University of Mumbai

No. AAMS_UGS/ICC/2024-25/107

CIRCULAR:-

Attention of the Principals of the Affiliated Colleges, Directors of the Recognized Institutions and the Head, University Departments is invited to this office circular No. AAMS_UGS/ICC/2023-24/23 dated 08th September, 2023 relating to the NEP UG & PG Syllabus.

They are hereby informed that the recommendations made by the **Ad-hoc Board of Studies in Life Science** at its meeting held on 01st July, 2024 and subsequently passed by the Board of Deans at its meeting held on 10th July, 2024 **vide** item No.6.9 (N) have been accepted by the Academic Council at its meeting held on 12th July, 2024 **vide** item No.6.9 (N) and that in accordance therewith **syllabus** for the **M.Sc (Life Sciences- Biotechnology) (Sem. III & IV)** is introduced as per appendix (NEP 2020) with effect from the academic year 2024-25.

(The circular is available on the University's website www.mu.ac.in).

Baliram

MUMBAI – 400 032
22nd August, 2024

(Prof.(Dr) Baliram Gaikwad)
I/c Registrar

To

The Principals of the Affiliated Colleges, Directors of the Recognized Institutions and the Head, University Department.

A.C/6.9 (N)/12/07/2024

Copy forwarded with Compliments for information to:-

1) The Chairman, Board of Deans,
2) The Dean, Faculty of Science & Technology,
3) The Chairman, **Ad-hoc Board of Studies in Life Science**,
4) The Director, Board of Examinations and Evaluation,
5) The Director, Board of Students Development,
6) The Director, Department of Information & Communication Technology,
7) The Director, Institute of Distance and Open Learning (IDOL Admin), Vidyanagari.
8) The Deputy Registrar, Admissions, Enrolment, Eligibility & Migration Department (AEM),

Copy forwarded for information and necessary action to :-	
1	The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Dept)(AEM), dr@eligi.mu.ac.in
2	The Deputy Registrar, Result unit, Vidyanagari drresults@exam.mu.ac.in
3	The Deputy Registrar, Marks and Certificate Unit,. Vidyanagari dr.verification@mu.ac.in
4	The Deputy Registrar, Appointment Unit, Vidyanagari dr.appointment@exam.mu.ac.in
5	The Deputy Registrar, CAP Unit, Vidyanagari cap.exam@mu.ac.in
6	The Deputy Registrar, College Affiliations & Development Department (CAD), deputyregistrar.uni@gmail.com
7	The Deputy Registrar, PRO, Fort, (Publication Section), Pro@mu.ac.in
8	The Deputy Registrar, Executive Authorities Section (EA) eau120@fort.mu.ac.in He is requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to the above circular.
9	The Deputy Registrar, Research Administration & Promotion Cell (RAPC), rapc@mu.ac.in
10	The Deputy Registrar, Academic Appointments & Quality Assurance (AAQA) dy.registrar.tau.fort.mu.ac.in ar.tau@fort.mu.ac.in
11	The Deputy Registrar, College Teachers Approval Unit (CTA), concolsection@gmail.com
12	The Deputy Registrars, Finance & Accounts Section, fort draccounts@fort.mu.ac.in
13	The Deputy Registrar, Election Section, Fort drelection@election.mu.ac.in
14	The Assistant Registrar, Administrative Sub-Campus Thane, thanesubcampus@mu.ac.in
15	The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan, ar.seask@mu.ac.in
16	The Assistant Registrar, Ratnagiri Sub-centre, Ratnagiri, ratnagirisubcentre@gmail.com

Copy for information :-	
1	P.A to Hon'ble Vice-Chancellor, vice-chancellor@mu.ac.in
2	P.A to Pro-Vice-Chancellor pvc@fort.mu.ac.in
3	P.A to Registrar, registrar@fort.mu.ac.in
4	P.A to all Deans of all Faculties
5	P.A to Finance & Account Officers, (F & A.O), camu@accounts.mu.ac.in

1	The Chairman, Board of Deans
2	The Dean, Faculty of Humanities,
3	Chairman, Board of Studies,
4	The Director, Board of Examinations and Evaluation, dboee@exam.mu.ac.in
5	The Director, Board of Students Development, dsd@mu.ac.in@gmail.com DSW direcotr@dsw.mu.ac.in
6	The Director, Department of Information & Communication Technology,
7	The Director, Institute of Distance and Open Learning (IDOL Admin), Vidyanagari, director@idol.mu.ac.in

AC – 12/07/2024
Item No. – 6.9 (N)

As Per NEP 2020

University of Mumbai

Title of the program

M. Sc. (Life Sciences – Biotechnology)

Syllabus for

Semester – Sem.- III & IV
Ref: GR dated 16th May, 2023 for Credit Structure of PG

(With effect from the academic year 2024-25)

University of Mumbai

(As per NEP 2020)

Sr. No.	Heading	Particulars
1	**Title of program** **O:_____ B**	**M.Sc. (Life Science-Biotechnology)**
2	**Scheme of Examination** **R: _____**	**NEP** **50% Internal** **50% External,** **Semester End Examination** **Individual Passing in Internal and External Examination**
3	**Standards of Passing** **R: _____**	**40%**
4	**Credit Structure** **R: SP-50A** **R: SP-50B**	**Attached herewith**
5	**Semesters**	**Sem. III**
6	**Program Academic Level**	**6.5**
7	**Pattern**	**Semester**
8	**Status**	**New**
9	**To be implemented from Academic Year**	**2024-25**

Indu Anna George
9/7/2024

Sign of the BOS Chairman **Prof. Indu Anna George** **BOS in Life Sciences**	**Sign of the Offg. Associate Dean** **Dr. Madhav Rajvade** **Faculty of Science & Technology**	**Sign of the Offg. Associate Dean** **Name of the Associate Dean** **Faculty of**	**Sign of the Offg. Dean** **Prof. Shivram Garje** **Faculty of Science & Technology**

PREAMBLE

1. Introduction:

The Department of Life Sciences at the University is delighted to introduce the Master of Science (MSc) Programme, a comprehensive and dynamic two-year full-time course that aims to provide students with a deep understanding of the diverse aspects of life and its related disciplines. Life Sciences encompass a wide range of fields, offering fundamental knowledge about animals, plants, microorganisms, and the abiotic factors that influence their existence.

This specialized program delves into the intricacies of the biotic world, exploring the structures and functions of living organisms from physical, physiological, metabolic, biochemical, ecological, and socio-economic perspectives. Through this curriculum, students will embark on an exciting journey into the world of various techniques and technologies employed in the study of life, enabling them to appreciate the economic and ecological importance of the living and non-living things.

The MSc Programme in Life Sciences comprises interdisciplinary courses that encompass animal and plant sciences, microbiology, biochemistry and biophysics, molecular biology, and applied genetics. These comprehensive modules empower students to strengthen their knowledge in their respective areas of interest and gain insights into the wide-ranging opportunities available in this field. Additionally, the curriculum is designed to cultivate a deep appreciation for nature and natural resources, fostering skills for data observation and analysis in preparation for future research endeavours.

The Programme structure entails core papers of three theory and two practicals in each semester, allowing students to gain theoretical knowledge as well as hands-on experience. With the implementation of the Choice Based Grading System, the evaluation process incorporates continuous assessment throughout the year, including both Internal Assessment and Term End Assessment. This comprehensive evaluation methodology ensures a holistic approach to students' progress and encourages active engagement throughout the academic year.

To further enhance the students' readiness for the industry, the curriculum incorporates a mandatory On Job Training (OJT) component in Semester II and Research Projects in Semester III and IV. This intensive training, equivalent to a full course, provides invaluable exposure to real-world scenarios within Life Sciences or Life Sciences-related organizations. By applying their theoretical knowledge in practical settings, students gain first-hand experience and develop the necessary skills to thrive in the professional world.

In addition to technical skills, this programme also focuses on cultivating research ethics and promoting a research-oriented mindset among learners. The inclusion of a Research Methodology Course helps students develop a strong research attitude, enabling them to contribute meaningfully to the advancement of Life Sciences.

Acknowledging the evolving trends in education and the need for flexible learning modes, the syllabus has been augmented to include an online component. Embracing the advantages offered by online learning, this component is designed to be optional, allowing both teaching faculties and students to collaboratively determine the topics to be covered in the online format. The authorities will oversee the final implementation of this innovative concept, recognizing its potential to revolutionize education by overcoming barriers of time, space, and infrastructure.

In conclusion, the MSc Programme in Life Sciences equips students with a comprehensive

understanding of the multidimensional aspects of life and its associated disciplines. With a curriculum that combines theoretical knowledge, practical skills, on-the-job training, and the integration of online learning, students are prepared for diverse career opportunities and future research endeavours. We invite students to embark on this transformative academic journey, here they will unravel the mysteries of life, contribute to the advancement of scientific knowledge, and make valuable contributions to society.

2. Aims and Objectives

The aims and objectives of the M. Sc. Life Sciences programme collectively aim to develop well-rounded Life Sciences professionals who are not only technically competent but also capable of contributing to research, innovation, and the overall advancement of the field.

Objectives:

The M. Sc Life Sciences programme is designed to help students to:

a) Acquire a comprehensive knowledge base in various disciplines of Life Sciences, providing a strong foundation for further studies and research. Students will develop a deep understanding of key concepts, theories, and methodologies in genetics, cellular biology, ecology, physiology, molecular biology, and other relevant areas.
b) Foster a deep interest in the diverse branches of Life Sciences, encouraging curiosity and exploration. Students will be inspired to delve into specialized areas of interest and engage in independent learning.
c) Understand the rich diversity of organisms and appreciate their ecological, genetic, and evolutionary significance. Students will gain insights into the interconnections between different species and ecosystems, recognizing the importance of biodiversity conservation.
d) Develop essential skills in observation, biological techniques, experimental skills, and scientific investigation, enabling them to contribute to the field through rigorous and reliable research. Students will be trained to design and execute experiments, analyse data, and draw scientifically sound conclusions.
e) Cultivate an understanding of the interconnectedness and harmony of different life systems, while recognizing the importance of maintaining good health through appropriate measures. Students will grasp the intricate relationships between organisms and their environment, emphasizing the significance of sustainable practices for both human and ecological well- being.
f) Gain knowledge and skills in applied branches of Life Sciences that can contribute to self-employment and entrepreneurial opportunities. Students will be equipped with practical knowledge and expertise in areas with direct applications, enabling them to explore entrepreneurial ventures or pursue specialized career paths.
g) Promote awareness and concern for the conservation of the biosphere, emphasizing the importance of environmental sustainability and responsible stewardship. Students will develop a deep appreciation for the biosphere and its conservation, becoming advocates for sustainable practices and environmental protection.
h) Enhance students' Social Intelligence Quotient (SIQ) and Emotional Quotient (EQ), fostering their development as well-rounded individuals and responsible citizens who can positively impact humanity through their acquired and developed knowledge. Students will develop strong interpersonal skills, empathy, and cultural sensitivity to effectively collaborate with diverse stakeholders and address societal challenges.
i) Equip students with the necessary skills and mindset to be self-sustainable and encourage them to become future entrepreneurs, fostering innovation and economic growth. Students will cultivate an entrepreneurial mindset, including critical thinking, problem-solving, creativity, and adaptability, preparing them to identify opportunities and contribute to the growth of the life sciences industry.
j) Provide students with a comprehensive understanding of key concepts, theories, and

methodologies in Life Sciences. It covers a range of topics including genetics, cellular biology, ecology, physiology, and molecular biology, enabling students to develop a deep knowledge base in these areas.

k) Equip students with practical skills through hands-on experience with laboratory techniques, data analysis, and scientific methodologies. Students will gain proficiency in conducting experiments, analysing data, and interpreting results, enhancing their ability to apply theoretical knowledge to practical situations.
l) Enhance students' critical thinking and problem-solving abilities by challenging them to analyse complex biological systems, evaluate scientific literature, and propose innovative solutions to biological problems.
m) Foster collaboration and an interdisciplinary approach to problem-solving by providing opportunities for teamwork, group projects, and interactions with professionals from different scientific disciplines. Students will develop effective communication and teamwork skills, preparing them for collaborative work environments.
n) Stay updated with the latest trends and advancements in Life Sciences to ensure graduates are well-prepared for the demands of the industry. Through industry collaborations, guest lectures, and exposure to emerging technologies, students will acquire knowledge and skills that are relevant and applicable to real-world scenarios.
o) Develop students' professional skills, including scientific writing, presentation skills, project management, and leadership. Students will have opportunities to participate in conferences, workshops, and seminars to enhance their professional development and networking abilities.
p) Cultivate research skills among students by providing training in research methodologies, data analysis techniques, and critical evaluation of scientific literature. Students will have opportunities to engage in independent or collaborative research projects, enabling them to contribute to the advancement of Life Sciences through original research findings.

By incorporating these objectives, the M. Sc. Life Sciences program aims to produce graduates who possess a strong foundation in Life Sciences, are adept at problem-solving and collaboration, have industry-relevant skills, and are well-prepared for both research and professional roles in the field. The program strives to foster a deep understanding of Life Sciences, promote scientific inquiry, nurture innovation, and empower students to make meaningful contributions to society.

3. Learning Outcomes

The proposed M. Sc. Programme in Life Sciences aims to provide students with a comprehensive and holistic understanding of the field, equipping them with the skills and knowledge necessary to excel in the ever-evolving biological sciences domain. Learning outcome of the Programme are:

a) Apply advanced scientific principles and cutting-edge technology to solve complex real- world problems in diverse fields such as healthcare, agriculture, and environmental conservation.
b) Critically analyze and evaluate current research literature and effectively communicate scientific concepts and findings to both scientific and non-scientific audiences.
c) Develop innovative and sustainable research projects that adhere to international standards and consider practical limitations and ethical considerations.
d) Demonstrate an in-depth understanding of the structural organization and functional interactions between organisms and their environments, with an emphasis on the integration of interdisciplinary knowledge.
e) Evaluate and synthesize advanced concepts in plant, microbial, and animal physiology and biotechnology, and apply this knowledge to address contemporary challenges in the field.
f) Conduct quantitative and comparative studies, employing advanced statistical methods, to investigate and elucidate various aspects of biological sciences, including ecological interactions, genetic diversity, and population dynamics.
g) Utilize bioinformatics tools and techniques to generate, analyse, and interpret large-scale biological data, including the construction of databases, sequence alignments, and predictive

modelling.

h) Apply state-of-the-art technologies and methodologies to explore and comprehend the intricate mechanisms underlying genome and protein biology, including gene expression regulation and protein-protein interactions.
i) Discuss and critically evaluate the legal and ethical aspects of intellectual property rights (IPR) and the responsible conduct of research, with an understanding of the social and economic implications of biology-related innovations.
j) Foster cross-cultural competence by actively collaborating in diverse teams, valuing and respecting diverse perspectives, and effectively contributing to scientific projects with individuals from different cultural backgrounds.

Second Year PG:

R: SP-50B										
Year (2 Yr PG)	**Level**	**Sem.** (2Yr)	**Major**		**RM**	**OJT/FP**	**RP**	**Cum. Cr.**	**Degree**
			Mandatory	**Electives**					
II	**6.5**	**Sem III**	Course LScBT601: Fermentation Technology Credits 4 Course LScBT602: Fermentation Technology Practical Credits 2	**Credits 4** Course LScBT606a: Enzymes Technology 2 TH + 2 PR **OR** Course LScBT606b: Clinical Research 2 TH + 2 PR **OR** Course LScBT606c: Marine Biotechnology 2 TH + 2 PR **OR** Course LScBT606d: Biochemical Toxicology 2 TH + 2 PR **OR** Course LScBT606e: Neurochemistry 2 TH + 2 PR			LScBT607 (4)	2 2	**PG Degree After 3-Yr UG**

		Sem IV	Course LScBT608: Environmental Sustainability Credits 4 Course LScBT609: Environmental Sustainability Practical Credits 2 Course LScBT610: Genetic Engineering Credits 4 Course LScBT611: Genetic Engineering Practical Credits 2	**Credits 4** Course LScBT612a: Synthetic and Regenerative Biology 2 TH + 2 PR **OR** Course LScBT612b: Omics Technology 2 TH + 2 PR **OR** Course LScBT612c: Lifestyle Disorders 2 TH + 2 PR **OR** Course LScT612d: Bioentrepreneurship 2 TH + 2 PR **OR** Course LScBT612e: Natural and Managed Ecosystems 2 TH + 2 PR			LScBT613 (6)	22	
Cum. Cr. for 1 YrPGDegree			**26**	**8**			**10**	**44**	
Cum. Cr. for 2 YrPGDegree			**54**	**16**	**4**	**4**	**10**	**88**	

1) Credit Structure of the Program (Sem III & IV) (Table as per Parishish with sign of HOD and Dean)

R_____

Post Graduate Programs in University Parishishta - 1

Exit option: PG Diploma (44Credits)after Three Year UG Degree									
II	**6.5**	**SemIII**	Course1 Credits 4 Course 2 Credits 2 Course 3 Credits 4 Course 4 Credits 2 Course 5 Credit 2	**Credits4** Course1 OR Course 2 OR Course 3 OR Course 4 OR Course 5			4	22	**PG DegreeAfter3-YrUG**
		SemIV	Course1 Credits 4 Course 2 Credits 2 Course 3 Credits 4 Course 4 Credits 2	**Credits4** Course1 OR Course 2 OR Course 3 OR Course 4 OR Course 5			6	22	
Cum.Cr. for1 Yr PG Degree			**26**	**8**			**10**	**44**	
Cum.Cr. for2 Yr PG Degree			**54**	**16**	**4**	**4**	**10**	**88**	

Detailed Syllabus
M.Sc. (Life Sciences - Biotechnology)
(Semester- III & IV)

Paper Code	Unit	Description	Credits	Hrs
Course LScBT601		**Fermentation Technology**	**4**	**60**
Module 1	I	Upstream Processes	1	
	II	Fermentation Process I	1	
Module 2	III	Fermentation Process II	1	
	IV	Downstream Processes	1	
Course LScBT602		**Fermentation Technology Practical**	**2**	**60**
		Fermentation Technology Practical		
Course LScBT603		**Plant and Animal Biotechnology**	**4**	**60**
Module 1	I	Plant Tissue Culture and allied topics	1	
	II	Transgenic Plants	1	
Module 2	III	Animal Biotechnology	1	
	IV	Animal Biotechnology Applications	1	
Course LScBT604		**Plant and Animal Biotechnology Practical**	**2**	**60**
		Plant and Animal Biotechnology Practical		
Course LScBT605		**Emergent Technologies**	**2**	**30**
Module 1	I	Nanotechnology and Biosensors	1	
	II	Microfluidics, Biomimetics and their applications	1	
ELECTIVES				
Course LScBT606a		**Enzyme Technology**	**4**	**90**
Module 1: **LScBT606aT**	I	Enzyme Kinetics and Applications	1	15
	II	Enzyme Technology	1	15
Module 2: **LScBT606aP**		Enzyme Technology Practical	2	60
Course LScBT606b		**Clinical Research**	**4**	**90**
Module 1: **LScBT606bT**	I	Clinical Trials	1	15
	II	Pharmacogenomics	1	15
Module 2: **LScBT606bP**		Clinical Research Practical	2	60
Course LScBT606c		**Marine Biotechnology**	**4**	**90**
Module 1: LScBT606cT	I	Mariculture	1	15
	II	Bioactive Compounds and Biomaterials from Marine Environment	1	15
Module 2: **LScBT606cP**		Marine Biotechnology Practical	2	60
Course LScBT606d		**Biochemical Toxicology**	**4**	**90**
Module 1: **LScBT606dT**	I	Fundamentals of toxicology	1	15
	II	Effects of Toxicants on humans	1	15
Module 2: **LScBT606dP**		Biochemical Toxicology Practical	2	60
Course		**Neurochemistry**	**4**	**90**

LScBT606e				
Module 1: **LScBT606eT**	I	Neurotransmitters	1	15
	II	Neurological Disorders	1	15
Module 2: **LScBT606eP**		Neurochemistry Practical	2	60
Course LscBT607		**Research Project I**	**4**	**100**

Semester- IV

Paper Code	**Unit**	**Description**	**Credits**	**Hrs**
Course LScBT608		**Environmental Sustainability**	**4**	**60**
Module 1	I	Aquatic Animal Husbandry	**1**	
	II	Mangroves	**1**	
Module 2	III	Biotechnology and sustainable methods	**1**	
	IV	Green technology	**1**	
Course LScBT609		**Environmental Sustainability Practical**	**2**	**60**
Module 1		Environmental Sustainability Practical		
Course LScBT610		**Genetic Engineering**	**4**	**60**
Module 1	I	Basics of Gene Cloning	**1**	
	II	Expression Systems	**1**	
Module 2	III	Strain Manipulation Strategies	**1**	
	IV	Therapeutics	**1**	
Course LScBT611		**Genetic Engineering Practical**	**2**	**60**
Module 1		Genetic Engineering Practical		
ELECTIVES				
Course LScBT612a		**Synthetic and Regenerative Biology**	**4**	**90**
Module 1: **LScBT612aT**	I	Introduction to Synthetic Biology	1	15
	II	Applications of Synthetic Biology	1	15
Module 2: **LScBT612aP**		Synthetic and Regenerative Biology Practical	2	60
Course LScBT612b		**Omics**	**4**	**90**
Module 1: **LScBT612bT**	I	Bioinformatics	1	15
	II	Genomics,Transcriptomics, Proteomics and Metabolomics	1	15
Module 2: **LScBT612bP**		Omics Practical	2	60
Course LScBT612c		**Lifestyle Disorders**	**4**	**90**
Module 1:	I	Metabolic Disorders	1	15

LScBT612cT	II	Cardiovascular Diseases	1	15
Module 2: **LSc612cP**		Lifestyle Disorders Practical	2	60
Course LScBT612d		**Bio-entrepreneurship**	**4**	**90**
Module 1: **LScBT612dT**	I	Biotechnology Industry and Business Environment - Concepts, motives	1	15
	II	Biotechnology Business Management	1	15
Module 2: **LScBT612dP**		Bio-entrepreneurship Practical	2	60
Course LScBT612e		**Natural and Managed Ecosystems**	**4**	**90**
Module 1: **LScBT612eT**	I	Natural Ecosystems	1	15
	II	Managed Ecosystems	1	15
Module 2: **LScBT612eP**		Natural and Managed Ecosystems Practical	2	60
LscBT613		**Research Project II**	**6**	**180**

Sem. - III

M.Sc. (Life Sciences - Biotechnology)
(Semester - III)

Programme Name: M.Sc. (Life Sciences - Biotechnology) Semester III **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name:** Fermentation Technology **Total Marks:** 100 **University assessment:** 50 marks

Course Outcome:

The learner would be able to:

1. Explain various fermentation processes.
2. Develop and fabricate fermenters and products.
3. Capture the convenience of bio-transformations in this industry.
4. Extend secondary metabolites for production.
5. Discuss Effluent treatment.

Course Code	Course Title	Total Credits
LScBT601	**Fermentation Technology**	**04**
MODULE I **Unit I: Upstream Processes (15L)** **Isolation and Screening of microorganisms**: Isolation of microorganisms from various sources, Preservation, Primary and Secondary Screening of microorganisms. **Microbial growth**: General parameters, growth kinetics for various fermentation and types of stock culture, scaling up of culture for fermentation. **Strain improvement**: Need for improvement, Criteria for improved strains, Physical, Chemical, Biological methods. **Fermentation Media:** Definition, Criteria, Various components, Types: crude and synthetic, sterilization, rheology of various components of media. **Fermenter design:** Components of the fermenter, sterilization, aeration and agitation. Types of Fermenters: batch, continuous, air lift, fluidized bed, stirred tank. **Unit II: Downstream Processes (15L)** **Product recovery:** Product: internal, external, cell disruption methods: physical, chemical and biological, precipitation, filtration, centrifugation, extraction and purification, drying. **Product Economics:** Microbial culture, Fermentation: Upstream and Downstream processes, recovery process, product processing. **Effluent Treatment:** Need, Traditional methods disposal and disadvantage, physical, chemical and biological methods.		02
MODULE II **Unit III: Fermentation Process I (15L)** **Single Cell Protein, Biomass and Immobilization**: Need of single cell production, production of bacteria, yeast, algae and fungi. Immobilization: cells and enzymes, methods of immobilization, applications.		02

Commercial Fermentations: Cheese: Strains, Fermentation process, Applications. **Alcohol:** Wine, Commercial Ethanol (by-product fusel oils): Strains, Process and Applications. **Acids:** Lactic acid industrial production and applications. **Carbohydrate:** Commercial starch production. **Flavour/fragrance production:** Nature similar products. **Unit IV:Fermentation Process II (15L)** **Biotransformations:** Classification and characteristics of enzymes – OTHLIL, applications of enzymes: (chiral synthesis of enantiomerically pure compounds, resolution of isomers). **Examples of biotransformations**: Oxidoreductases- Oxidation of 1- amino - D - sorbitol in the production of miglitol using *Gluconobacteroxydans*; Hydrolases: any one example, catalytic antibodies. **Secondary metabolites production from plants:** Secondary metabolite types (alkaloids, terpenes [include IPP synthesis: Classic pathway and Alternate pathway for IPP synthesis in plastids], tannins, lignans pigments, lipids); Selection of callus cultures, Bioreactor types: Stirred-tank (hollow paddle), roller drum, immobilized, membrane, surface – immobilized; elicitation, permeation. **Examples of secondary metabolite production (industrial scale):** [shikonin, taxol (biosynthesis and bioreactor production) capsasin/ berbrine]. **From microbes**: Polymers [dextrans, xanthan gums, alginate], antibiotics [peptide, lantibiotics, aminoglycosides, beta lactam], cyclosporins, medicinal mushrooms, biosurfactants.	

Reference:

1. Principles of Fermentation Technology byStanbury and Whitaker
2. Industrial Microbiology by Casida
3. Industrial Microbiology by Prescott and Dunn

Programme Name: M.Sc. (Life Sciences - Biotechnology) Semester III **Total Credits:** 02 **Department assessment:** 25 marks	**Course Name:** Fermentation Technology Practical **Total Marks:** 50 **University assessment:** 25 marks

Course Outcome:

The learner would be able to:

1. Explain the working of a bioreactor.
2. Screen and isolate economically important naturally occurring microorganisms.
3. Illustrate commercial production of fermentation products.
4. Determine and analyze the presence of secondary metabolites in media/biomass.
5. Demonstrate the concept of elicitation or permeation.
6. Summarize the effluent treatment process.

Course Code	Course Title	Total Credits
LScBT602	**Fermentation Technology Practicals**	**02**
MODULE I 1. Immobilization of cells 2. Demonstration of fermenter/ chemostat 3. Estimation of alcohol production: Sucrose/ fruit (s)/ sugarcane juice. 4. Preparation of media for isolation of cellulase producing microorganisms from natural source(s). 5. Determination of cellulase activity using Filter paper assay/ carboxy-methyl cellulose assay. 6. Pilot Fermentation for Biomass Production 7. Secondary metabolite production using plant tissue culture (dye/ drug, Alkaloids etc.) 8. Separation of bioactive compounds using HPTLC and Bioautography. 9. Effect of elicitor(s) on the production of the plant secondary metabolite and its quantification using Spectrofluoro/ UV-VIS Spectrophotometry. 10. Visit to the Effluent Treatment Plant**.**		02

Programme Name: M.Sc. (Life Sciences - Biotechnology) Semester III **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name:** Plant and Animal Biotechnology **Total Marks:** 100 **University assessment:** 50 marks

Course Outcome:

The learner would be able to:

1. Elaborate on the different plant tissue culture techniques.
2. Explain various methods used for the conservation of biodiversity (plants).
3. Manage the greenhouse as a post plant tissue culture operation.
4. Discuss methods for producing transgenic plants.
5. Applications of animal tissue culture.
6. Articulate techniques for animal cell and tissue culture.
7. Apply knowledge of animal cell culture in medicine and pharmacology.

Course Code	**Course Title**	**Total Credits**
LScBT603	**Plant and Animal Biotechnology**	**04**
MODULE I **Unit I: Plant Tissue Culture and allied topics (15L)** **Basics of plant tissue culture**: totipotency, macro and micro nutrients, media. **Culture Methods**: Micropropagation -types of micropropagation methods, Callus culture, Suspension cell culture, Protoplast culture, Somatic hybridization, Cybrids, Somatic embryogenesis and synthetic seed production. **Conservation:** cryopreservation of genetic resources. **Green-House Management**: Greenhouse structure, and design, Environmental Control Systems, Pest management. medicinal plant cultivation. vertical farming: Concept, examples and methods (hydroponics, aquaponics and aeroponics), advantages, Vertical Farming in India, Challenges. **Unit II: Transgenic Plants (15L)** **Plant transformation methods**: *Agrobacterium tumefaciens* [mechanism of T DNA transfer in wild type *Agrobacterium* and its modification for transformation], *A. rhizogenes*- its plasmid. Biolistics: factors that influence transformation success, Chloroplast transformation: vectors, advantages and disadvantages of the technique. **Applications of transgenic plants**: Recombinant proteins of pharmaceutical importance in plants (vaccine subunits, edible vaccines etc.)Transgenic plants: Strategies for virus resistance, Herbicide resistance, Insect resistance, nematode infections and stress resistance (salt, drought) **Improved nutrition and shelf life**: Metabolic engineering [carbohydrate, protein], Novel applications: change in lipid profile for industrial purposes, biodegradable plastics, novel horticultural traits [flower colour, variegation], improvement of shelf life.		02
MODULE II **Unit III: Animal Biotechnology (15L)** **Basic of animal tissue culture:** Media Components and different media (Dulbecco, Eagles,)		02

Methods of cell dissociation/separation and preparation of primary cell culture, characteristics of cells *in vitro*, cell culture growth parameters, detection, prevention and determination of contamination in tissue culture. **Culture:** Stem cells, Specialized cells: bone marrow myogenesis *in vitro* skin cell culture, erythrogenesis, leukemia cells, chondrogenesis- *in vitro*, cryopreservation of tissues and cell lines. **Analysis and Production:** cell synchronization, cell transformation *in vitro*, Mass cultivation-cytodex and biofermentors. Cell cloning and Transgenic animals. **Unit IV: Animal Biotechnology Applications (15L)** **Gene therapy:** Overview, viral and non viral Vectors for somatic cell gene therapy, Gene therapy for inherited immunodeficiency syndromes, Cystic fibrosis gene therapy, HIV-1 gene therapy, CarT. **Antisense therapy:** Introduction, strategies. oligodeoxyribonucleotide, catalytic antisense RNA, triple - helix forming oligonucleotides (TFOs), production, and limitations, first generation antisense drugs, second generation antisense drugs. **Tissue engineering and 3D printing** - bone, skin, vascular grafts, Artificial meat (culturing muscle and fat cells) and their environmental advantage, stem cells in medicine. **Molecular Pharming of animals**: Cloning and production of recombinant proteins and vaccines. insect larvae as mini bioreactors. **Applications of Transgenic animals**: Various methods to develop transgenic animals – livestock, dairy and other animals (rodents, mosquitos). **Assisted Reproduction techniques** :*In vitro* fertilization: sperm and egg culture, fertilization, embryonic culture at various stages of development, transfer of Embryos.	

Reference:

1. Diego A. Sampietro, Cesar A. N. Catalan, Marta A. Vattuone (2009) Isolation, Identification and Characterization of Allelochemicals/Natural Products. Series Editor S. S. NARWAL Science publishers US.
2. Khan and Khanum (2001) Role of Biotechnology in Medicinal and Aromatics Plants by Vol. 1 to 4. Ukkaz Publications
3. M. K. Razdan (2006) Plant Tissue Culture. Oxford and IBH Publishing.
4. Arupratan Ghosh (2019) Greenhouse Technology: Principle and Practices. CRC Press Dr. Dickson Despommier (2011) The Vertical Farm: Feeding the World in the 21st Century Paperback – 25 October 2011 by (Author), Majora Carter (Foreword)
5. Gary Grending (2019) Vertical Farming: How to combine business with environmental
6. awareness.
7. Relevant Research/ Review papers.
8. Ian Freshney (1999) Culture of Animal Cells Set: A Manual of Basic Technique. 3rd Ed. Wiley–Blackwell
9. J. M. Davis (2005) Basic Cell Culture. 2nd Ed. Oxford University Press.
10. Sudha Gangal (2007) Principles and Practice of Animal Tissue Culture. Universities Press
11. National Academies of Sciences, Engineering, and Medicine. 2017. Preparing for Future Products of Biotechnology. Washington, DC: The National Academies Press. doi:
12. https://doi.org/ 10.17226/24605.
13. B Singh, S K Gautam and M S Chauhan (2013) Textbook of animal biotechnology; TERI.
14. Ashish S. Verma and Anchal Singh (2014) Animal Biotechnology; Elsevier.
15. Relevant research/ review articles.

Programme Name: M.Sc. (Life Sciences - Biotechnology) Semester III **Total Credits:** 02 **Department assessment:** 25 marks	**Course Name:** Plant and Animal Tissue culture Practical **Total Marks:** 50 **University assessment:** 25 marks

Course Outcome:

The learner would be able to:

1. Develop studies and protocols to improve nutrition and agricultural qualities of plants
2. Prepare methods to conserve biodiversity of plants.
3. Design and execute micropropagation procedures for plants.
4. Understand and apply propagation techniques in vertical farming
5. Demonstrate Green-house management
6. Discuss the latest developments in Animal Tissue Culture Techniques.

Course Code	**Course Title**	**Total Credits**
LScBT604	Plant and Animal Tissue culture Practical	**04**
MODULE I 1. Micropropagation: a. Media preparation b. Shoot culture establishment c. Rooting of the obtained shoots. d. Hardening and Acclimatization of plantlets. 2. Study of the Greenhouse. 3. Vertical farming demonstration. 4. Natural product from animals: extraction of chitin/ chitosan from a suitable source. 5. Assignments on latest techniques in Animal Biotechnology		02

Programme Name: M.Sc. (Life Sciences - Biotechnology) Semester III **Total Credits:** 02 **Department assessment:** 25 marks	**Course Name:** Emergent Technologies **Total Marks:** 50 **University assessment:** 25 marks

Course Outcomes:

The learner would be able to:

1. Outline developing technologies in the field of biotechnology.
2. Application of these technologies in medicine, novel products, agriculture and the environment.
3. Identify the effects of structure and their function on nanoscale.
4. Apply biological activities for estimation and determination of an environment.
5. Extend simulation of nature to novel product development.
6. Adapt current diagnostics and methods to a small scale.
7. Relate micro-environments in an organism to *in vitro* experimentation.

Course Code	Course Title	Total Credits
LScBT605	**Emergent Technologies**	**02**
MODULE I **Unit I: Nanotechnology and Biosensors (15 L)** **Bionanotechnology: Concept. Types of bio-nanostructures:** Carbon nanostructures **(**fullerenes, nanotubules, graphene**) n**anoshells, dendrimers, quantum dots, nanowires, liposomes. **Synthesis of nanoparticles**: Physical (Ball Milling, Physical vapour Deposition), chemical (Sol gel,) and biological methods (microbial, plant and animal systems). **Applications of nanotechnology**: medicine and diagnostics (antimicrobial properties, therapies, drug delivery including rate programmed drug delivery, Microencapsulation of cells. imaging) cosmetics, food packaging, agriculture (fertilizer, microbial and pest, management, plant growth), environment (remediation, renewable energy, green technology). **Potential risks of Bionanotechnology**: Effect on health and environment. **Biosensors** Biosensors: Concepts. Types of biosensors and their applications: amperometric, potentiometric, conductometric, calorimetric, piezoelectric, optical, evanescent wave sensors, Surface Plasmon Resonance. **Unit II:Microfluidics, Biomimetics and their applications (15 L)** **Microfluidics** **Introduction to Microfluidics:** Fundamental characteristics of fluidics at microscale, **Overview of manufacturing methods:** Photolithography, molding and casting and 3D printing methods. **Application of microfluidics:** Cell sorting and separation, dip sticks, PCR methods. ELISA, Chip devices - laboratory, organs on a chip, water/ soil pollution biosensors, microorganism detection, **Biomimetics:** Concept and possible applications: Dry adhesion (lizard's foot, seed burrs) Water repulsion (lotus leaf), nanostructures in colour display (butterfly wings/ peacock feather), structure and attachment of a lizard's tail.		02

Reference:

1. Madhuri Sharon (2012) Bio-Nanotechology. CRC Press
2. Jean Berthier and Pascal Silberzan (2005) Microfluidics for Biotechnology 2nd Edition. Artech House Publishers
3. Patrick Tabeling and Suelin Chen (2010) Introduction to microfluidics. OUP Oxford
4. Sulabha K. Kulkarni (2017) Nanotechnology: Principles and Practices - 3rd Edition. Capital Publishing Company
5. Elisabeth S. Papazoglou, Aravind Parthasarathy (2007) BioNanotechnology. Morgan and Claypool Publishers
6. Relevant review articles and papers.

SEMESTER III - ELECTIVES

Programme Name: M.Sc. (Life Sciences - Biotechnology) Semester III **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name:** Enzyme technology **Total Marks:** 100 **University assessment:** 50 marks

Course Outcome:

The learner would be able to:

1. Understand the kinetics of enzyme catalysed reactions.
2. Explain the concept and application of immobilization of enzymes.
3. Learn the purification, characterization and estimation of enzymes.
4. Understand the applications of protein engineering for novel enzyme design.

Course Code	Course Title	Total Credits
LScBT606a	**Enzyme technology**	**04**
MODULE I: Course LScBT606a T (Credits 2) **Unit I: Enzyme Kinetics and Applications (15L)** Enzyme Kinetics: Enzyme catalysis and factors contributing to high catalytic rates; Molecular aspects of catalysis for specific enzyme substrate complexes (Lysozyme, carbonic anhydrase, carboxypeptidase and chymotrypsin); Multisite binding of ligands to proteins; Bohr's effect; Models of Allostery – MWC and KNF models, Hill's equation coefficient; Kinetics of multisubstrate enzyme-catalysed reactions; Ping-pong bi-bi, random order and compulsory order mechanism. Immobilised enzymes: Methods and applications. Enzyme therapy, enzyme inhibitors and drug design; enzymes as biosensors, enzyme reactors; Applications of enzymes in medicine, textile, leather, detergent, paper, bakery, dairy industry, beverage and fruit processing, food processing and preservation, clinical applications of enzyme estimation. **Unit II: Enzyme Technology (15L)** Strategies used for enzyme production, isolation and purification at laboratory and industrial scale from plant, animal and microbial sources, purification fold; estimation of enzyme activity; characterization of an enzyme, criteria of enzyme purity, determination of the molecular weight (MW) and the number of sub-units of an enzyme; Protein Engineering Design and construction of novel proteins and enzymes using site-directed mutagenesis and Random/directed evolution strategies; Conformation of proteins in general and enzymes in particular; Effect of amino acids on structure of proteins; Energy status of a protein molecule, Structure- function relations of enzymes. Basic concepts for design of a new protein/enzyme molecule; Specific examples of enzyme engineering – Dihydrofolate reductase and Subtilisin	02

MODULE II: Course LScBT606a P (Credits 2) **Practical:** 1. Enzyme inhibition a. Inhibition of enzyme activity b. Determination of Ki values 2. Immobilization studies a. Preparation of urease entrapped in alginate beads and determination of percent entrapment b. Study of the kinetics of the rate of urea hydrolysis by urease entrapped alginate beads c. Study of reusability and storage stability of urease entrapped alginate beads d. Immobilization of urease by covalent attachment to solid support 3. Protein purification methods: a. Isolation of casein from milk b. Purification of an enzyme by ion exchange chromatography/affinity chromatography c. Use of ammonium sulphate precipitation and dialysis d. Use of gel filtration e. SDS-PAGE 4. Polyacrylamide gel electrophoresis under non-denaturing conditions a. Silver staining b. Activity staining of enzymes c. Determination of effect of acrylamide concentration on the mobility of proteins	02

Reference:

1. Bailey JE, Ollis, DF: Biochemical Engineering Fundamentals
2. Blanch HW and Clark DS: Biochemical Engineering Marcel Decker
3. Schugerl K., Bellgart KH (Eds): Biorection Engineering, modeling and control: Springer-Verlag, Berlin.
4. Nicholas C. Price, Lewis Stevens, and Lewis Stevens, Fundamentals of Enzymology: The cell and molecular Biology of Catalytic Proteins by (2000) Publisher: Oxford University Press, USA
5. Alejandro G. Marangoni, Enzyme Kinetics: A modern Approach Book: Enzyme Kinetics: A Modern
6. Approach, (2003) Publisher: Wiley-Interscience Enzyme Kinetics and Mechanisms by Taylor Publisher: Springer
7. Christian Müller (Editor), Protein Engineering Protocols (Methods in Molecular Biology) K, Publisher: Humana Press; Softcover reprint of hardcover 1st ed. 2007
8. Anders Liljas, Structural Aspects of Protein Synthesis Publisher: World Scientific Pub Co Inc; 1 edition (November 2004)
9. Wiseman, A: Handbook of Enzyme Biotechnlogy, 3rd Edition, Ellis Horwood Publication
10. Moser, A: Bioprocess technology, kinetics and reactors: Springer Verlag

ELECTIVE

Programme Name: M.Sc. (Life Sciences - Biotechnology) Semester III **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name:** Clinical Research **Total Marks:** 100 **University assessment:** 50 marks

Course Outcome:

The learner would be able to:

1. Understand the process of clinical trials.
2. Understand the basics of pharmacology.
3. Outline and capture the essence of the pharmaceutical industry.
4. Recall aspects of pharmacogenomics and its importance in medicine.
5. Extend the concepts of pharmacovigilance in industry and other activities.

Course Code	Course Title	Total Credits
LScBT606b	**Clinical Research**	**04**
MODULE I: Course: LScBT606b T (Credits 2) **Unit I: Clinical Trials (15 L)** Phase I, II, III, IV: Criteria, FDA approval, Role of India in clinical trials. **Concept of Pharmacology:** Pharmacodynamics, Pharmacokinetics, Bioavailability, ADME, Adverse Drug Reactions,Types of Adverse Drug Reactions, Management of Adverse Drug Reactions, Various Pharmacovigilance systems. **Methods in Pharmacovigilance:** Sources and Documentation of Individual Case Safety Reports (ICSRs), Medical dictionary (MedDRA) and Medical aspects in Pharmacovigilance Regulation- Global and Indian: Regulatory submissions (E2b, MHRA, FDA), Periodic Safety Update Reports (PSURs) For Marketed Drugs (ICH E2C) **Unit II: Pharmacogenomics (15L)** **Introduction to Pharmacogenomics**: Definition, Basic Concepts of Pharmacogenomics and Pharmacogenetics, Concept of Personalized Drugs, Disorders: Monogenic and Polygenic disorders. **Concept of Drug Metabolism**: Basic concept of Receptors, Enzymes and signalling involved, Phase I and Phase II Enzymes, Types of drug responders. Genetics of Drug Metabolism: CYP genes and various mutations Genetic Variations: SNPs, CNVs, Repeat Sequences; Population Genetics: Variance- Major and Minor Allelic Frequencies. Methods and Markers used in Pharmacogenomics: Genome Wide Associated Studies**,** Pharmacogenomics **Generation Sequencing**- NGS, Biomarkers and Therapeutic Markers (Drug Design). **Pharmacogenomics of Cancer**: Mutations: Proto-oncogene and Tumour Suppressor Gene, Cancer **Database**: COSMIC, Screening of Cancer biomarkers and therapeutic markers, Application in cancer treatment.		02

MODULE II: Course: LScBT606b P (Credits 2) **Practical** 1. Study of polymorphisms using SNP database. 2. Study of phenotypic and genotypic cancer using COSMIC Database 3. Study of pharmacogenomics database – PharmGKB Database 4. Case Study- Cancer Pharmacogenomics- NPM1 mutation in Acute myeloid leukaemia 5. Case Study- Regulatory Affairs	02

Reference:

1. Michael J. Klepper and Barton Cobert (2010) Drug Safety Data: How to Analyze, Summarize and Interpret to Determine Risk;
2. Elizabeth B. Andrews and Nicholas Moore (2014) Mann's Pharmacovigilance;
3. Dr. S. Gunasakaran and R. Satheesh Kumar (2010) A Practical Guide On Pharmacovigilance For Beginners
4. James Paxton (2012) Topics on Drug Metabolism; InTechOpen
5. Gary Walsh (2007) Pharmaceutical Biotechnology: Concepts and Applications; Wiley.

ELECTIVE

Programme Name: M.Sc. (Life Sciences - Biotechnology) Semester III **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name:** Marine Biotechnology **Total Marks:** 100 **University assessment:** 50 marks

Course Outcome:

The learner would be able to:

1. Elaborate on mariculture.
2. Summarize the scope and challenges of marine biotechnology.
3. Demonstrate the use and application of marine bio-compounds.
4. Apply the use of marine biomimetics.

Course Code	Course Title	Total Credits
LScBT606c	**Marine biotechnology**	**04**
MODULE I: Course: LScBT606c T (Credits 2) **Unit I: Mariculture (15L)** **Production and Status:** Introduction, an overview of status of Mariculture, Global production, Top countries, Present status in India, Mariculture Production By species. An overview of marine progress in India. **Commercially Important Mariculture Species:** Status of farming of selected species Marine finfish, Crustaceans, Molluscs, Sea cucumbers, Sponges, Corals, Seaweeds, Global status, Present trend and scope in India. **Marine metagenomics:** Flora, fauna, bacteria, algae, fungi and archea.Scope and Challenges in marine and aquatic biotechnology **Global and Indian scenario**; Demand for marine bioproducts; market value; marine bioproduct based industries; marine bioeconomy; Marine socio-economics; Entrepreneurship; International and Indian policies; Marine biotechnology parks in various states; R&D institutions, centers and consultation services. **Unit II: Bioactive Compounds and Biomaterials from Marine Environment:** **Diversity of marine derived compounds** - Alkaloid, Terpenoids and steroids, nucleoside, amino acids, peptides, depsipeptide, polyketide, Macrolide; Marine Toxins - Paralytic shellfish poisoning (PSP), Neurotoxic shellfish poisoning (NSP), Diarrhetic shellfish poisoning (DSP), Ciguatera poisoning, Amnesic shellfish poisoning (ASP), azaspiracid shellfish poisoning, tetrodotoxin, other miscellaneous toxins; Marine biominerals; Biomineralized structures; Biocomposites; Biopolymers - polysaccharides, chitin, marine collagens. **Marine biomimetics**: Concept of Marine biomimetics and marine technology. Examples of marine Biomimetics: propulsion mechanisms (Manta ray), locomotion (humpback whale flipper), underwater robotics, biomaterial for tissue regeneration, design-based tissue engineering inspired by jellyfish, Advances in marine biomimetics, Applications of biomimetics. Fish scale type nanotechnology for reduction of resistance in water.	02

MODULE II: LScBT606c P (Credits 2) **Practical** 1. Isolation of Fish/Shrimp/Bivalve DNA 2. Data mining of DNA sequences of marine organisms (Bivalves, Fin Fish, Shellfish Jellyfish, Bacteria, Algae) 3. BLAST Analysis of the mined DNA sequences 4. Assignments and case studies in the above topics.	0 2

Reference:

1. S.D.Tripathi, W.S. Lakra& N.K. Chadha, 2018. Aquaculture in India, Narendra Publishing House
2. S. Ayyappan, 2011. Handbook of Fisheries and Aquaculture. ICAR.
3. Didier Montet and Ramesh C. Ray (Eds.) 2011, Aquaculture Microbiology and Biotechnology, Vol 2. Science Publishers; 1 edition.
4. George Karleskint, Richard Turner, and James Small (Eds.) Brooks Cole, 2013, Introduction to Marine Biology.; 4th edition.
5. Dewan S. Bhakuni and, D.S. Rawat (Eds.), 2010, Bioactive Marine Natural Products. Springer.
6. Munn and Munn, 2011, Marine Microbiology: Ecology and Applications. BIOS, Scientific Publisher.

ELECTIVE

Programme Name: M.Sc. (Life Sciences - Biotechnology) Semester III **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name:** Biochemical Toxicology **Total Marks:** 100 **University assessment:** 50 marks

Course Outcome:

The learner would be able to:

1. Understand the principles of toxicology
2. Explain the dose response of the toxicants and their risk assessment
3. Analyse the physiological effect of toxicant on humans
4. Familiar with various regulatory policies and treaties related to toxicants

Course Code	Course Title	Total Credits
LScBCM606d	**Biochemical Toxicology**	**04**
MODULE I: Course LScBT606dT (Credits 2) **Unit I: Fundamentals of toxicology** **Principles of toxicology:** Introduction to toxicology, toxicants and their types, The Importance of Dose and the Dose–Response Relationship, Factors Influencing Dose–Response Curves, Descriptive Toxicology: Testing Adverse Effects of Chemicals and Generating Dose–Response Data, Extrapolation of Animal Test Data to Human Exposure **Absorption, Distribution, and Elimination of Toxic Agents:** Toxicology and the Safety and Health Professions, Risk Assessment, Transfer across Membrane Barriers, Absorption, Disposition: Distribution and Elimination **Biotransformation:** Sites of Biotransformation, Biotransformation Reactions **Unit II: Effects of Toxicants on humans** **Xenobiotics:** Mode of Entry of Toxins, Translocation of Xenobiotics, Phases of Metabolism, Disposition of Epoxides, Conjugations, Glutathione, Induction and Inhibition of P-450 Isozymes, Activation of Precarcinogens **Organ directed toxicology:** Hematotoxicology, Hepatotoxicology, Nephrotoxicology, Neurotoxicology, Dermal and Ocular Toxicology,Pulmonotoxicity, Immunotoxicity, Reproductive Toxicology, Mutagenesis and Genetic toxicology **Regulatory Policies & International Treaties:** The National Environmental Policy Act, Environmental Regulatory framework, EPA and its responsibilities, OSHA and its responsibilities, Miscellaneous Environmental Acts and Treaties		02
MODULE II: Course LScBT606d P (Credits 2) 1. To study dose response curves of toxicants w.r.t. LD_{50}, LC_{50}, EC_{50}, IC_{50} using appropriate animals (example *Daphnia*) 2. To study effect of toxicants on growth of Moong seeds. 3. Assessment of heavy metal toxicity using Beta-galactosidase 4. *In vitro* Toxicity Evaluation of on animal/plant cell culture 5. Microsomal Mutagenicity Assay (AMES Test)		02

6. To study Metal ion toxicity (oligo dynamic effect)on microorganisms. **7.** To study Inhibition of phosphatase by cyanotoxin (Extraction, detection and bioactivity). **8.** Case study: DDT, Asbestos, Bhopal gas tragedy, Acid rain, Minamata disease	

Reference:

1. An introduction to environmental toxicology by Dong, Michael H (2014)Publisher : North Charleston, SC : Create Space Publishing
2. Essentials of Toxicology, 3e by Curtis D. Klaassen, John B. Watkins III (2015) The McGraw-Hill publication
3. Environmental Toxicology 3rd edition 2002 By Sigmund F. Zakrzewski Oxford University press
4. Principles of toxicology: Environmental and Industrial Applications SECOND EDITION (2000) by Phillip L. Williams, Robert C. James and Stephen M. Roberts. A Wiley-Interscience Publication
5. Introduction to environmental toxicology : impacts of chemicals upon ecological systems Wayne G. Landis, Ming-Ho Yu.—3rd ed. (2003) Lewis Publishers

ELECTIVE

Programme Name: M.Sc. (Life Sciences - Biotechnology) Semester III **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name:** Neurochemistry **Total Marks:** 100 **University assessment:** 50 marks

Course Outcome:

The learner would be able to:

1. Acquire knowledge about the functioning of neurotransmitters.
2. Understand the receptor involved in neurotransmission and their function.
3. Elucidate the underlying molecular basis of neurological disorders.
4. Comprehend the effects and molecular mechanisms of selected neurological disorders..

Course Code	**Course Title**	**Total Credits**
LScBT606e	Neurochemistry	**04**
MODULE I: Course: LScBT606e T(Credit 2) **Unit I:** **Neurotransmitters:** **Classes ofNeurotransmitters-** chemistry, synthesis, storage and release of neurotransmitters: Acetylcholine, dopamine, norepinephrine, Amino acids. **Neurotransmitter signalling**: Classification of neurotransmitter receptors, Receptor agonists and antagonists, Second messengers, Phospholipase C pathways, cross-talk between signalling pathways. **Nuclear receptors**: Super families, mechanism of steroid hormone action, transmission, synaptic modulation, and mechanism of neuronal integration. Unit II: **Neurological Disorders:** **Nervous System Disorders**: Neurochemical and molecular mechanisms of peripheral Neuropathy, Ischemia and hypoxia, Epileptic seizures, Metabolic Encephalopathies and Coma. **Myelin Sheath Disorders**: Multiple sclerosis and other demyelinated disorders, **Neurodegenerative Disorders**: Alzheimer's disease, Dementia, Prion's Disease **Neuromuscular Disorder**: Parkinson's disease **Psychotic disorders:** Anxiety and Mood disorders, Schizophrenia **Substance abuse**: Molecular targets of abused drugs, Alcoholic Cerebellar Degeneration		02
MODULE II: Course: LScBT606e P (Credit 2) 1. Case study on Epileptic seizures 2. Case study on Multiple sclerosis 3. Case study on Dementia 4. Case study on Parkinson's disease 5. Case study on Schizophrenia 6. Case study on Depression 7. Case study on Drug addiction 8. Case study on Schizophrenia		02

Reference:

1. Brady, Basic Neurochemistry (8th Edition) Academic Press, 2012
2. Siegel et al., Basic Neurochemistry, 6th Edition,
3. Kandel et al., Principles of Neural science, 4 Edition, McGraw-Hill Medical, 2000.
4. Zegmond, Fundamentals of Neuroscience, 1st Edition, Academic Press, 1999
5. Squire, Fundamental Neuroscience (4th Edition), Elsevier,2013
6. Kandel, Principles of Neural Science (5th edition), McGraw Hill,2013
7. Duchene E. Haines, Fundamental Neuroscience for Basic & Clinical Applications (3rd Edition), Churchill Livingstone, 2006
8. Bear, Neuroscience-Exploring the Brain (3rd Edition), Lippincott, 2007
9. Lippincott Williams & Wilkins, 2001 C. Pharmaceutical

Programme Name: M.Sc. (Life Sciences - Biotechnology) Semester III **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name:** Research Project I **Total Marks:** 100 **University assessment:** 50 marks

Course Outcome:

The learner would be able to correlate the theoretical and practical aspects of research. The learner would be able to:

1. Collate, organize and analyse the existing literature in any given field of study.
2. Formulate a hypothesis following literature review.
3. Design a study to prove/ disprove the hypothesis using the tenets of Research Methodology.
4. Design data/ sample collection.
5. Prepare a presentation and appropriately record the studies done in this course.

Course Code	Course Title	Total Credits
LScBT607	**Research Project I**	**04**
Introduction: This course is designed to extend the concepts capturedin the theory lectures into practical applications and discovery. The learner would be able to identify and organize the existing literature on a given topic and plan experiments to prove a hypothesis. The research project is aimed to enhance research temper in the learner. The learner would be able to formulate a hypothesis and design a research project using the concepts of research methodology. The learner would be able to effectively document and present the parameters of the research project. What is required: There are four credits assigned to the course. As this is of a practical and hands-on nature, every two hours spent on the project in a week would earn a credit. The course spans over 15 weeks and hence the time that needs to be devoted would be 120 hours. This could be planned and completed over a span of 15 weeks or continuously 4 - 5 weeks. Where can these projects be done: The projects could be conducted in-house or could be in industry or research institutes or recognized institutes that carry out research. The host institution would be from any field of Life Sciences. The project would be carried out with the consent and understanding between the thetheUDLSc and the relevant Academic/ research Institute or the Industry Documentation for the Research Project I: The proforma for internal evaluation by the mentor (at the place of work) is given at the end of the syllabus. This evaluation along with a thesis submission would be proportionately added for the calculation of the internal marks. The scheme for the same is given at the end of the syllabus. A draft paper of the project and its presentation would be evaluated by external examiners as the external evaluation. The relevant weightages are given at the end of the document. The reports will be governed by the plagiarism rules as dictated in the document No. Th./ICD/2018 – 19/ 448		04

Sem. - IV

M.Sc. (Life Sciences - Biotechnology)
(Semester- IV)

Programme Name: M.Sc. (Life Sciences - Biotechnology) Semester IV **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name:** Environmental Sustainability **Total Marks:** 100 **University assessment:** 50 marks

Course Outcomes:

1. Correlate biotechnological methods for improved aquaculture.
2. Identify and articulate the importance of mangroves.
3. Outline various environmental issues and integrate biotechnology in its mitigation.
4. Enumerate the environmentally friendly practices and methods for improvement.
5. Integrate remediation principles with revenue generation
6. Explain the feasibility in setting up a biotechnology industry.
7. Elucidate the fate and legal issues in biotechnology industry

Course Code	**Course Title**	**Total Credits**
LScBT608	**Environmental Sustainability**	**04**
MODULE I **Unit I: Aquatic Animal Husbandry (15L)** **Molecular Selection:** Marker Assisted Selection- QTLs, Microsatellites, SNPs, Genome wide associated studies (GWAS) **Development of transgenic aquatic animals** (for growth rate, disease resistance, usable muscle meat, temperature tolerance), triploid and monosex stocks, Bioflock method. **Aquatic Animal Health**: Modified yeasts, Probiotics in feed, Immunostimulants, Molecular diagnostics and Vaccines. **Unit II: Mangroves (15L)** **Mangroves**: Introduction, Classification of mangroves, Types of mangroves, Mangrove diversity in the world, Role in ecosystem, Medicinal value of secondary metabolites from mangrove Plants **Mangroves Endophytes**: Existence of endophytes in mangroves, Compounds secreted by endophytic microorganisms, Bioactivity of the secondary metabolites secreted using endophytes, Commercial application of endophytes **Bioprospecting potential of mangrove resources**: Artificial honey using yeasts, Polythene and plastic degrading microbes, Mangrove-derived enzymes, Bioethanol production by mangrove-derived yeasts, Biofertilizer, **Mangrove genomics**: bioprospecting and valuable genes.		02

MODULE II **Unit III: Biotechnology and sustainable methods (15L)** **Biofertilizers**: definition, methods of manufacture, application to soil and seed. Nitrogen fixation: Molecular genetics: nif genes and regulation of nif gene expression. **Mycorrhiza**: Types, importance to plant health (nutrient uptake, resistance to stress, microbial symbiosis), importance of network analysis, role in ecosystem (Plant to plant interaction). **Biopesticides**: types, advantage over chemical pesticides, mode of action, stability and formulation in natural and genetically modified organisms, Selective targeting, Molecular mechanism of resistance development and strategies including integrated pest management. **Biopesticides from Plants**: Neem and pyrethrins, mode of action on insect pests, Bio-control: against fungal diseases of plants. Biological Controls: Viral/ fungal/ bacterial parasites for control of insects pests, life cycle, symptoms and mode of action **Biosurfactants**: Types - Glycolipids (Rhamnolipids, Sophorolipids, trehalose lipids) and lipopeptides, lipoproteins, phospholipids, fatty acids and neutral lipids. sources of biosurfactants and applications. **Unit IV: Green technology (15L)** **Bioremediation**: Effect of metals and salts on the growth of microbes and higher organisms, Different adaptation mechanisms to tolerate higher concentration of metals by organisms. Bioremediation of soil and water using natural, genetically engineered bacterial systems and other approaches. **Phytoremediation**: Mechanism of phytoremediation, Restoration of soil, water and air quality citing suitable examples. **Phytomining and Biomining**: Concept, Indicator plants, hyperaccumulator plants, extraction of valuable minerals/ metals from low grade ore/ soil using plants and microorganisms, gold extraction, heaps and dumps. **Biofuels**: Liquid and gaseous. Bioenergy: Biofuels - Introduction, in the form of gas– hydrogen and methane (biogas), biofuel in form of liquid– ethanol and diesel, biofuel from phytoplankton. **Biotechnology of coal**: The microorganisms involved, mechanism of action, applications - conversion of coal to efficient/ cleaner fuels and methane, Biocoal.	02

Reference:

1. A.D. Diwan, B.J. Zahurne (2004) Biotechnology of Aquatic Animals:CRC Press
2. S. Felix (2010) Marine and Aquaculture Biotechnology: ISBN 10: 8177543970 / ISBN 13:
3. 9788177543971 Published by Agrobios
4. M. H. Fulekar (2010) Environmental Biotechnology; CRC Press
5. Odum Environmental Sciences;
6. Alan Scragg (2004) Environmental Biotechnology; Longman
7. Bimal Bhattachraya and Rintu Banerjee (2008) Environmental Biotechnology; Oxford
8. University Press; 1st edition.
9. Rao. C. S. (2007) Environmental pollution control engineering. New Age International Publishers.
10. T.V.S Rama Mohan Rao (2007) Economics of Biotechnology; New Age International Pvt Ltd;
11. First edition
12. S. N. Jogdand (2007) Entrepreneurship and Business of Biotechnology.
13. Maureen D. McKelvey, Annika Rickne, Jens Laage-Hellman () Economic dynamics of Modern
14. Biotechnology;
15. AyyapanS et. al. (2006) Handbook of Fisheries and Aquaculture: ICAR.
16. Ujwala Jadhav (2009) Aquaculture Technology and Environment; PHI Publishers.

Programme Name: M.Sc. (Life Sciences - Biotechnology) Semester IV **Total Credits:** 02 **Department assessment:** 25 marks	**Course Name:** Environmental Sustainability Practical **Total Marks:** 50 **University assessment:** 25 marks

Course Outcome:

The learner would be able to:

1. Demonstrate the effect of biopesticide.
2. Analyze the components and efficacy of a biofertilizer.
3. Evaluate the mangrove species and their metabolites using analytical methods.
4. Demonstrate the production of biosurfactant.
5. Summarize the functioning of an aquatic farm/ecosystem.

Course Code	**Course Title**	**Total Credits**
LScBT609	**Environmental Sustainability Practical**	**02**
MODULE I 1. Biopesticide effect of Neem/ Extraction and demonstration of Azadirachtin/ Nimbolide. 2. Demonstration of mycorrhiza in a suitable plant. 3. Regeneration studies in some mangrove species. 4. Determination of free amino acid content in saline plants. 5. Estimation of proline from saline species. 6. Estimation of tannins from bark/stems of different mangroves 7. Determination of Spatial Disturbance Index and similarity index of mangroves. 8. Detection of bioactive compounds in some mangrove species by TLC. 9. Production of biosurfactant using *Bacillus subtilis*. 10. Visit to an aquaculture farm.		02

Programme Name: M.Sc. (Life Sciences - Biotechnology) Semester IV **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name:** Genetic Engineering **Total Marks:** 100 **University assessment:** 50 marks

Course Outcome:

The learner would be able to:

1. Customize various latest genetic engineering techniques.
2. Understanding the genetic improvement of industrially important strains.
3. Understand recombinant protein production and its challenges.

Course Code	Course Title	Total Credits
LScBT610	**Genetic Engineering**	**04**
MODULE I **Unit I: Basics of Gene Cloning (15L)** **Cloning**: Importance of DNA Cloning, Principles of Cell-based DNA Cloning and cell independent DNA cloning, Primers, PCR and its types, Cutting and Joining DNA methods - nucleases, polymerases, phosphatases, kinases, terminal transferase, adaptors and linkers, homopolymer tailing. Construction of Genomic and cDNA libraries **Vectors**: Essential components of vectors and their significance. Natural Vectors: F Plasmid, R Plasmid, Col Plasmids, Tol Plasmid, Vir Plasmids, Artificial Plasmid vectors - pBR322 and pUC18, Vectors based on the bacteriophage Lambda, Cosmids, M13 vectors, Yeast Plasmids, YACs and BACs. Expression vectors - bacterial, mammalian and plant. **Unit II: Expression Systems (15L)** **Gene/ regulatory sequence/ protein engineering**: Promoter, Gene, Protein and ribosome engineering **Expression systems** – pET, pBAD systems, *Bacillus* and *Streptomyces* expression systems, YAC and Pichia expression system, Lexsy, Chlamydomonas expression system, Baculovirus, Adenoviral and retroviral expression systems, choice of expression systems, Problems in expression: Inclusion body, codon bias and codon optimization post translational modification, **Expression of modified genes** – phage, cell, DNA, RNA, ribosome and IVC display, analysis and detection.		02
MODULE II **Unit III: Strain Manipulation Strategies (15L)** **Introduction**: Mutagenesis, recombination and cell/protoplast fusion. Mutagenesis: Effect of amino acid changes on protein function, Site- directed Mutagenesis – Non- PCR Methods - Cassette mutagenesis, oligo primed mutagenesis and whole plasmid mutagenesis and PCR based **Methods**: Overlap PCR; Molecular Evolution/Random mutagenesis – Error prone PCR, Site Saturation mutagenesis, DNA/Domain/Exon shuffling, ICTHY, SCRATCHY, RACHITT; de novo Sequence design **Genome editing**: CRISPR/Cas9, TALENS, Modified nucleases – meganuclease, zinc		02

finger nuclease, genome shuffling. RNAi based strain improvement: use of siRNA, shRNA, miRNA, ribozymes and riboswitches to regulate and optimize gene expression. **Unit IV: Therapeutics (15L)** **Therapeutic Proteins**: Monoclonal Antibodies, Peptibodies: Definition, peptide-Fc fusion, advantages over monoclonal antibodies, production in E. coli using recombinant DNA technology, production, and mechanism of action, applications – pain, ovarian cancer and immune thrombocytopenic purpura, limitations. **Proteins of pharmaceutical importance**: Human hormones Growth hormones, insulin, somatostatin,), Factors VIII, IX, interferons, interleukins and erythropoietin, **Vaccines**: Recombinant Live Vectors - Poliovirus Chimeras, adenovirus, Eg: Ebola, Covid Peptide Vaccines, Anti-idiotypes, Nucleic acid vaccines - DNA and RNA vaccines - types, methods of delivery, efficacy, safety, **Peptidomimetics**: Definition, design, features, analysis and application. **Biosimilars**: Definition, design, features, analysis and application.	

Reference:

1. Maniatis, Fritsch and Sambrook (1989). Molecular Biology: A laboratory Manual, 2nd edition,
2. Cold Spring Harbor Laboratory Press.
3. M. Green and J. Sambrook (2012). Molecular Biology: A laboratory Manual, 4th edition. Cold
4. Spring Harbor Laboratory Press.
5. Walker John M. and Ralph Rapley (2000). Molecular Biology and Biotechnology 4th Edition.
6. RSC Publishing.
7. Walker John M. and Ralph Rapley (2009). Molecular Biology and Biotechnology 5th Edition.
8. RSC Publishing.
9. Walker John M. and Ralph Rapley (2015). Molecular Biology and Biotechnology 6th Edition.
10. RSC Publishing.
11. Vittal, R. R. and R. Bhat (2009). Biotechnology, Concepts and Applications.
12. Paulina Balbas and Argelia Lorence (2004). Recombinant Gene Expression. Reviews and
13. Protocols 2nd ed. Methods in Molecular Biology vol. 267, Humana Press.
14. Gerd Gellissen (2005). Production of Recombinant proteins - Novel Microbial and Eukaryotic
15. Expression Systems, Wiley - VCH Verlag GmbH & Co. KGaA
16. Argelia Lorence (2012). Recombinant Gene Expression. Reviews and Protocols 3rd ed. Methods
17. in Molecular Biology #24, Springer Protocols, Humana Press.
18. Primrose, Twymann and Old (2002). Principles of Gene Manipulation, 6th ed,
19. Kakoli Bose (2022). Textbook on Cloning, Expression and Purification of Recombinant
20. Proteins, Springer Nature Singapore Pte Ltd.
21. David P. Clark, Nanette Pazdernik (2009). Biotechnology: applying the genetic revolution,
22. Elsevier Inc.
23. Jogdand S. N. (2008) Medical Biotechnology, Himalaya Publishing House, Mumbai.
24. JuditPongracz, Mary Keen (2009) Medical Biotechnology, Churchill Livingstone, Elsevier.
25. Pratibha Nallari& V. Venugopal Rao (2010) Medical Biotechnology, Oxford University Press,
26. India.
27. A. K. Banga (2005) Therapeutic peptides and proteins; CRC Press.
28. Bernard R. Glick, Terry L. Delovitch and Cheryl L. Patten (2014). Medical Biotechnology

Programme Name: M.Sc. (Life Sciences - Biotechnology) Semester IV **Total Credits:** 04 **Department assessment:** 25 marks	**Course Name:** Genetic Engineering Practical **Total Marks:** 50 **University assessment:** 25 marks

Course Outcome:

The learner would be able to:

1. Explain various concepts and methods used in Gene engineering.
2. Interpret the genetic improvement of industrially important strains.
3. Analyze recombinant protein products and its challenges.

Course Code	Course Title	Total Credits
LScBT611	**Genetic Engineering Practical**	**02**
MODULE I 1. Construction of amylase expression cassette and expression in *E. coli*. 2. Isolation and estimation of plasmid from bacteria. 3. Isolation of Protease degraders from soil and estimation of the protease activity. 4. Preparation and regeneration of fungal protoplast. 5. Detection and estimation of gene copy number by real time PCR (demonstration). 6. Transformation of yeast/ bacteria. 7. Slide culture of filamentous fungi 8. Study Restriction Fragment length polymorphism. 9. Residual DNA Analysis of therapeutic proteins. 10. Multiplex PCR of virulence factors/ antibiotic resistance genes/ multiple targets.		02

SEMESTER IV – ELECTIVES

Programme Name: M.Sc. (Life Sciences - Biotechnology) Semester IV **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name:** Synthetic and Regenerative Biology **Total Marks:** 100 **University assessment:** 50 marks

Course Outcome:

The learner would be able to:

1. Gain insight into the basic concepts of Synthetic Biology.
2. Comprehend the applications of Syntheic Biology in various fields of biology.
3. Interpret the genetic and re-engineered pathways.
4. Create BioBricks and model networks.

Course Code	Course Title	Total Credits
LScBT612a	**Synthetic and Regenerative Biology**	**04**
MODULE I: Course LScBT612a T (Credits 2) **Unit I: Introduction to Synthetic Biology (15L)** **Introduction:** Concept**,** History, Present status, Jargaon of Synthetic Biology (Parts, devices, systems, modules, chassis, orthogonality, retroactivity.), Key Biology numbers. **Central Dogma:** Transcription, Reverse Transcription, Translation and Post-Translational Modifications **Genome**: Genome editing, DNA and Genome Assembly, Codon Optimization, Genetic Network **Transcriptome**: Transcription and Translation, process controls, Noise in gene expression(Origin, propagation, consequences, and control) **Network circuits:** Bacterial- Feedback, feed-forward, signal propagators, and band filter **Unit II: Applications of Synthetic Biology (15L)** **BioBricks**: DNA, parts, devices and System, BioBricks assembly and Gibson assembly **BioBuilder -** iTune Device, Development of synthetic DNA, genome, gene circuits and cell (protocell) and xenobiology, **Reengineering pathways:** Synthetic biology of Cyanobacteria - Solazyme; Production of fuels, chemicals, pharmaceuticals, food and eco safe solutions for sustainable development and other applications **Synthetic Biology and Regenerative Biology**: Medical applications - Stem cells and Tissue re-engineering.		02
MODULE II: Course LScBT612a P (Credits 2) **Practical** 1. Modelling of expression network 2. SBML-A mark-up language for mathematical models in systems biology using cell		02

designer 3. Site directed mutagenesis (Kit based) 4. BioBrick Assembly of expression cassette (virtual lab) 5. V labs: analysis of biological networks for feature detection. 6. V labs: Import and simulate a model from different databases.	

Reference:

1. Edda Klipp, Wolfram Liebermeister, Christoph Wierling, Axel Kowald, Hans Lehrach, and RalfHerwig (2009). Systems Biology A Textbook, Wiley - VCH Verlag GmbH & Co. KGaA
2. Edda Klipp, Wolfram Liebermeister, Christoph Wierling and Axel Kowald (2016). Systems Biology A Textbook, 2nd Edition, Wiley - VCH Verlag GmbH & Co. KGaA
3. Jens Nielsen, Stefan Hohmann, Sang Yup Lee and George Stephanopoulos (2017). Systems Biology, Wiley - VCH Verlag GmbH & Co. KGaA
4. Markus W. Covert (2015). Fundamentals of Systems Biology - From Synthetic Circuits to Whole-cell Models, CRC Press, Taylor & Francis Group.
5. Christina Smolke, Sang Yup Lee, Jens Nielsen and George Stephanopoulos (2018). Synthetic Biology Parts, Devices and Applications, Wiley - VCH Verlag GmbH & Co. KGaA
6. Natalie Kuldell, Rachel Bernstein, Karen Ingram, and Kathryn M. Hart (2015). BioBuilder - Synthetic Biology in the Lab, 1st edition, O'Reilly Media, Inc.
7. Josefine Liljeruhm, Erik Gullberg and Anthony C. Forster (2014). Synthetic biology : a lab manual, Uppsala University, Sweden.
8. Christina D Somlke (2010). The Metabolic Pathway Engineering Handbook - Fundamentals,Taylor and Francis Group, LLC.
9. Christina D Somlke (2010). The Metabolic Pathway Engineering Handbook - Tools and Applications, Taylor and Francis Group, LLC.

ELECTIVE

Programme Name: M.Sc. (Life Sciences - Biotechnology) Semester IV	**Course Name:** Omics
Total Credits: 04	**Total Marks:** 100
Department assessment: 50 marks	**University assessment:** 50 marks

Course Outcome:
The learner would be able to:

1. Capture the essence of bioinformatics.
2. Handle and analyze biological sequences.
3. Design and evaluate the biological experimental systems using bioinformatics tools.

Course Code	**Course Title**	**Total Credits**
LScBT612b	**Omics**	**04**
MODULE I: Course LScBT612b T (Credits 2) **Unit I: Bioinformatics (15 L)** **Introduction to Bioinformatics:** History of Bioinformatics, Different Omics and its application and Current status. **Biological databases:** Primary DNA and Protein Databases, Secondary Protein Databases, Secondary Composite Structure Databases, Protein Databank (PDB), Metabolism Database (KEGG). **Multiple Sequence Alignment (MSA):** Definition, Objective, Motif, Consensus, Methods for MSA, Heuristic approach, Dynamic programming approach. **Pairwise Alignment:** Introduction, PAM Matrix, BLOSUM Matrix, The Dot Plot, Global alignment, Local alignment, FastA and BLAST. Statistics: P and E value. **Phylogenetic Analysis:** Terminology of tree- reconstruction, rooted and un- rooted trees.Methods: UPGMA, Neighbor- Joining Method, Maximum Parsimony. **Unit II: Genomics,Transcriptomics, Proteomics and Metabolomics (15L)** **Genomics:** Gene finding, OMIM database, reference genome sequence, integrated genomic maps, SNP database (DbSNP). **Transcriptomics:** RNA- types and their analysis, Gene expression profiling (SAGE, qPCR) Genome wide associated studies, Manhattan Plot. **Proteomics:** Introduction and current status. **Prediction of secondary structure:** PHD and PSI- PRED method. **Tertiary (3- D) Structure prediction:** Fundamentals of the methods for 3D structure prediction (sequence similarity/identity of target proteins of known structure, fundamental principles of protein folding etc.) Homology Modelling, fold recognition, threading approaches, and ab- initio structure prediction methods. **In silico drug designing:** Computer aided Drug Designing (CADD) **Metabolomics:** Introduction, Current status, Technology (Microarray, GWAS, LC-MS, GC-MS), Applications		02

MODULE II: Course LScBT612b P (Credits 2) **Practical:** 1. Multiple sequence alignment and Phylogenetic tree analysis 2. BLAST- BLASTn, BLASTp, primer BLAST. 3. Motif Finding- MEME and myhits 4. Secondary Structure Prediction: Interproscan 5. CATH and SCOP 6. KEGG 7. Tertiary Structure: PDB, Rasmol 8. Homology Modelling – SWISS- MODEL 9. *In silico* drug designing- Swiss-ADME	02

Reference:

1. Attwood T. K., Parry-Smith D. J and Phukan S. (2009). Introduction to Bioinformatics. Pearson Education
2. Mount D. W. (2004). Bioinformatics: Sequence and Genome Analysis. Cold Spring Habour Laboratory
3. Pevsner J. (2015). Bioinformatics and Functional Genomics. Wiley-Blackwell
4. Harisha S. (2019). Fundamentals of Bioinformatics. Dreamtech Press
5. Higgs P. G. and Attwood T. K. (2005). Bioinformatics and Molecular Evolution. Wiley
6. Bal H. P. (2004). Bioinformatics: Principles and Applications. McGraw Hill Education

ELECTIVE

Programme Name: M.Sc. (Life Sciences - Biotechnology) Semester IV **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name: Lifestyle Disorders** **Total Marks:** 100 **University assessment:** 50 marks

Course Outcome:

The learner would be able to:

1. Define lifestyle diseases and health conditions associated with them
2. Identify common lifestyle-related diseases, their molecular basis and treatment
3. Learn about various techniques for preliminary diagnosis of lifestyle disorders
4. Understand methods of prevention, treatment and management of the diseases.

Course Code	Course Title	Total Credits
LScBT612c	**Lifestyle disorders**	**04**
MODULE I: Course LScBT612c T (Credits 2) **Unit I: Metabolic Disorders (15 L)** Definition of Lifestyle disorders, common lifestyle disorders in India. Definition and types of Metabolic Disorders, Nutritional and Molecular Perspectives. **Diabetes:** Introduction, types of Diabetes, causes and risk factors, role of insulin and other hormones, involvement of metabolic pathways and enzymes in Diabetes, Pathophysiology of type I and type II diabetes, Glycation and oxidative stress as modern theory of diabetes, significance of glycated haemoglobin as measurement index for hyperglycaemia, secondary complications of Diabetes, management of diabetes, mechanism of action of modern and traditional therapeutic approaches. **Obesity**: Introduction, causes and risk factors, indices for obesity, fat deposits, hormonal control of obesity (Leptin, Adiponectin, Gherlin, Resistin), pathophysiology of obesity, health risks associated with obesity, regulation of metabolic pathways and enzymes in obesity, Signalling pathways in the pathogenesis of obesity, management of obesity, mechanism of action of modern and traditional therapeutic approaches. **Biochemical basis of Polycystic Ovarian Syndrome**, relationship between PCOS, obesity, Diabetes and Insulin **Unit II: Cardiovascular Diseases (15 L)** **Definition of Cardiovascular Diseases**, Risk factors for cardiovascular diseases, Common symptoms, Types of CVD (Brief description of coronary heart disease - angina, myocardial infarction and/or heart failure, Atherosclerosis; cerebrovascular disease - stroke, peripheral arterial disease, rheumatic heart disease; congenital heart disease, and deep vein thrombosis and pulmonary embolism), Genetic and Molecular bases of CVDs, Lipids and lipoproteins in CVDs, Biomarkers in CVD, Biochemical diagnostic tests for CVDs, Management and prevention of CVDs, Nutrition and CVDs, Diabetes and CVDs, Obesity and CVDs.		02

MODULE II: Course LScBT612c P (Credits 2) **Practical:** 1. Estimation of blood glucose parameters 2. Analysis of Glycation and oxidative stress parameters 3. Analysis of damage of proteins during diabetes/hyperglycemia 4. Analysis of glycoxidation damage of DNA during diabetes/hyperglycemia 5. Determination and significance of BMI and other obesity indices 6. Project Work based on Case studies related to risk factors of Diabetes/obesity/PCOS/CVD 7. Antidiabetic, antiobesity and cardiovascular health natural products analysis 8. Databases for lifestyle disorders	0 2

Reference:

1. Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Harcourt Asia PTE Ltd/W.B. Saunders Company.
2. Widmaier E, Raff H and Strang K. (2013) Vander's Human Physiology: The Mechanism of Body Functions. McGraw-Hill Education 13th Edition.
3. Kathleen Botham, Owen McGuinness, P. Anthony Weil, Peter Kennelly, Victor Rodwell. Harper's Illustrated Biochemistry, Thirty-Second Edition
4. Devlin, Thomas M, Textbook of biochemistry with clinical correlations Edition: 5th
5. Chatterjea, MN , Shinde, Rana, Textbook of Medical Biochemistry
6. D.M.Vasudevan&S.Sree Kumari, Textbook of Biochemistry for Medical Students 4/e, 2004
7. Colleen Smith, Allan D. Marks, Michael Lieberman, Mark's Basic Medical Biochemistry - A Clinical Approach 2nd Edition
8. Richard Harvey and Denise Ferrier, Lippincott's Illustrated Reviews - Biochemistry 5th Edition
9. Michael L. Bishop, Edward P. Fody, Larry Schoeff, Clinical Chemistry – Principles, procedures, correlations 5th Edition

ELECTIVE

Programme Name: M.Sc. (Life Sciences - Biotechnology) Semester IV **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name:** Bio-Entrepreneurship **Total Marks:** 100 **University assessment:** 50 marks

Course Outcomes:

The learner would be able to:

1. Analyse the feasibility of a biotechnology industry.
2. Appreciate the scope of Biotechnology Industry in India.
3. Outline the regulatory processes and agencies involved in the biotechnology industry.
4. Assess the Intellectual property and Patentability of the Biotechnology Products.
5. Relate to processes involved product, vendor and inventory management.
6. Assess the market for Biotechnology products.

Course Code	**Course Title**	**Total Credits**
LScBT612d	**Bio-entrepreneurship**	**04**
MODULE I: Course LScBT612d T (Credits 2) **Unit I: Biotechnology Industry and Business Environment - Concepts, motives (15 L):** **Biotechnology policies, laws and guidelines:** National Biotechnology Development Strategy **Biotechnology Regulatory Affairs**: Regulatory processes and agencies; Legal Aspects of Biotechnology **Intellectual Property Rights (IPR)**: basis of patentability, patent application procedure, compulsory license, infringement of patents **Product**: Product Registration for Regulated and Non Regulated Markets; **Vendors**: Vendor analysis; Vendor rating **Inventory and Materials Management:** (EO Quantity; Lead time; BOM; ABC analysis; VED analysis; SCD analysis; Store management; FIFO and LIFO systems) **Collaboration and Technology Transfer in Biotechnology:** Incubation cells to Start-ups, Industry to Industry **The Biotechnology Industry:** Scope of biotechnology in the industrial environment, the Biotech industry in India with examples**.** **Unit II: Biotechnology Business Management (15 L):** Marketing Management in Biotechnology Industry: **Marketing practices and application**: Market research and forecast; Marketing plan; Relationship between the marketing and sales functions; Niche market, Market penetration; Market skimming; Marketing a scientific product and a scientific service **Pricing strategies**: Distribution alternatives and channels **Communication**: Promotion, Advertising of the products **International marketing trends in biotechnology**: Global Biotechnology Industries as examples.		02

Role of Finance in the development of Biotechnology industry: **Finance Management for Biotechnology Industry**: Authorized and paid up capital assets and liabilities; **Types of costing and pricing methods**: Cost - benefit-analysis Business Strategic components Marketing and sales finance Break even analysis; Working capital management; and financial ratios and break-even point financial ratios; Balance sheet; P and L account; Commercializing biotechnology and technology transfer; Infrastructure required for biotech industries and investment opportunities. **Production and Operations Management of Biotechnology Industry**: Emerging Areas of Biotechnology Industry Social issues in biotechnology industry Biotechnology Product Management- product development, assessment of market potential, testing and life cycle analysis Operations and Maintenance management of the product line Preclinical and clinical trial design and conduct Risk analysis **Quality control and assurance**: Total quality management; Fundamentals of validation; GLP; GCP; GMP.	
MODULE II: Course LScBT612d P (Credits 2) **Practical** 1. Biotechnology Industry: Management Project Report and viva. 2. Buisiness plan based on a Biotechnology product and feasibility studies.	02

Reference:

1. Ramsey David (2011). EntreLeadership: 20 Years of Practical Business Wisdom from the Trenches. New York: Howard Books
2. Byrne John A. (2011). World Changers: 25 Entrepreneurs Who Changed Business as We Knew it. New York: Penguin.
3. Lynn Jacquelyn (2007). The Entrepreneur's Almanac: Fascinating Figures, Fundamentals and Facts at your Fingertips. Canada: Entrepreneur Media Inc.
4. Kotler (): Marketing Management. Publisher -
5. Rajan Saxena () Marketing Management. Publisher -
6. Prasanna Chandra () Finance and Accounts.
7. Business Strategy Management.

ELECTIVE

Programme Name: M.Sc. (Life Sciences - Biotechnology) Semester IV	**Course Name:** Natural and Managed Ecosystems
Total Credits: 04	**Total Marks:** 100
Department assessment: 50 marks	**University assessment:** 50 marks

Course Outcome:

The learner would be able to:

1. Understand the concept of ecosystems and their importance.
2. Appreciate the different types of ecosystems and their advantages.
3. Maintain ecosystems and conserve biodiversity.
4. Manage artificial ecosystems for best productivity.
5. Appreciate the effect of biotechnology in managed ecosystems.

Course Code	Course Title	Total Credits
LScBT612e	Natural and Managed Ecosystems	**04**
	MODULE I: Course LScBT612e T (Credits 2) **Unit I: Natural Ecosystems (15 L)** **Natural ecosystems:** Concept of an ecosystem. Examples of Natural ecosystems (Forest, Ocean/ Marine, Pond ecosystem, river, estuarine, grassland, desert etc.). **Components and functions of an ecosystem:** Abiotic/ biotic factors, food chain and web, nutrient cycling, services to society. **Advantages of natural ecosystems:** Characteristics**,** biodiversity, maintenance and resilience. **Ecosystem services:** Conservation, preservation and restoration. **Unit II: Managed Ecosystems (15 L)** **Artificial/ managed systems:** Agriculture (crop fields, aquaculture farms, orchards), Dams, Zoos, Greenhouses, Artificial wetlands, Managed forestry, Hydroponics, Home-scale (aquariums, home gardens, terrariums) as ecosystems. **Characteristics of managed ecosystems**: Productivity, maintenance, resilience, biodiversity, threats, balancing environmental concerns. **Effect of Biotechnology in managed ecosystems:** Effect on food security, environment, climate mitigation, and natural populations using suitable examples.	02
MODULE II: Course LScBT612e T (Credits 2) **Practical:** 1. Determination of quadrant size for biodiversity experiments. 2. Case studies of the natural systems in India/ world. 3. Case studies of artificial systems in India/ world. 4. Case Study: Miyawaki forests.		02

Reference:

1. John Vandermeer; Ivette Perfecto (2017): Ecological Complexity And Agroecology, Routledge.

Programme Name: M.Sc. (Life Sciences - Biotechnology) Semester IV **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name:** RESEARCH PROJECT II **Total Marks:** 100 **University assessment:** 50 marks

Course Outcome:

The learner would be able to:

1. Analyze and determine the lacunae of the existing literature in any given field of study.
2. Formulate a hypothesis based on a focussed literature review.
3. Use the tenets of research methodology to design an effective research study.
4. Demonstrate the actual execution of the research design
5. Highlight the weaknesses and strengths of the study.
6. Prepare a presentation and appropriately record the studies done in this course.

Course Code	Course Title	Total Credits
LScBT613	**RESEARCH PROJECT II**	**06**
Introduction This course is designed to extend the concepts in Research Methodology to address a lacuna in the existing knowledge in a particular area of the discipline of Life Sciences. The learner would be able to identify and organize the existing literature on a given topic, formulate a hypothesis, design a research project and plan experiments to prove a hypothesis. The research project is aimed to enable the researcher to conduct scientifically designed experiments for a meaningful assessment and conclusion of the observations and results. The learner would be able to effectively document and present the parameters and findings of the research project. There are six credits assigned to the course. As this is of a practical and hands-on nature, every two hours spent on the project in a week would earn a credit. The course spans over 15 weeks and hence the time that needs to be devoted would be 180 hours. This could be planned and completed over a span of 15 weeks or continuously 6 - 8 weeks. Where can these projects be done: The projects could be conducted in-house or could be in industry or research institutes or recognized institutes that carry out research. The host institution would be from any field of Life Sciences. The project would be carried out with the consent and understanding between the the the University Department of Life Sciences and the relevant Academic/ research Institute or the Industry Documentation for the Research Project II: The proforma for internal evaluation by the mentor (at the place of work) is given at the end of the syllabus. The formulation of the project, the application and attendance of the learner would be evaluated on a continuous basis. This would be the backbone of the internal assessment. The scheme for the same is given at the end of the syllabus. The submitted thesis of the project, a draft research paper based on the results obtained in Research Project II and its presentation would be evaluated by external examiners The relevant weightages are given at the end of the document. The reports will be governed by the plagiarism rules as dictated in the document No. Th./ICD/2018 – 19/ 448.	06

EVALUATION SCHEME

Evaluation: SEMESTER III

Paper Code	Theory		Practical		Total
	Internal	External	Internal	External	
LSc601	50	50			100
LSc602			25	25	50
LSc603	50	50			100
LSc604			25	25	50
LSc605	25	25			50
LSc606 (Electives: a to e)	25	25	25	25	100
LSc607 (ResearchProject I)	Evaluation scheme at the end of the Document				100

Evaluation: SEMESTER IV

Paper Code	Theory		Practical		Total
	Internal	External	Internal	External	
LSc608	50	50			100
LSc609			25	25	50
LSc6010	50	50			100
LSc611	25	25			50
LSc612 (Electives: a to e)	25	25	25	25	100
LSc613 (ResearchProject II)	Evaluation scheme at the end of the Document				100

A. Evaluation for Mandatory Theory Courses (4 Credit Courses)

I. Internal Evaluation for Mandatory Theory Courses: 50 Marks

The internal evaluation for mandatory theory courses comprises two components, each carrying a specific weightage. Students can choose between the following options to fulfil the evaluation requirements:

Option 1: (i) The course teacher will have the liberty to choose the assessment tools/ methods (class test/assignment/record book/tutorials/seminars/case study/ field work/ project work/ quiz/ etc.) – 50 marks.

Option 2: (i) Completion of SWAYAM (Advanced Course) of minimum 2 credits and certification exam - 50 Marks

Option 3: (i) Completion of NPTEL (Advanced Course) of minimum 2 credits and certification exam - 50 Marks

Option 4: (i) Possession of valid International Certifications from recognized providers such as Prometric, Pearson, Certiport, Coursera, Udemy, or similar platforms - 50 Marks

Note: It's important to note that each certification will be awarded marks for only one course. For example, if a student completes four courses, they will need to obtain four different certifications to fulfil the certification marks requirement for each course.

II. External Examination for Mandatory Theory Courses- 50 Marks

- Duration: **2.0 Hours**
- Theory question paper pattern:

	All questions are compulsory.		
Question	**Based on**	**Options**	**Marks**
Q.1	Unit I	Any 1 out of 2 (1 or 1 a, b)	10
Q.2	Unit II	Any 1 out of 2 (2 or 2 a, b)	10
Q.3	Unit III	Any 1 out of 2 (3 or 3 a, b)	10
Q.4	Unit IV	Any 1 out of 2 (4 or 4 a, b)	10
Q.5	Unit I, II, III& IV	Any 4 out of 8 (short notes)	10

B. Evaluation for Elective Theory Courses (4 Credit Courses)

Evaluation for Elective Theory Courses (2 Credit Courses)

I. Internal Evaluation for Elective Theory Courses: 25 Marks

The internal evaluation for elective theory courses consists of two components, each carrying a specific weightage. These components are as follows:

The course teacher will have the liberty to choose the assessment tools/ methods (class test/assignment/record book/tutorials/seminars/case study/ field work/ project work/ quiz/ etc.) – 50 marks.

II. External Examination for Elective Theory Courses- 25 Marks

- Duration: **1 Hour**
- Theory question paper pattern:

	All questions are compulsory.		
Question	**Based on**	**Options**	**Marks**
Q.1	Unit I	Any 1 out of 2 (1 or 1 a, b)	10
Q.2	Unit II	Any 1 out of 2 (2 or 2 a, b)	10
Q.3	Unit I & II	Any 2 out of 4 (short notes)	5

C. Evaluation for Mandatory & Elective Practical Courses (2 Credit Courses)

The evaluation for both mandatory and elective practical courses is conducted according to the following criteria:

- Each practical course carries a **total of 50 Marks**, distributed as follows:
  - University Assessment: 25 Marks for practical performance (1 question of 15 marks, spot tests for 5 marks and viva for 5 marks)
  - Departmental Assessment: 5 Marks for the journal, 5 marks for attendance, 5 marks for participation and 10 marks for viva – total 25 marks.
  - The duration of each practical course is 6 to 8 hours.
- To be eligible for evaluation, students must complete a minimum of 80% of the practical work assigned in each core subject.
- It is mandatory for students to submit a certified journal at the time of the practical examination. The journal serves as a record of their practical work and is an essential component of the evaluation process.

Evaluation of Research Project Work I (4 Credit Course):

(Proforma for the Evaluation of the learner by the industry mentor /to whom the learner was reporting in the organization)

Internal Evaluation (by the institution/ at place of Internship by Mentor): 50 Marks

No	Particular	Excellent	Very Good	Good	Moderate	Satisfactory
1	Attendance & Punctuality					
2	Ability to work in a team					
3	Written and oral communication skills					
4	Problem solving skills					
5	Ability to grasp new concepts					
6	Technical skill in terms of technology, programming, etc					
7	Ability to complete tasks					
8	Quality of overall work done					
9	Time management*					
10	Critical thinking*					

- **Time Management:** Evaluating the ability to effectively manage time and meet deadlines.
- **Critical Thinking:** Assessing the ability to analyze information, evaluate options, and make reasoned decisions.

- **Patterns of Marks: out of 50 as per marks obtained in each of the 10 categories**

Excellent	Very Good	Good	Moderate	Satisfactory
5	4	3	2	1

Comments:_____

Signature: _____

Name:

Designation:

Contact details:

Email:

(Seal of the organization)

Research Project (I): Total Marks = 100.
Internal Assessment: 50 mks.
Thesis submission and evaluation along with Feedback From the organization: 25 mks
Viva: by an Internal Committee (2 members): 25 mks.

External Assessment: 50 mks.
Draft Paper submission: 25 mks
Presentation: 25 mks.

D. Evaluation of Research Project Work II (6 Credit Course):

(Proforma for the Evaluation of the learner by the industry mentor /to whom the learner was reporting in the organization)

Internal Evaluation (by the institution/ at place of Internship by Mentor): 50 Marks

No	Particular	Excellent	Very Good	Good	Moderate	Satisfactory
1	Attendance & Punctuality					
2	Ability to work in a team					
3	Written and oral communication skills					
4	Problem solving skills					
5	Ability to grasp new concepts					
6	Technical skill in terms of technology, programming, etc					
7	Ability to complete tasks					
8	Quality of overall work done					
9	Time management*					
10	Critical thinking*					

- **Time Management:** Evaluating the ability to effectively manage time and meet deadlines.
- **Critical Thinking:** Assessing the ability to analyze information, evaluate options, and make reasoned decisions.

- **Patterns of Marks: out of 50 as per marks obtained in each of the 10 categories**

Excellent	Very Good	Good	Moderate	Satisfactory
5	4	3	2	1

Comments:_____

Signature: _____

Name:

Designation:

Contact details:

Email:

(Seal of the organization)

Research Project (II): Total Marks = 150.

Internal Assessment: 75 mks

- Research Proposal: 25 mks
- Progress evaluation by internal committee or along with Feedback from the organization: 25
- Attendance: 25

External Assessment: 75 mks.

- Thesis submission and evaluation: 25
- Draft paper/ Presentation: 25
- Viva: 25

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

Appendix-I

Maintain the weekly online diary for each week in the following format.

	Day	Date	Name of the Topic/Module Completed	Remarks
1st WEEK	Monday			
	Tuesday			
	Wednesday			
	Thursday			
	Friday			
	Saturday			

Signature of the Faculty mentor: _____

Seal of the University Department

Appendix-II

(Proforma for the certificate for internship in official letter head)

This is to certify that Mr. /Ms. ……..... of University Dept of Life Sciences worked as an intern as part of his/her M.Sc. course in Life Sciences of University of Mumbai. The particulars of internship are given below:

Internship starting date: _____

Internship ending date: _____

Actual number of days worked: _____

Tentative number of hours worked:_____Hours

Broad area of work: _____

A small description of work done by the intern during the period:

Signature: _____

Name:

Designation:

Contact details:

Email:

(Seal of the organization)

Appendix-III

(Proforma for the certificate for Project Work in official letter head)

This is to certify that Mr. /Ms. ……..... of University Dept of Life Sciences worked as an Project Student as part of his/her M.Sc. course in Life Sciences of University of Mumbai. The particulars of internship are given below:

Project Work starting date: _____

Project Work ending date: _____

Actual number of days worked: _____

Tentative number of hours worked:_____Hours

Broad area of work: _____

A small description of work done by the Project Student during the period:

Signature: _____

Name:

Designation:

Contact details:

Email:

(Seal of the organization)

Team for Creation of Syllabus (M. Sc. Life Sciences - Biotechnology)

Name	College Name	Sign
Prof. Indu Anna George	Department of Life Sciences, University of Mumbai	
Dr. Tejashree Shanbag	Principal, K.C. College, HSNC University	
Dr. Prashant Ratnaparkhi	Head, Department of Life Science, St. Xaviers College	
Prof. Priya Sundarrajan	Department of Life Science, St. Xaviers College	
Dr. Nilima Gajbhiye	Department of Life Science, Ramnarain Ruia College	
Dr. Kanchan Chitnis	Department of Life Science, Ramnarain Ruia College	
Dr. Ahmad Ali	Department of Life Sciences, University of Mumbai	
Dr. Suruchi Jamkhedkar	Department of Life Sciences, University of Mumbai	
Dr. Nisha Shah	Department of Life Sciences, University of Mumbai	
Dr. Hina Alim	Department of Life Sciences, University of Mumbai	
Prof. Aruna Deshpande	Alkesh Dinesh Modi Institute of Management	

Sign of BOS Chairperson	Sign of Offg. Assoc. Dean	Sign of Offg. Dean
Indu Anna George 9/7/2024		
Prof. Indu Anna George **Department of Life Sciences** **University of Mumbai**	**Dr. Madhav Rajvade** **Offg. Assoc. Dean** **Science and Technology** **University of Mumbai**	**Prof. Shivram Garje** **Dean Science and Technology** **University of Mumbai**