2023 for Credit Structure of PG

Preamble

1) Introduction

Biotechnology, a multidisciplinary subject has had and will continue to have a major impact on our lives. The technology uses biological sources like cells and their derivatives for applications spanning agriculture aka Green Biotechnology, medicine /Red Biotechnology, textiles, dairy (White Biotechnology), food and pharmaceuticals from marine resources (Blue Biotechnology), packaging, fuels etc. Mankind has witnessed its immense contribution in the last three years, especially some discoveries that revolutionized diagnostics and therapeutics. Personalized medicine, designer genes, CRISPR Cas 9 are increasingly being tested for the benefit of mankind.

Bioremediation however has been successfully implemented for the clean-up of hazardous pollutants as has the use of biopesticides and biofertilizers which have reduced the use and hazards of toxic chemical insecticides and pesticides.

Green Biotechnology has very well addressed the increase in crop productivity, addressing the concerns of malnutrition and starvation. Renewable, and sustainable energy sources for production of biofuels have been the forte of Biotechnology. Marine biotechnology has been exploring the products that can be tapped from aquatic flora and fauna.

Ethical concerns, unseen fears and environmental impacts loom the horizon, nonetheless. An in-depth study of the subject is thus essential to enable understanding the field better and wider, define laws governing the feasibility and approve conduct of research not only for the benefit of mankind but the environment in toto.

2) Aims and Objectives

The course aims at empowering the learner with a knowledge base in processes and applications that would impact and influence existing prototypes of green, blue, red, and white Biotechnology.

After the completion of the course the students will be skilled and equipped with contemporary knowledge in Biotechnology and would be eligible for jobs in varied industrial sectors.

3) Learning Outcomes

The M.Sc. Biotechnology course has been designed based on learning outcome-based curriculum framework. The course covers the fundamental and advanced areas of Biotechnology with a range of core subjects in each semester. Along with providing the traditional biotechnology knowledge, the course also has enough scope for inter- and multi-disciplinary subjects in the form of departmental electives.

This course also caters the skill enhancement needs of the students as well as provides opportunity for collaboration and learning from other disciplines.

Every semester has a practical course for strengthening their skills in designing and conducting experiments in the field of Biotechnology.

4) Any other point (if any)

PROGRAMME LEARNING OUTCOMES (PLO) –

After the completion of this programme, the students will be able –

PLO 1 - To identify, formulate, review research literature, analyze, and design experiments and identify the solutions for complex problems using modern tools.

PLO 2 - To apply the knowledge of basic biotechnology to solve complex problems in society.

PLO 3 - To apply reasoning informed by contextual knowledge to assess societal, health, safety, and the consequent responsibilities relevant to the professional biotechnology practices.

PLO 4 - To recognize the need and have ability to engage in independent and lifelong learning in technological change.

PLO 5 - To function effectively as an individual and as a member or leader in diverse teams and in inter- and multi-disciplinary areas.

Scheme of Examination: (THEORY AND PRACTICALS):

a) **Summative assessments (THEORY):**

For 2 credit courses	**25M (45min)**
Q1. Answer any three questions out of six (covering unit I and II)	15M
Q2. MCQ/Match the following/Ture Or False (covering unit I and II)	05M
For 4 credit courses	**50M (1.5h)**
Q1. Answer any 2 questions out of 3 (based on unit I)	10M
Q2. Answer any 2 questions out of 3 (based on unit II)	10M
Q3. Answer any 2 questions out of 3 (based on unit III)	10M
Q4. Answer any 2 questions out of 3 (based on unit IV)	10M
Q5. Write one Essay type answer out of 3 (based on units I-IV)	10M

b) **Formative assessments** (informal and formal tests administered during the learning process).

For 2 credit courses	**25M**
Group tasks/ Assignments/ Quizzes at the time of completion of each unit	15 M
Spoken/oral examination after completion of each unit	10M
For 4 credit courses	**50M**

Open book test/assignments/presentation/quiz/role play/MCQ/problem solving to be designed for each unit

c) **Summative assessments (Practical):**

For 4 credit courses **50M (3 h)**

- Major (20M)
- Minor (20M)
- Journal (5M)
- Viva. (5M)

d) **Formative assessments** (informal & formal tests administered during the learning process).

Submission of two Assignments poster/presentation (15M each) based on history/discovery/application/ problems based on techniques/experiments Performed **30M**

Viva and/ field visit report **20M**

Varsha M

Sign of HOD
Professor Varsha Kelkar Mane
University Dept of Biotechnology

Sign of Dean,
Professor Shivram Garje
Name of the Faculty: Science

R:_____

Credit Structure of the Program (Sem I, II, III & IV)

MSc. (Biotechnology) Course Structure
Semester I and II

Year	Level	Sem. (2 Yr)	Major		RM	OJT / FP	RP	Cum. Cr.	Degree
			Mandatory*	**Electives Any one Credits 4**					
I	**6.0**	**Sem I**	**Course 1** Biochemistry **Credits 4** **Course 2** Bioprocess Engineering and technology **Credits 4** **Course 3** Practical –Lab work- I **Credits 4** **Course 4** Basics in IPR and Patents **Credits 2**	**Course 1** Immunology **Theory 2 Credits + Practical 2 Credits** **OR** **Course 2** Molecular Diagnostics **Theory 2 Credits + Practical 2 Credits** **OR** Any of MOOCs **Credits 4**	4	-	-	22	**PG Diploma after (3 years degree)**
		Sem II	**Course 1** Bioinformatics & Biostatistics **Credits 4** **Course 2** Plant and Animal Biotechnology **Credits 4** **Course 3** Practical –Lab work-II **Credits 4** **Course 4** Patenting in Biotechnology and Bioethics **Credits 2**	**Course 1** Bio entrepreneurship **Theory 3 Credits+ Practical 1 Credit** **OR** **Course 2** Molecular Biology **Theory 2 Credits + Practical 2 Credits** **OR** Any of MOOCs **Credits 4**	-	4*	-	22	
Cum. Cr. For PG Diploma			**28**	**8**	**4**	**4**	**-**	**44**	

*OJT with emphasis on instrumentation- /primary data collection that can be used for their research projects in subsequent semester

MSc. (Biotechnology) Course Structure
Semester III and IV

Year	Level	Sem (2 Yr)	Major		RM	OJT / FP	RP	Cum. Cr.
			Mandatory*	Electives Any one Credits 4				
II	6.5	Sem III	**Course 1** Nanobiotechnology **Credits 4** **Course 2** Environmental Biotechnology **Credits 4** **Course 3** Practical – lab work **Credits 4** **Course 4** Bioanalytical and Biophysical techniques/ **Credits 2**	**Course 1** Biologics and regulatory affairs **Credits 4** **OR** **Course 2** Applied Virology and Microbiology **Theory 2 Credits + Practical 2 Credits** **OR** Any of MOOCs **Credits 4**	-	-	4	22
		Sem IV	**Course 1** Omics and system biology **Credits 4** **Course 2** Drug Discovery and Clinical Studies **Credits 4** **Course 3** Molecular Enzymology **Credits 4**	**Course 1** Food Biotechnology Credits 4 **OR** **Course 2** Scientific writing and Programing Language **Credits 4** **OR** Any of MOOCs **Credits 4**	-	-	6	22
Cum. Cr.for PG Diploma			**26**	**8**			**10**	**44**
Cum Cr for 2 Yr PG degree			**54**	**16**	**4**	**4**	**10**	**88**

Sign of HOD Varsha M
Professor Varsha Kelkar Mane
University Dept of Biotechnology

Sign of Dean,
Professor Shivram Garje
Name of the Faculty: Science

Syllabus
MSc. (Biotechnology)
(Sem. I & II)

Semester –I

Course-I Biochemistry **Credit 4**

Course Outcomes: CO1: to build upon undergraduate level knowledge of biochemical principles. CO2: Special emphasis on different metabolic structures in correlation to the pathways.			
Units	**Topics**	**Credit**	**No of lectures**
Unit-I Glycobiology & Membrane Biochemistry	Glycosylation of Biomolecules - Synthesis N-linked, O-linked, and GPI linked glycoproteins and role of glycosylation. 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 **Protein Transport & Membrane Trafficking**	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 stabilising nucleic acid structures, triple helix. Superhelix 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	Biosynthesis of Amino acids; phenylalanine, tyrosine, threonine, and methionine. Bioenergetics- coupled interconnecting reactions in metabolism; oxidation of		15

regulation of metabolism	carbon fuels; recurring motifs in metabolism. Integration of central 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		

References

For theory:

1. Stryer, L. (2015). *Biochemistry*. (8th edition) New York: Freeman.
2. Lehninger, A. L. (2012). *Principles of Biochemistry* (6th edition). New York, NY: Worth.
3. Voet, D., & Voet, J. G. (2016). *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. 0-321-50781-9

Course II - Bioprocess engineering and technology **Credit 4**

Course Outcomes: CO1: The objectives of this course are to educate students about the fundamental concepts of bioprocess technology and its related applications, CO 2: prepare them to meet the challenges of the new and emerging areas of biotechnology industry.			
Units	**Topics**	**Credit**	**No of 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. Media formulation and optimization methods; sterilization of bioreactors aeration and agitation in bioreactors KLa value (factors affecting and methods of determination).		15
Unit- II **Production of proteins from recombinant microorganisms**	Principles of Microbial Growth: Batch Fermentation, Fed-Batch Fermentation, Continuous Fermentation Maximizing the Efficiency of the Fermentation Process High-Density Cell Cultures, Increasing Plasmid Stability, Quiescent E. coli Cells, Protein Secretion and Reducing Acetate Bioreactors: Typical Large-Scale Fermentation Systems Two-Stage Fermentation in Tandem Airlift Reactors, Two-Stage Fermentation in a Single Stirred-Tank Reactor, Batch versus Fed-Batch Fermentation, Harvesting Microbial Cells, Disrupting Microbial Cells, Downstream Processing, Protein Solubilization, Large-Scale Production of plasmid DNA	4	15
Unit- III Applications of enzyme technology in food processing	Introduction and scope 1. Enzymes sourced from animals and plants used in food manufacturing technology 2. Enzyme usage in food applications. Mechanism of enzyme function and reactions in food processes 1. Starch-processing and related carbohydrates. 2. Lipases for production of food components: interesterified fat 3. Enzymes in protein modification: hydrolyzed protein 4.Enzymes in bread making - flavour, texture and keeping quality 5. Enzymes in dairy product manufacture 6. Enzymes in fruit and vegetable processing and juice extraction 7.Enzymes in fish and meat processing 8. Beer Production using Immobilized Cell Technology		15
Unit- IV Applications of Microbial technology	1. Microbial biomass production: mushrooms, SCP 2.Fermented foods from: meat and fish, bread, Vegetables (sauerkraut, cucumber), Legumes and Oil, Seeds soya bean fermentations		15

	3. Beverages: a) Stimulant Beverages -coffee, cocoa and tea fermentations b) Alcoholic beverages - Cider production 4. Food additives and supplements: a) Lipids, Nucleosides, nucleotides, and related compounds- Vitamins b) Natural food preservatives- bacteriocins from lactic acid bacteria – production and applications e.g. Nisin c) Microbial production of colours and flavours. d) Polyhydric alcohols: low-calorie sweetener particularly useful for sweetening food products for diabetics e) Microbial exopolysaccharides - Xanthan gum 5. 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 2nd ed
9. Nduka Okafor Modern industrial microbiology and biotechnology Science Publishers, Enfield, (2007)

Course III – Practical –Lab Work -I **Credit 4**

Course Outcomes:
On successful completion of the course the learner would demonstrate and explain the understanding of the following:
CO1: Fundamentals of biochemistry and analytical techniques
CO2: Correlating the applications of the techniques in real world.

Topics	**Credit**	**No of Hours**
1. To prepare Acetate and Phosphate buffers using the Henderson-Hassel Bach equation. 2. Purification of protein by ammonium sulphate fractionation, dialyze and separation. using PAGE CBB/silver staining, Glycoprotein staining. 3. To determine an unknown protein concentration using Biuret, Folin lowry's and Bradford's assay 4. Isolation of genomic DNA from plant/animal source 5. Isolation of cholesterol and lecithin from egg yolks. 6. Paper chromatography of Aminoacids, detection using Ninhydrin 7. Microbial pigment/metabolite: a. production – factors affecting – pH, temp, nutrients, static/ shaker conditions, submerged/ surface. b. extraction – soluble and insoluble pigments- organic solvent extraction and purification. 8. Immobilize an organism / enzyme and detect the conversion of substrate to product. 9. Demonstration of media optimization by Placket Burman test- demonstration 10. Methods for measurement of cell mass: a. Direct physical measurement of dry weight, wet weight, or volume of cells after centrifugation. b. Indirect measurement. c. Turbidity measurements employ instruments to determine the amount of light scattered by cell suspension. 11. Demonstration of Analytical techniques like HPLC, FPLC, GC, GC-MS etc. for measurement of amounts of products/substrates. 12. Quality Assurance in a Biotechnology/food/beverage industry – Field visit and report 13. Method validation for any biochemical test (Accuracy, Limit of Detection, Limit of Quantitation, Specificity, Linearity and range, Ruggedness and Robustness) – Report writing.	**4**	**120**

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.

Course IV - Basics in IPR and Patents **Credits 2**

Course Outcomes: On successful completion of the course the learner would demonstrate and explain the understanding of the following: CO1: basic knowledge on intellectual property rights and their implications in biological research and product development. Co 2: Familiarizing with India's IPR Policy;			
Unit	**Topics**	**Credit**	**No of Lectures**
Unit I **Introduction to IPR**	World Intellectual Property Organization (WIPO) – Functions of WIPO – Membership – GATT Agreement – Paris Convention – TRIPS agreement. Types of IP: patents, trademarks, trade secrets, copyright & related rights, industrial design, geographical indications, Biodiversity importance and legislation, plant variety protection and farmers rights act, traditional knowledge.	**2**	**15**
Unit II **Basics of Patent**	Eligibility criteria, concept of novelty, concept of inventive step. Patenting systems- Indian Patent Act and amendments, Process of Patenting, Types of patent applications, Patent Agent, Patent Search, Rights of the patent holder, Assignment and licensing of patents and patent Infringement, case studies.		**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. Padma Nambisan (Auth.) - An Introduction to Ethical, Safety and Intellectual Property Rights
4. Issues in Biotechnology- Academic Press (2017)
5. David Castle - The Role of Intellectual Property Rights in Biotechnology Innovation (2011)
6. Goel, D., & Parashar, S. (2013). IPR, Biosafety and Bioethics. Pearson Education India.
7. Singh, S. S. (2004). The Law of Intellectual Property Rights. Deep and Deep Publications, New Delhi, 96.
8. Talwar Shabana; Intellectual Property Rights in WTO and Developing Countries, Edition 2010,Serials Publications, New Delhi.

Elective Course I Immunology **Credits (Theory) 2**

Course Outcomes:
CO1: This course will provide students with an overview of current developments in different areas of vaccines.
CO2: 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.

Unit	Topics	Credit	No of Lectures
I **Vaccinology**	Active and passive immunization; live, killed, attenuated, subunit vaccines; vaccine technology: role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; peptide vaccines, conjugate vaccines; antibody genes and antibody engineering: chimeric, generation of monoclonal antibodies, hybrid monoclonal antibodies; catalytic antibodies and generation of immunoglobulin gene libraries, idiotypic vaccines and marker vaccines, viral-like particles (VLPs), dendritic cell based vaccines, vaccine against cancer, T cell based vaccine, edible vaccine and therapeutic vaccine.	2	15
II **Antigen-antibody interactions**	Precipitation, agglutination and complement mediated immune reactions; advanced immunological techniques: RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence microscopy, flow cytometry and immunoelectron microscopy; surface plasmon resonance, biosensor assays for assessing ligand –receptor interaction; CMI techniques: lymphoproliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays, apoptosis, microarrays, transgenic mice, gene knock outs.		15

Elective Course 1 Practical **2 Credits**

1. Preparation and sterility testing of heat killed vaccines.
2. To perform the Dot blot assays
3. Latex bead agglutination / precipitation test for detection of rheumatoid factor (RF)
4. Separation of lymphocytes on Ficoll Histopaque and viability count
5. Study of precipitation reactions- Ouchterlony and Mancini
6. Demonstration of Western blotting
7. Widal test- quantitative
8. RPR (Rapid Plasma Reagin)- kit based
9. Determination of ESR

References

1. Kindt, T. J., Goldsby, R. A., Osborne, B. A., &Kuby, J. (2006). Immunology. New York: W.H. Freeman.
2. Murphy, K., Travers, P., Walport, M., & Janeway, C. (2012). Janeway's Immunobiology. New York: Garland Science.
3. An introduction to Immunology C V Rao Narosa Publishing house

4. Immunology essential and fundamental, Second edition S Pathak & U P Parveen Publishing House
5. Text Book of Medical Biochemistry, Praful Godkar. Bahalani Publishers
6. Immunology, An introduction, fourth edition. Ian R Tizard Thomson
7. Immunology, fifth Ed Goldsby, T J. Kindt, Osborne, Janis Kuby Freeman and company.
8. Immunology, sixth Ed Roitt, Brostoff, Male Mosby, An imprint of Elsevier science Ltd
9. Practical immunology, Frank Hay, 4th Edition , Blackwell Science
10. Medical Microbiology, Anantnaraya

Elective Course II: Molecular diagnostics **Credits (Theory) 2**

Course Outcomes:

CO1: The objectives of this course are to sensitize students about recent advances in molecular biology and various facets of molecular medicine.

CO 3 The course would enable leaners understand different aspects of modern medicine including pre- or post-natal analysis of genetic diseases and identification of individuals predisposed to disease ranging from common cold to cancer.

Unit	Topics	Credit	No of Lectures
Unit I Diagnostic Microbiology	Techniques: Molecular amplification techniques ● Target amplification systems ● Probe amplification systems ● Signal amplification PCR in molecular diagnostics; viral and bacterial detection Quantitation of organisms – internal controls, external standards, calibrators, absolute and relative quantification Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing Detection and identity of microbial diseases Direct detection and identification of pathogenic organisms/ viruses e.g. TB and HIV Clinical utility of molecular diagnostics tests (NAAT) for Hepatitis and AIDS. Molecular identification of fungal pathogens Pharmacogenetics	2	15
Unit II Functional Genomics and Proteomics	Genomics: Gene expression by SAGE and Functional Microarrays- Construction of microarrays – genomics and genomic arrays, cDNA arrays and oligo arrays and Proteomics its applications, NGS platforms, high and low read sequences Proteomics: Separation and Identification of Proteins 2D-PAGE, isoelectric focusing, Edmand 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 15 (Difference in Gel Electrophoresis) Clinical and biomedical applications of proteomics, Introduction to metabolomics, lipidomics, metagenomics and systems biology.		15

Elective Course II practical : **2 credits**

1. Antimicrobial sensitivity test and demonstration of drug resistance.

2. Identification of microorganisms using biochemical testing (performing) and 16S rDNA sequencing (demonstration)
3. Visit to molecular diagnostic lab/ cytogenetic lab: Report
4. Sample collection, storage and processing in molecular diagnostic labs
5. 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.
6. Separation of human serum / plasma proteins / egg white using Native PAGE.
7. Demonstration/ video of 2D PAGE
8. Demonstration of Affinity chromatography

References:

For theory

1. Campbell, I. D. (2012). Biophysical Techniques. Oxford: Oxford University Press.
2. Serdyuk, I. N., Zaccai, N. R., & Zaccai, G. (2007). Methods in Molecular Biophysics: Structure,Dynamics, Function. Cambridge: Cambridge University Press.
3. Phillips, R., Kondev, J., & Theriot, J. (2009). Physical Biology of the Cell. New York: Garland 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. Lander, E. (2016). The Heroes of CRISPR. Cell, 164(1-2), 18-28. doi:10.1016/j. cell.2015.12.041.
5. Ledford, H. (2016). The Unsung Heroes of CRISPR. Nature, 535(7612), 342-344. doi:10.1038/535342a.
6. 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.
7. Molecular biology of the cell by Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Rafi, Keith Roberts, and Peter Walter. 5th ed. 2008
8. Molecular Microbiology Diagnostic Principles and practice third edition, David H. Persing and Fred C. Tenover Copyright _ 2016 by ASM Press
9. Methods in Molecular Biology, Vol. 204: Molecular Cytogenetics: Protocols and Applications, Edited by: Y. S. Fan © Humana Press Inc., Totowa, NJ 2001
10. Genome 3 TA Brown Molecular Biotechnology – Principles and applications of recombinant technology, Glick 4th edition 2010
11. Human Molecular Genetics. Tom Strachan and Andrew Read, 2004, 3rd Edition, Garland
12. Introduction to human molecular genetics. Jack Pasternak, 2005, 2nd Edition, Wiley publication.

For Practicals

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

Course: Research Methodology **Credits 4**

Unit	Topic	Credit	Number of lectures
Course Outcomes: On successful completion of the course the learner would be able to: CO1: Demonstrate knowledge of characteristics of research and research types and processes (reading, evaluating, and developing). Identify, explain, compare, and prepare the key elements of a research proposal/report. CO 2 Describe sampling methods, measurement scales and instruments, and appropriate uses of each. Describe, analyze, and apply computational tools with suitable examples. Describe, Discuss, and evaluate plagiarism and its types.			
I Introduction to Research and its types	Definition and Characteristics of Research: Research – Definition; Concept of Construct, Postulate, Proposition, Thesis, Hypothesis, Law, Principle. Philosophy and validity of research. Objective of research. Various functions that describe characteristics of research such as systematic, valid, verifiable, empirical and critical approach. Research process. Types of Research: Pure and applied research. Descriptive and explanatory research. Qualitative and quantitative approaches. Formulating the Research Problem, Literature Review, Developing the objectives, Preparing the research design including sample Design, Sample size.	**4**	**15 lectures**
II Data and Methods of Data Collection	Data collection, primary and secondary sources of data, and Selecting a method for data collection. Collection of primary data through questionnaires and schedules. Collection of secondary data, processing, and analysis of data. Sample survey, simple random sampling, stratified random sampling, systematic sampling, cluster sampling, area sampling, and multistage sampling. The pilot survey, measurement and scaling techniques.		**15 lectures**
III Writing & Communication of Research and computer applications	Scientific writing (including Language proficiency), scientific literature comprehension, Art and ethics of writing -steps in writing research paper and/or thesis, writing a research proposal, and patents in Science. Abstract writing. SOP writing for laboratory instruments. Skills of making PowerPoint presentations Statistical data analysis: generating charts/ graph and other features. Introduction to tools: Tools used may be Microsoft Excel, Open office, Microsoft Power Point or similar tools and Application of internet in Research.		**15 lectures**
IV Plagiarism	Introduction to plagiarism, reasons for plagiarism, Types of plagiarism, software used for identifying plagiarism, Plagiarism policies and techniques to avoid plagiarism. Use of open educational resources and licenses under creative commons, use of AI tools (any Current references)		**15 lectures**

Reference Books:

1. Research Methodology – Methods and Techniques, C K Kothari, New Age International.
2. Design and Analysis of Experiments, D C Montgomery, Wiley.
3. Applied Statistics & Probability for Engineers, D C Montgomery & G C Runger, Wiley.

4. Management Research Methodology: Integration of Principles, Methods and Techniques, K N Krishnaswamy, A I Sivakumar and M Mathiranjan, Pearson Education.
5. Conducting educational research -Tuckman, B. W. & Harper, B. E. (2012). Conducting educational research (6th ed.). Lanham, MD: *Rowman* & Littlefield Publishers. (ISBN: 978-1-4422-0964-0)
6. CSIR Guidelines for Ethics in Research and in Governance - CSIR (2019)
7. Ethics in Science Education, Research and Governance- Kambadur Muralidhar, Amit Ghosh, Ashok Kumar Singhvi - INSA (2019)
8. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches by John W. Creswell and J. David Creswell
9. The Craft of Research by Wayne C. Booth, Gregory G. Colomb, and Joseph M. Williams
10. Research Methodology: A Step-by-Step Guide for Beginners by Ranjit Kumar.
11. Research Methodology edited Vinayak Bairagi and Mausami Munot. CRC publication

Semester II

Course I - Bioinformatics and Biostatistics **Credit 4**

Course Outcomes:
On successful completion of the course the learner would demonstrate and explain the understanding of the following:
CO 1: practical training in bioinformatic methods including accessing major public sequence databases, use of different computational tools to find sequences, analysis of protein and nucleic acid sequences by various software packages.

Unit	Topics	Credit	No of Lectures
Unit I Bioinformatics	Bioinformatics basics: Computers in biology and medicine; Introduction to Unix and Linux systems and basic commands; Biological XML DTD's; databases and search tools: biological background for sequence analysis, NCBI- publicly available tools; resources at EBI; DNA sequence analysis: gene bank sequence database; submitting DNA sequences to databases, pairwise alignment techniques: BLAST and FASTA, 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 Bioinformatics	Multiple sequence alignment: CLUSTALW and CLUSTALX for multiple sequence alignment, submitting DNA protein sequence to databases: where and how to submit, SEQUIN; submitting aligned sets of sequences, updating submitted sequences; methods of phylogenetic analysis. Protein modelling: Protein structure and classification databases; Protein structure visualization; Protein structure analysis: Secondary, (Chou Fasman algorithm, GOR algorithm, Tertiary (Homology modelling, Threading, Ab initio)		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, stratified random sampling and systematic sampling and non-random sampling. Measures of central tendency; Mean, Median and Mode. Measures of Dispersion: Variance/ standard deviation, coefficient of variation and standard error. 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, t-test a single sample, two samples and testing the significance of the correlation. Coefficient: t paired test, Chi-square (x2 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. S. P. Gupta, Statistical Methods, (45th Revised Edition), Publisher SCHAND
8. William G. Cochran, Sampling Techniques (3th Edition), Wiley and sons
9. Boris V. Gnedenko, Theory of Probability (6th Edition), CRC Press, 13-May-1998
10. Oscar Kempthorne, Klaus Hinkelmann, Design and Analysis of Experiments, Volume1: Introduction
to Experimental Design, 2nd Edition, ISBN: 978-0-471-72756-9 December 2007
11. Acheson Johnston Duncan, Quality Control and Industrial Statistics (5th Edition), Irwin; 5 edition January 1, 1986
12. BK Mahajan, Methods in Biostatistics (7th Edition), Published December 1st 2008 by JP Medical Ltd

Course II - Plant and Animal Biotechnology **Credit 4**

Course Outcomes:
Co 1: Students will be acquainted with the principles, practices and application of animal biotechnology, plant tissue culture, plant and animal genomics, genetic transformation and molecular breeding of plants and animals.

Unit	Topics	Credit	No of Lectures
I Plant tissue culture	Historical perspective; totipotency; culture and organogenesis; Somatic embryogenesis; establishment of Animal cell cultures – callus culture, cell suspension culture, media culture preparation – nutrients and plant hormones; sterilization techniques; applications of tissue culture - micropropagation; somaclonal 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.	4	15
II Plant Genetic manipulations	Genetic engineering: Agrobacterium-plant interaction; Genetic virulence; Ti and Ri plasmids; opines and their manipulations significance; T-DNA transfer; disarmed Ti plasmid; Genetic transformation - Agrobacterium-mediated gene delivery; cointegrate and binary vectors and their utility; direct gene transfer - PEG-mediated, electroporation, particle bombardment and alternative methods; screenable and selectable markers; characterization of transgenics; chloroplast transformation; marker-free methodologies; advanced methodologies - cisgenesis, intragenesis and genome editing; molecular pharming -concept of plants as biofactories, production of industrial enzymes and pharmaceutically important compounds.		15
III Animal cell culture and animal reproductiv eBiotechnol ogy	Brief history of animal cell culture; ATC media: serum, serum free and plant based serum alternatives and chemically defined media.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. Novel strategies and advancement in mammalian cell line development, large scale production of animal cells, advances in tissue engineering, use of genetic engineering tools for therapy. Animal reproductive biotechnology: structure of sperms reproductive and ovum; cryopreservation of sperms and ova of biotechnology livestock; artificial insemination; super ovulation, and embryo recovery and in vitro fertilization; culture of Vaccinology 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
IV Molecular mapping and marker	Molecular markers - hybridization and PCR based mapping and markers RFLP, RAPD, STS, SSR, AFLP, SNP markers; marker DNA fingerprinting-principles and applications; assisted introduction to mapping of genes/QTLs; marker-assisted selection - strategies for		15

assisted selection.	Introducing genes of biotic and abiotic stress resistance in plants: genetic basis for disease resistance in animals; molecular diagnostics of pathogens in plants and animals; detection of meat adulteration using DNA based methods.		

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: HumanaPress.
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

Course III – Practical –Lab Work -II **Credit 4**

Course outcomes: The aim of this course is
CO 1: to provide practical training in bioinformatic methods including accessing major public sequence databases,
CO 2: use of different computational tools to find sequences, analysis of protein and nucleic acid sequences by various software packages.

Topics	**Credit**	**No of Hours**
	4	**120**

1. Using NCBI and Uniprot web resources
2. Introduction and use of various genome databases.
3. Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, Swissprot/ TrEMBL, UniProt.
4. Similarity searches using tools like BLAST and interpretation of results.
    a. Multiple sequence alignment using ClustalW.
5. Phylogenetic analysis of protein and nucleotide sequences.
6. Use of gene prediction methods (GRAIL, Genscan, Glimmer) (Demonstration)
7. Homology modeling
8. Use of various primer designing and restriction site prediction tools.
9. Use of different protein structure prediction databases (PDB, SCOP, CATH).
10. Measures of central tendency: Mean, median and mode for grouped and ungrouped data
11. Measures of dispersion: Standard deviation for grouped and ungrouped data: standard value for the mean and proportion
12. Confidence limits for the mean and proportion
13. Probability: Normal distribution and Binomial distribution use of normal tables
14. Correlation and Regression: Estimation of correlation coefficient, to fit regression equations from bivariate data
15. Test of hypothesis: a) Z-test, b) t-test c) x2 test
16. Prepare culture media with various supplements for plant tissue culture.
17. Prepare explants from suitable plants for inoculation under aseptic conditions.
18. Isolate plant protoplast by enzymatic and mechanical methods and attempt fusion by PEG
19. Culture *Agrobacterium tumefaciens* and attempt transformation of any dicot species.
20. Undertake plant genomic DNA isolation by CTAB method and its quantitation by visual as well as spectrophotometric methods.
21. Count cells of an animal tissue and check their viability.
22. Prepare culture media with various supplements for plant and animal tissue culture.
23. Prepare single cell suspension from spleen and thymus.
24. Isolate DNA from animal tissue by SDS method.
25. Attempt animal cell fusion using PEG.

Course IV - Patenting in Biotechnology and Bioethics **Credit 2**

Course outcome: **CO1:** The course will provide basic knowledge on intellectual property rights and their implications in biological research and product development; **CO2**: The course will facilitate the students in understanding India's IPR Policy.			
Unit	**Topics**	**Credit**	**No of Lectures**
Unit I Patenting	Patentability of Statutory Provisions Regarding Biotechnological Biotechnology Inventions Under the Current Patent Act 1970 (as Inventions Amended 2005). Interpreting TRIPS in the Light of Biotechnology, Territorial Nature of Patents: From Territorial to Global Patent Regime, Inventions, Feasibility of a Uniform Global Patent, System, Merits and Demerits of Uniform Patent Law, Relevance of the Existing International Patent, Tentative Harmonization Efforts, Implications of Setting up a Uniform World Patent System.	2	15
Unit II Bioethics	Introduction, bioethics in health care- euthanasia, Bioethics 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, labeling 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
5. Issues in Biotechnology- Academic Press (2017)
6. Kshitij Kumar Singh (auth.) - Biotechnology and Intellectual Property Rights_ Legal and Social Implications-Springer India (2015)
7. Talwar Shabana; Intellectual Property Rights in WTO and Developing Countries, Edition 2010, Serials Publications, New Delhi.

Elective Course 1: Bio Entrepreneurship **Credits 3**

Course outcomes: CO1: Bio-entrepreneurship, an interdisciplinary course, revolves around the central theme of how to manage and develop life science companies and projects. CO2: The objectives of this course are to teach students about concepts of entrepreneurship including identifying a winning business opportunity, gathering funds and launching a business, growing and nurturing the organization and harvesting the rewards			
Unit	**Topics**	**Credit**	**No of Lectures**
Unit I **Innovation and entrepreneurship**	Innovation and entrepreneurship in bio-business Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (e.g. pharmaceuticals vs. Industrial biotech), Strategy and operations of bio-sector firms; Factors shaping opportunities for innovation and entrepreneurship in bio-sectors, and the business implications of those opportunities, Alternatives faced by emerging biofirms and the relevant tools for strategic decision, Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India), strategic dimensions of patenting & commercialization strategies.	**3**	**15**
II **Business strategies**	Bio markets: business strategy and marketing Negotiating the road from lab to the market (strategies and processes of negotiation with financers, government and regulatory authorities), Pricing strategy, Challenges in marketing in bio business (market conditions & segments; developing distribution channels, the nature, analysis and management of customer needs), Basic contract principles, different types of agreement and contract terms typically found in joint venture and development agreements, Dispute resolution skills.		**15**
Unit III **Finance and accounting**	Business plan preparation including statutory and legal requirements, Business feasibility study, financial management issues of procurement of capital and management of costs, Collaborations & partnership, Information technology		**15**

Elective Course 1 Practical **1 credit**

1. Case study - Successful Entrepreneurship in Biotechnology/pharma industry - Presentation
2. Project submission on startup ideas and validation, presentation and report writing.
3. Any MOOC related to Biotechnology.

References -

Adams, D. J., & Sparrow, J. C. Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences Scion
Shimasaki, C. D. Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies Academic Press Latest Edition
Onetti, A., & Zucchella, A. Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge Routledge Latest Edition
Jordan, J. F. Innovation, Commercialization, and Start-Ups in Life Sciences CRC Press Latest Edition

Elective Course II: Molecular Biology **Credit 2 (Theory)**

Course outcomes:
CO1: The objectives of this course are to provide students with theoretical and experimental knowledge of molecular biology and tools essential for techniques in molecular biology

Unit	Topics	Credit	No of Lectures
I Molecular Cloning Methods	Gene cloning – The role of restriction endonucleases, Vectors, Identifying a specific clone with a specific probe, cDNA cloning, Rapid amplification of cDNA ends. The Polymerase Chain Reaction – Standard PCR, Using RT-PCR in cDNA cloning, Real-time PCR. Methods of expressing cloned genes – Expression vectors, Other eukaryotic vectors, Using the Ti plasmid to transfer genes to plants,.	2	15
II Molecular Tools for Studying Genes and Gene Activity	Molecular separations – Gel electrophoresis, 2D-gel electrophoresis, Ion-exchange chromatography, Gel-filtration chromatography, affinity chromatography. Labelled tracers – Autoradiography, Phosphorimaging, Liquid Scintillation Counting, Non-radioactive tracers. Nucleic acid hybridization – Southern blots, DNA fingerprinting and DNA typing, in-situ hybridization, Immunoblots (Western blots). DNA sequencing and physical mapping – Sanger method, Automated DNA sequencing, High-throughput sequencing, Restriction mapping. Site directed mutagenesis. Mapping and quantifying transcripts – Northern blots, S1 mapping, Primer extension, Run-off transcription and G-less cassette transcription. Measuring transcription rates in-vivo – Nuclear run-on transcription, Reporter gene transcription, Measuring protein accumulation *in vivo*. Assaying DNA-protein interactions – Filter binding, Gel mobility shift, DNase and other footprinting, ChIP. Assaying protein-protein Interactions. Finding RNA sequences that interact with other molecules – SELEX, Functional SELEX. Knockout and Transgenics – Knockout mice, Transgenic mice.		15

Elective Practical Course II **2 credits**

1. Extraction of genomic DNA from bacteria using commercial kit.
2. PCR and PCR amplicon clean-up.
3. Extraction and purification of DNA band from agarose gels (gel extraction).
4. Cloning of a gene into a plasmid and transforming it into *E. coli*.
5. Restriction digestion and ligation.
6. Expression of cloned gene using an inducer.
7. Chromatin immunoprecipitation (ChIP).

References :

1. Molecular Biology (5th Edition) – Robert Weaver.(McGraw Hill)
2. Molecular Biotechnology- Glick and Pasternak ASM Press.
3. Cell and Molecular Biology- Concepts and Experiments—Karp – Wiley International.
4. Molecular Cell Biology Fifth Edition by Lodish *et al* W. H. Freeman (2003)

Semester	Programme Code	Programme Name	Course Name	Compulsory/ Elective	Theory Marks(Internal)	Theory Marks(External)	Practical Marks(Internal)	Practical Marks(External)	Project Marks(Internal)	Project Marks(External)	Total Marks	Credit
I	IS01121	M. Sc. (Biotechnology)	Biochemistry	Compulsory	50	50	--	--	--	--	100	4
I	IS01121	M. Sc. (Biotechnology)	Bioprocess Engineering and	Compulsory	50	50	--	--	--	--	100	4
I	IS01121	M. Sc. (Biotechnology)	Practical –Lab work- I	Compulsory	--	--	50	50	--	--	100	4
I	IS01121	M. Sc. (Biotechnology)	Basics in IPR and Patents	Compulsory	25	25	--	--	--	--	50	2
I	IS01121	M. Sc. (Biotechnology)	Immunology	Elective	25	25	25	25	--	--	100	4
I	IS01121	M. Sc. (Biotechnology)	Molecular Diagnostics	Elective	25	25	25	25	--	--	100	4
I	IS01121	M. Sc. (Biotechnology)	Any of MOOCs	Elective	--	--	--	--	50	50	100	4
I	IS01121	M. Sc. (Biotechnology)	Research Methodology	Compulsory	50	50	--	--	--	--	100	4
										Total	550	22

II	IS01122	M. Sc. (Biotechnology)	Bioinformatics & Biostatistics	Compulsory	50	50	--	--	--	--	100	4
II	IS01122	M. Sc. (Biotechnology)	Plant and Animal Biotechnology	Compulsory	50	50	--	--	--	--	100	4
II	IS01122	M. Sc. (Biotechnology)	Practical –Lab work - II	Compulsory	--	--	50	50	--	--	100	4
II	IS01122	M. Sc. (Biotechnology)	Patenting in Biotechnology	Compulsory	25	25	--	--	--	--	50	2
II	IS01122	M. Sc. (Biotechnology)	Bioentrepreneurship	Elective	25	25			25	25	100	4
II	IS01122	M. Sc. (Biotechnology)	Molecular Biology	Elective	25	25	25	25	--	--	100	4
II	IS01122	M. Sc. (Biotechnology)	Any of MOOCs	Elective	--	--	--	--	50	50	100	4
II	IS01122	M. Sc. (Biotechnology)	OJT	Compulsory	--	--	--	--	50	50	100	4
										Total	550	22

Varsha K

Dr. Varsha Kelkar - Mane
Head of the Department
University Dept. of Biotechnology
University of Mumbai

DEPT. OF BIOTECHNOLOGY * VIDYANAGARI MUMBAI 400 098 * UNIVERSITY OF MUMBAI

Letter Grades and Grade Points:

Semester GPA/ Programme CGPA Semester/ Programme	% of Marks	Alpha-Sign/ Letter Grade Result
9.00 - 10.00	90.0 -100	O (Outstanding)
8.00 - < 9.00	80.0 < 90.0	A+ (Excellent)
7.00 - < 8.00	70.0 < 80.0	A (Very Good)
6.00 - < 7.00	60.0 < 70.0	B+ (Good)
5.50 - < 6.00	55.0 < 60.0	B (Above Average)
5.00 - < 5.50	50.0 < 55.0	C (Average)
4.00 - < 5.00	40.0 < 50.0	P (Pass)
Below 4.00	Below 40.0	F (Fail)
Ab (Absent)	-	Absent

Varsha M

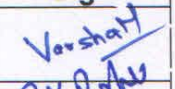
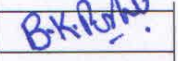
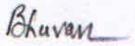
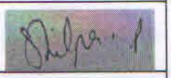
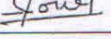
Sign of HOD

Professor Varsha Kelkar Mane

University Dept of Biotechnology

Syllabus
P.G. Diploma in Biotechnology
(Sem. I & II)

Team for Creation of Syllabus

No	Name	College Name	Sign
1	Prof Varsha Kelkar Mane	UD Biotechnology	
2	Dr Bhupendra Pushkar		
3	Dr Rohan Gavankar	VIVA College	
4	Dr Bhuvaneshwari Krishna	CHM College	
5	Ms Rashmi Bhave	Gogate Jogalekar College	
6	Dr Shilpa Gharat	Sonopant Dandekar College	
7	Dr Shailaja Palan		
8	Dr Sonal Upadhyay	Vikas College	
9	Dr Namrata Desai	ICLES' Motilal Jhunjhunwala College	
10	Ms Archana Tajane	BNN College	
11	Dr Ganesh Lad	Thakur Shyamnarayan Degree College	
12	Mr Chetan Patil	R.D. and S.H. National College and S.W.A. Science College	
13	Dr Mukesh Pimpliskar	KME's G M Momin Women's college	
14	Dr. Shobha Gupta	Vidyavardhini's Annasaheb Vartak College	
15	Ms Shweta Khopde	MVLU College	
16	Mrs Vaishalee Chaudhari	N. B. Mehta Science College	
17	Ms Vinaya Jategaokar	VES college	

Sign of HOD	Sign of Dean
Name of the Head: Professor Varsha Kelkar Mane Name of the Department: Biotechnology	Name of the Dean: Prof S S Garje Name of the Faculty: Science

Justification for M.Sc.(Biotechnology)

1.	Necessity for starting the course:	**AMultidisciplinary field that integrates biological sciences with technology.Its emerging applications in diagnostics and therapeutics, food and environment have made the subject essential for learners.**
2.	Whether the UGC has recommended the course:	**No**
3.	Whether all the courses have commenced from the academic year 2023-24	**Yes (NEP course has commenced from 2023-24)**
4.	The courses started by the University are self-financed, whether adequate number of eligible permanent faculties are available?:	**Self-financed Permanent faculty available in partial strength**
5.	To give details regarding the duration of the Course and is it possible to compress the course:	**Course duration: 02 years Completion of one year would yield diploma**
6.	The intake capacity of each course and no. of admissions given in the current academic year:	**20**
7.	Opportunities of Employability / Employment available after undertaking these courses:	**Research positions in Institutes and Managerial positions in healthcare, personal care industry, Faculty in colleges, Schools, Scientific writers Scientific assistant/officer/Medical representatives/Entrepreneurs etc**

Sign of HOD Varsha
Professor Varsha Kelkar Mane
University Dept of Biotechnology

Sign of Dean,
Professor Shivram Garje
Name of the Faculty: Science