Curriculum Book

and

Assessment and Evaluation Scheme

based on

Outcome Based Education (OBE)

and

Choice-Based Credit System (CBCS)

in

Master of Science in Biotechnology

M. Sc. (Biotechnology)

2 Year Degree Program

Revised as on 01 August 2023
Applicable w.e.f. Academic Session 2023-24

AKS University

Satna 485001, Madhya Pradesh, India

Faculty of Life Sciences and Technology
Department of Biotechnology

Dr. Kamlesh Choure
Professor & Head
Department of Biotechnology
AKS University, Satna (MP) 485001

DEAN
Faculty of Life Sciences
AKS University, Satna (M.P.)

B A Chopade

Professor B.A. Chopade
Vice - Chancellor
AKS University
Satna, 485001 (M.P.)

Curriculum & Syllabus of M.Sc. (Biotechnology) Program

(Revised as of 2023)

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AKS University
Faculty of Life Sciences and Technology

Department of Biotechnology
Curriculum of M.Sc. (Biotechnology) Program
(Revised as on 2023)

Foreword

I am delighted to see that the Biotechnology Department's redesigned curriculum for the M. Sc. (Biotechnology) Programme smoothly incorporates the newest technological developments while adhering to UGC criteria. The curriculum has been redesigned with consideration to include the Sustainable Development Goals and NEP-2020 guidelines.

The alignment of course outcomes (COs), Programme Outcomes (POs), and Programme Specific Outcomes (PSOs) has been intricately executed, aligning perfectly with the requisites of NEP-2020 and NAAC standards. I hold the belief that this revised syllabus will significantly enhance the skills and employability of our students.

With immense satisfaction, I hereby present the revised curriculum for the M. Sc. (Biotechnology) program for implementation in the upcoming session.

Er. Anant Soni
Pro Chancellor & Chairman
AKS University, Satna

01 August 2023

AKS University, ***Faculty of Life Sciences and Technology***

Department of Biotechnology

Curriculum of M.Sc. (Biotechnology) Program

(Revised as on 2023)

From the Desk of the Vice-Chancellor

AKS University is currently undergoing a process to revamp its curriculum into an outcome-based approach, to enhance the teaching and learning process. The foundation of quality of quality education lies in the implementation of a curriculum that aligns with both societal and industrial needs, focusing on relevant outcomes. This entails dedicated and inspired faculty members, as well as impactful industry internships. Hence, it is of utmost importance to begin this endeavor by crafting an outcome-based curriculum in collaboration with academia and industry experts. This curriculum design should be informed by the latest technological advancements, market demands, the guidelines outlined in the National Education Policy (NEP) of 2020, and sustainable goals.

I'm delighted to learn that the revised curriculum has been meticulously crafted by the Biotechnology Department, in consultation with an array of experts from the Biotechnology industry, research institutes, and academia. This curriculum effectively integrates the principles outlined in the NEP-2020 guidelines, as well as sustainable goals. It also adeptly incorporates the latest advancements in Biotechnology manufacturing technology.

The curriculum tailored for the Indian biotechnology industry prioritizes the production of cost-effective, high-quality microbial products while emphasizing energy optimization. It integrates insights on waste heat recovery systems to minimize power consumption in biotechnological plants, fostering independent thinking among students for potential enhancements. This holistic approach not only equips students with essential knowledge but also nurtures a culture of innovation, preparing them to make meaningful contributions to the industry's advancement.

I am confident that the updated curriculum for M. Sc Biotechnology will not only enhance students' technical skills but also contribute significantly to their employability. During the process of revising the curriculum, I am pleased to observe that the Biotechnology department has diligently adhered to the guidelines provided by the UGC. Additionally, they have maintained a total credit requirement of 88 for the M. Sc. Biotechnology program.

It's worth noting that curriculum revision is an ongoing and dynamic process, designed to address the continuous evolution of technological advancements and both local and global concerns. This ensures that the curriculum remains responsive and attuned to the changing landscape of education and industry. AKS University warmly invites input and suggestions from industry expert technocrats and Alumni students to enhance the curriculum and make it more student-centered. Your valuable insights will greatly contribute to shaping an education that best serves the needs and aspirations of our students.

AKS University, Satna ***Professor B. A. Chopade***

01 August 2023 *Vice-Chancellor*

Preface

As part of our commitment to ongoing enhancement, the Department of Biotechnology consistently reviews and updates its M. Sc. Biotechnology curriculum every three years. Through this process, we ensure that the curriculum remains aligned with the latest technological advancements, as well as local and global industrial and social demands.

During this procedure, the existing curriculum for the M. Sc. Biotechnology Program undergoes evaluation by a panel of technocrats, industry specialists, and academics. Following meticulous scrutiny, the revised curriculum has been formulated and is set to be implemented starting from August 01, 2023. This implementation is contingent upon the endorsement of the curriculum by the University's Board of Studies and Governing Body.

This curriculum closely adheres to the UGC model syllabus distributed in May 2023. It seamlessly integrates the guidelines set forth by the Ministry of Higher Education, Government of India, through NEP- 2020, as well as the principles of Sustainable Development Goals. To foster the holistic skill development of students, a range of practical activities, including Hands-On Training, Industrial Visits, Project planning and execution, Report Writing, Seminars, and Industrial on-the-job training, have been incorporated. Furthermore, in alignment with UGC's directives, the total credit allocation for the M. Sc. Biotechnology program is capped at 93 credits.

This curriculum is enriched with course components in alignment with UGC guidelines, encompassing various disciplines such as Fundamental Science Concepts: 24 credits, Engineering Science: 25 credits, Humanities and Social Sciences: 12 credits, Core Program Courses: 66 credits, Elective Program Courses: 9 credits, Open Electives: 9 credits, Project and Practical Training: 17 credits, Seminars: 3 credits, Indian Knowledge System: 2 credits, Sustainable Development Goals: 2 credits.

To ensure a comprehensive learning experience, detailed evaluation schemes and rubrics have also been meticulously provided.

For each course, a thorough mapping of Course Outcomes, Program Outcomes, and Programme Specific Outcomes has been undertaken. As the course syllabus is meticulously developed, various elements such as session outcomes, laboratory instruction, classroom instruction, self-learning activities, assignments, and mini-projects are meticulously outlined.

We hold the belief that this dynamic curriculum will undoubtedly enhance the independent thinking, skills, and overall employability of the students.

INTRODUCTION

OVERVIEW OF THE DEPARTMENT

The Department of Biotechnology was established in 2006 to provide excellent and sensible teaching with maximum practical and research exposure to create skilled and well-trained bio-technocrats and entrepreneurs as per academia and industry needs in the frontier areas of Microbiology and Biotechnology. We, at the Department of Biotechnology, endorse each student by providing them maximum practical approach to understanding their subjects in a better way of global standards and making them technologically advanced and ethically of high quality to serve society.

VISION

The vision of the department is to dedicate research to Human and Environmental welfare. To become a center of excellence for biotechnology education, research, training, and entrepreneurship under the direction of good scientific principles, excellent instruction, and an ambition for continuous improvisation.

MISSION

At the Biotechnology Department, our mission is to be at the forefront of biotechnological innovation, research, and education. We are committed to advancing the frontiers of biotechnology through cutting-edge research, interdisciplinary collaboration, and the development of skilled and ethical professionals. We aim to address global challenges, improve human well-being, and contribute to sustainable development through the application of biotechnological solutions by following aspects:

- M1. To develop a strong Biotechnology program based on quality education, research, and training.
- M2. To impart quality education to the students and enhance their skills which will make them globally competitive.
- M3. To create trained biotechnology professionals who can contribute to the continuous improvement of biotechnological services and products.
- M4. To design scientific and/or technical resources as per biotechnology industry demands.
- M5. To develop as a benchmark University in emerging technologies.
- M6. To provide a state-of-the-art teaching-learning process and R&D environment.
- M7. To harness human capital for sustainable competitive edge and social relevance.

PROGRAM OUTCOMES

- **PO1:** Students will able to understand all the fundamentals of the field of biotechnology while gradually introducing them to all the essentials of the field through solid practical instruction and exposure to the most cutting-edge ideas
- **PO2:** Exhibit technical proficiency in the use and upkeep of advanced apparatus so that the student would be qualified to start a domain-related job as well as discipline-specific study.
- **PO3:** Write and present a substantial technical report/research document.
- **PO4**: Apply research-based knowledge and biotechnological methods to investigate complex biological
- Problems related to energy, environment, health, safety, and society following ethical principles.
- **PO5:** Pursue life-long learning to enhance knowledge and skills for professional advancement

PROGAM EDUCATIONAL OBJECTIVES

PEO1: Pursue successful industrial, academic, and research careers in specialized fields of Biotechnology
PEO2: Apply the knowledge of advanced topics in Biotechnology to meet industrial and research needs
PEO3: Use modern computational, and analytical tools and techniques to address biotechnological challenges.
PEO4: Identify issues related to ethics, society, safety, and environment in the context of Biotechnology
applications
PEO5: Engage in lifelong learning for career and professional growth for society and the environment

Program Specific Objectives (PSOs) for M.Sc. Biotechnology program

PSO1 Consolidation of the fundamentals and principles of basic and applied aspects of biotechnology to serve society.

PSO2 Develop a technical skill set for generating, analyzing, and interpreting scientific data for employability, entrepreneurship, and research aptitude.

PSO3 Introducing scientific cognition, critical thinking, and analysis using in-age computational tools to develop competence for academic research and industry at par with the global scenario.

General Course Structure and Credit Distribution

A. Definition of Credit:

1 Hr. Lecture (L) per week	1 Credit
1 Hr. Tutorial (T) per week	1 Credit
1 Hr. Practical (P) per week	0.5 Credit
2 Hours Practical (P) per week	1 Credit

B. Range of Credits:

As per the UGC model Curriculum for the PG Degree Course in Biotechnology, the total number of credits proposed for the Two-year M. Sc. (Biotechnology) is kept as 92.

C. Structure of PG Program in Biotechnology:

The structure of the PG program in Biotechnology shall have essentially the following categories of courses with the breakup of credits as given:

S. No.	Category	Breakup of Credits
2.	Basic Science Courses	20
3.	Discipline Specific Courses	26
4.	Program Core Courses (Branch specific)	21
5.	Professional Elective Courses (Branch specific)	6
6.	Open Elective Courses (from Humanities, Technical Emerging or other Subjects)	-
7.	Project work, Seminars and Internships in Industry or elsewhere, or research courses	15
	TOTAL	88

D. Course Code and Definition:

Course code	Definitions
L	Lecture
T	Tutorial
P	Practical

C	Credits
HS	Humanities & Social Science Courses
BSC	Basic Science Courses
DSC	Discipline Specific Courses
PCC	Program Core Courses
PE	Professional Elective Courses
OE	Open Elective Courses
AU	Audit Courses
EEC	Employment Enhancement Courses (Project/Summer Internship/Seminar)

- **Course level coding scheme:** Three-digit number (odd numbers are for the odd semester courses and even numbers are for even semester courses) used as a suffix with the Course Code for identifying the level of the course. The digit at hundred's place signifies the year in which the course is offered. e.g. 101, 102 … etc. for the first year. 201, 202 …. etc. for second year. 301, 302 … for third year.

Department of Biotechnology

Scheme and Syllabus

The department provides a two-year M.Sc. program in Biotechnology using a Choice Based Credit System (CBCS) that consists of four semesters. The regulations for the M.Sc. in Biotechnology provided by AKS University under the Choice Based Credit System (CBCS) are shown here.

Semester I							
Sl. No.	**Code**	**Category**	**Subject**	**L**	**T**	**P**	**C**
1	52BT101	BSC	Cell Structure & Dynamics	3	-	-	3
2	52BT102	BSC	Microbial Technology	3	-	-	3
3	52BT103	BSC	Advanced Biochemistry	3	-	-	3
4	52BT104	DSC	Biostatistics & Computer Application	2	1	-	3
5	52BT105	BSC	Molecular Biology	3	-	-	3
6	52BT106	DSC	Bioanalytical Tools and Techniques	3	-	-	3
7	52BT151	BSC	Cell Structure & Dynamics Lab	-	-	2	1
8	52BT152	BSC	Microbial Technology Lab	-	-	2	1
9	52BT153	BSC	Advanced Biochemistry Lab	-	-	2	1
10	52BT154	DSC	Biostatistics & Computer Application Lab	-	-	2	1
11	52BT155	BSC	Molecular Biology Lab	-	-	2	1
12	52BT156	DSC	Bioanalytical Tools and Techniques Lab	-	-	2	1
			TOTAL	**17**	**-**	**12**	**24**
Semester II							
Sl. No.	**Code**	**Category**	**Subject**	**L**	**T**	**P**	**C**
1	52BT201	BSC	Immunology	3	-	-	3
2	52BT202	DSC	Computational Biology & Bioinformatics	3	1	-	4
3	52BT203	DSC	Stem Cell and Tissue Engineering	2	1	-	3
5	52BT204	PCC	Animal Biotechnology	3	-	-	3
6	52BT205	DSC	Industrial Microbiology	3	-	-	3
	52BT206	PCC	Plant Biotechnology	2	1	-	3
7	52BT251	BSC	Immunology lab	-	-	2	1
8	52BT252	DSC	Computational Biology & Bioinformatics lab	-	-	2	1

9	52BT253	DSC	Stem Cell and Tissue Engineering lab			2	1
10	52BT254	PCC	Animal Biotechnology lab			2	1
11	52BT255	DSC	Industrial Microbiology lab			2	1
12	52BT256	PCC	Plant Biotechnology lab			2	1
			TOTAL	**16**	**3**	**12**	**25**

Semester III

Sl. No.	**Code**	**Category**	**Subject**	**L**	**T**	**P**	**C**
1	52BT301	PCC	Environmental Biotechnology	3	-	-	3
2	52BT302	PCC	Genetic Engineering & Bionanotechnology	3	1	-	4
3	52BT303	PCC	Agriculture Biotechnology	3	-	-	3
4	52BT304	DSC	Scientific Writing and Patenting Process	3	1	-	4
5	52BT305	PE	Elective 1 (Group A/B/C)	2	-	-	2
6	52BT306	PE	Elective 2 (Group A/B/C)	2	-	-	2
7	52BT351	PCC	Environmental Biotechnology lab	-	-	2	1
8	52BT352	PCC	Genetic Engineering & Bionanotechnology lab	-	-	2	1
9	52BT353	PCC	Agriculture Biotechnology lab	-	-	2	1
10	52BT354	DSC	Scientific Writing and Patenting Process lab	-	-	2	1
11	52BT355	PE	Elective 1 (Group A/B/C) lab	-	-	2	1
12	52BT356	PE	Elective 2 (Group A/B/C) lab	-	-	2	1
			TOTAL	**16**	**2**	**10**	**24**

LIST OF ELECTIVE SUBJECTS
Semester III

Group	Name of Specialization	Elective no.	Name of subjects
A	**Industrial Biotechnology**	1	52BT305-A Design and Operation of Bioreactors
		2	52BT306-A Down Stream Processing
		1	52BT355-A Design and Operation of Bioreactors Lab
		2	52BT356-A Down Stream Processing Lab
B	**Pharmaceutical Biotechnology**	1	52BT305-B Pharmaceutical Biotechnology
		2	52BT306-B Vaccine Biotechnology and Drug Action
		1	52BT355-B Pharmaceutical Biotechnology Lab
		2	52BT356-B Vaccine Biotechnology and Drug Action lab
C	**Bioinformatics**	1	52BT305-C Molecular Modelling and Drug Designing
		2	52BT306-C Bioprogramming and Soft Computing Techniques
		1	52BT305-C Molecular Modelling and Drug Designing lab
		2	52BT306-C Bioprogramming and Soft Computing Techniques lab

Note: Students can choose only one group of the above and study both the subjects of the group

Semester IV

Sl. No.	Code		Subject	L	T	P	C
1	52BT451		6 Months Project work/ Dissertation	0	0	30	15
			TOTAL	**0**	**0**	30	15

Total Credits=88

Semester 1

Program Name	**Master of Science in Biotechnology (M.Sc. (BT)**	
Semester	I	
Course Code:	52BT101	
Course title:	Cell structure and dynamics	**Curriculum Developer**: Chahana Desai, Teaching Associate
Pre-requisite:	Students should have basic knowledge and understanding about structure and historical perspective about cell.	
Rationale:	The students studying Cell structure and dynamics would possess fundamental understanding about Cell structure, function, transport across the membrane and to understand how different cells communicate with one another through comprehending distinct signaling pathways and their function in cancer.	
Course Outcomes (COs):	**CO1-52BT101.1-** The student can comprehend how the cell, the fundamental structural and functional unit of life, is furnished with machinery to carry out operations **CO2-52BT101.2-** Understanding of the physical characteristics of cell organelles and machinery. **CO3-52BT101.3-** Understand the working principles of cellular phenomena. **CO3-52BT101.4-** Analyze the detailed concept of cell signaling and its regulation. **CO3-52BT101.5-** Elucidate the cellular development in various living organism and the knowledge about Cancer in detail.	

Scheme of Studies:

Board of Study	CourseCode	Course Title	Scheme of studies (Hours/Week)					Total Credits(C) (L:T:P=3:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Basic Science Course (BSC)	52BT101	Cell structure and Dynamics	3	2	1	1	7	3+1=4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);
SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits.
Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class act any one (CAT)	Class Attendance	Total Marks (CA+CT+CAT+SA+AT)		
BSC	52BT101	Cell structure and Dynamics	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
BSC	**52BT151**	Cell structure and Dynamics	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	02	01	02	14

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-52BT101.1- An overview of cells and cell research.	**SO1.1** Understand the basic knowledge about cell	**LI1.1** To demonstrate the structure of cell	**Unit-1 Detailed overview of cells and cell research** **CI1.1** Origin and evolution of cell.	**SL1.1** Historical perspective of cell.
	SO1.2 & SO1.3 Concept of origin and evolution of cell		**CI1.2 & CI1.3** cell theory and experimental models.	
	SO1.4 & SO1.5 Understanding of cell theory and various instruments used in cell biology.		**CI1.4 & CI1.5** tools of cell biology.	**SL1.2** Principle and instrumentation of various tools used in cell biology.

	SO1.6 & SO1.7 To understand the overall composition of cell.		**CI1.6 & CI1.7** molecular composition of cells.	
	SO1.8 & SO1.9 biosynthesis of cell constituents.		**CI1.8 & CI1.9** biosynthesis of cell constituents.	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	1. Biosynthetic pathways for cell constituents. 2. Experimental models to understand statements of cell theory
	SW1.2 Mini Project	Diagram of Instrumentation of different types of microscopy used to understand the structure of cell.
	SW1.3 Other Activities (Specify)	Find out the Visual aspects of how the cell evolved

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	02	01	01	13

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO2-52BT101.2- Acquire knowledge regarding detailed structure of cell and its function.	**SO2.1** To Understand the detailed structure and function of various cell organelles present in the cell.	**LI2.1** To demonstrate the various cell organelles in the cell.	**Unit-2 Cell structure and function:** **CI2.1** Structure and function of Cell wall and plasma membrane	**SL2.1** Study the various cell organelles present in the cell.
	SO2.2 To learn about the structure and function of cell organelles involved in Bioenergetics and metabolism		**CI2.2** Detailed structure and function of Nucleus	
	SO2.3 Elaborate the Types, structure and function of the cytoskeleton		**CI2.3** Types, structure and function of endoplasmic reticulumn	
	SO2.4 Elucidate the mechanism of		**CI2.4** Structure and function of	

	cell movement through the microfibers and microfilaments.		Golgi apparatus,	
	SO2.5 Formation, structure and function of lysosomes.		**CI2.5** Formation, structure and function of lysosomes.	
	SO2.6 Structure and function of mitochondria and role in bioenergetics and metabolism		**CI2.6** Structure and function of mitochondria and role in bioenergetics and metabolism	
	SO2.7 Structure and function of chloroplast.		**CI2.7** Structure and function of chloroplast.	
	SO2.8 structure and function of peroxisomes		**CI2.8** structure and function of peroxisomes	
	SO2.9 types, structure and function of cytoskeleton an mechanism of cell movement.		**CI2.9** types, structure and function of cytoskeleton an mechanism of cell movement.	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	1. Diagram of plant cell and animal cell 2. Diagram of prokaryotic and eukaryotic cell.
	SW2.2 Mini Project	Detailed structure of cytoskeleton and show how they involved in cell movement
	SW2.3 Other Activities (Specify)	Show some visual content how cytoskeleton help in movement.

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	02	01	02	14

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**

CO3-52BT101.3- Gain an understanding of the various types of cell surface transport and cellular interactions	**SO3.1** Elucidate Types of cellular transport	**LI3.1** To demonstrate the transport of small molecules on cell surface.	**Unit-3 Cell interaction and protein targeting:** **CI3.1** Cell surface-transport of small molecules	
	SO3.2 Various mechanisms of cell-cell interactions		**CI3.2** Various mechanisms of cell-cell interactions	**SL3.1** Basic concept of diffusion phenomena.
	SO3.3 & SO3.4 cell-cell interaction- adhesion junctions, gap junctions, plasmodesmata.		**CI3.3 & CI3.4** cell-cell interaction- adhesion junctions, gap junctions, plasmodesmata.	**SL3.2** Structure of cell organelles.
	SO3.5 & SO3.6 Elaborate the concept of protein targeting- nucleus, mitochondria, chloroplast, peroxisome.		**CI3.5 & CI3.6** Protein targeting- nucleus, mitochondria, chloroplast, peroxisome.	
	SO3.7 molecular chaperons		**CI3.7** molecular chaperons	
	SO3.8 & SO3.9 folding of polypeptides		**CI3.8 & CI3.9** folding of polypeptides	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	1. Differentiate between diffusion and osmosis. 2. Pathways of protein translocation. 3. Mechanism of passive transport.
	SW3.2 Mini Project	Make a detailed diagram of functioning of different types of Cell Junctions
	SW3.3 Other Activities (Specify)	Get the practical knowledge about the mechanism of osmosis with experiment of raisin.

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	02	01	02	14

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO4-52BT101.4-	**SO4.1**		**Unit-4 Cell signaling and**	

Analyze the detailed concept of cell signaling and its regulation.	Elucidate the Basic concept of cell Signaling mechanism and their receptor, function		**regulation** **CI4.1** Signaling molecules and their receptors, function	
	SO4.2 pathways of intracellular signal transduction.		**CI4.2** pathways of intracellular signal transduction.	**SL4.1** characteristics of signaling molecules.
	SO4.3 & SO4.4 Understanding the cell cycle in detail with various phases and the regulation aspect.	**LI4.1** To demonstrate the cell cycle phase.	**CI4.3 & CI4.4** Cell cycle- phases of cell cycle.	**SL4.2** cell division and its types.
	SO4.5 molecular events during cell cycle.		**CI4.5** molecular events during cell cycle.	
	SO4.6 & SO4.7 Regulation of cell cycle-checkpoints, cyclins and protein kinases.		**CI4.6 & CI4.7** Regulation of cell cycle-checkpoints, cyclins and protein kinases.	
	SO4.8 & SO4.9 Elaborate the Basic concept about cell death and renewal mechanism.		**CI4.8 & CI4.9** Cell death and renewal.	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	1. Write cell signaling pathway with required diagram. 2. Describe briefly the cell death mechanism.
	SW4.2 Mini Project	Draw a diagram of types of cell cycle with its phases and the checkpoints.
	SW4.3 Other Activities (Specify)	1. Visual Presentation of cell signaling. 2. Power point presentation of cell cycle regulation.

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	02	01	02	14

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO5-52BT101.5-	**SO5.1**		**Unit-5 Cellular development**	**SL5.1**

Elucidate the cellular development in various living organism and the knowledge about Cancer in detail.	To understand the development of multicellular organisms- *C. elegans*.		**and cancer** **CI5.1** Development of multicellular organisms- *C. elegans*.	Basics of developmental biology.
	SO5.2 & CI5.3 Development of multicellular organisms- *Arabidopsis thaliana*		**CI5.2 & CI5.3** Development of multicellular organisms-*Arabidopsis thaliana* .	
	SO5.4 & SO5.5 Development of multicellular organisms- *Drosophila melanogaster*.		**CI5.4 & CI5.5** Development of multicellular organisms-*Drosophila melanogaster*.	
	SO5.6 & SO5.7 Detailed knowledge about mutation, its types and mutagens.		**CI5.6 & CI5.7** Mutation- types and causes	
	SO5.8 & SO5.9 Give detailed mechanism, types of Cancer and carcinogens.		**CI5.8 & CI5.9** Cancer as a multi evolutionary process- tumor cells, proto-oncogenes, oncogenes, tumor suppressor genes and carcinogens.	**SL5.2** Basic knowledge about cancer.

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	1. Development of Drosophila *melanogaster*. 2. Development of cancer.
	SW5.2 Mini Project	List out various carcinogens and its effect on development of cancer.
	SW5.3 Other Activities (Specify)	Search the videos about how cancer develops?

Course duration (in hours) to attain Course Outcomes:

Course Title: cell structure and dynamics **Course Code:** 52BT101

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-52BT101.1- An overview of cells and cell research.	9	2	2	1	14
CO2-52BT101.2- Acquired the knowledge regarding detailed structure of cell and its function.	9	2	1	1	13
CO3-52BT101.3- Gain an understanding of the various types of cell surface transport and cellular interactions.	9	2	2	1	14

CO4-52BT101.4- Analyze the detailed concept of cell signaling and its regulation.	9	2	2	1	14
CO5-52BT101.5- Elucidate the cellular development in various living organism and the knowledge about Cancer in detail.	9	2	2	1	14
Total Hours	45	10	09	05	69

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Cell structure and dynamics **Course Code:** 52BT101

Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1-52BT101.1- An overview of cells and cell research.	2	1	1	1	5
CO2-52BT101.2- Acquired the knowledge regarding detailed structure of cell and its function.	2	4	5	1	12
CO3-52BT101.3- Gain an understanding of the various types of cell surface transport and cellular interactions.	3	5	5	1	14
CO4-52BT101.4- Analyze the detailed concept of cell signaling and its regulation.	2	3	5	1	11
CO5-52BT101.5- Elucidate the cellular development in various living organism and the knowledge about Cancer in detail.	2	4	1	1	10
Total Marks	**11**	**17**	**17**	**05**	**50**

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

S.No.	**Title/Author/Publisher details**
1	Cell & molecular biology- De Robertis B.J. publications Pvt.Ltd.
2	Cell & molecular biology - Gerald karp john wills & essential cell biology Balberts D. Bray
3	Developmental biology- SF Gilbert senior associates.
4	Molecular Biology of Cell- Alberts, B et al.
5	Genetics- Strickberger, 2 nd.
6	Microbial Genetics – D. Frifielder.

(b) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Group Discussion
4. Role play
5. Demonstration
6. ICT Based teaching Learning
7. Brainstorming

CO, PO and PSO Mapping

Program Name: M.Sc. Biotechnology
Semester: I Semester
Course Title: Cell structure and dynamics.
Course Code: 52BT101

CO/PO/PSO Mapping								
Course Outcome (COs)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-52BT101.1- An overview of cells and cell research.	1	2	-	1	2	2	2	1
CO2-52BT101.2- Acquired the knowledge regarding detailed structure of cell and its function.	-	1	1	-	-	1	1	2
CO3-52BT101.3- Gain an understanding of the various types of cell surface transport and cellular interactions.	1	1	2	1	-	3	1	1
CO4-52BT101.4- Analyze the detailed concept of cell signaling and its regulation.	1	1	1	-	2	1	1	3
CO5-52BT101.5- Elucidate the cellular development in various living organism and the knowledge about Cancer in detail.	2	1	1	-	-	1	3	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	Cos	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,4,5 PSO 1,2, 3	**CO1-52BT101.1-** An overview of cells and cell research.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	LI1.1	1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8,1.9	1SL-1,2
PO 2,3, PSO 1,2, 3	**CO2-52BT101.2-** Acquired the knowledge regarding detailed structure of cell and its function.	SO2.1 SO2.2 SO2.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	LI2.1	2.1, 2.2, 2.3,2.4,2.5,2.6,2.7,2.8,2.9	2SL-1
PO 1,2,3,4 PSO 1,2, 3	**CO3-52BT101.3-** Gain an understanding of the various types of cell surface transport and cellular interactions.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	LI3.1	3.1,3.2,3.3,3.4,3.5,3.6,3.7,3.8,3.9	3SL-1,2
PO 1,2,3,5 PSO 1,2, 3	**CO4-52BT101.4-** Analyze the detailed concept of cell signaling and its regulation.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9	LI4.1	4.1,4.2,4.3,4.4,4.5,4.6,4.7,4.8,4.9	4SL-1,2
PO 1,2,3, PSO 1,2, 3	**CO5-52BT101.5-** Elucidate the cellular development in various living organism and the knowledge about Cancer in detail.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9	LI5.1	5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8,5.9	5SL-1,2

Curriculum Developer Team:
Prof. Kamlesh Choure
Prof. Ashwini A. Waoo
Prof. Deepak Mishra
Dr. Monika Soni
Er. Arpit Srivastava

Program Name	**Masters of Science (M.Sc.)- Biotechnology**	
Semester	I	
Course Code:	52BT102	
Course title:	Microbial Technology	**Curriculum Developer**: Mr. Vivek Kumar Agnihotri, Assistant Professor
Pre-requisite:	Prerequisites for studying microbial technology include a master's degree in microbiology, biotechnology, or related fields, along with foundational knowledge in biology, microbiology, genetics, and biochemistry. Proficiency in laboratory techniques, understanding microbial physiology, basic chemistry principles, and some mathematics skills are also essential. Strong communication and computer skills are advantageous.	
Rationale:	Microbial technology's rationale lies in its ability to harness microorganisms for diverse applications, from sustainable agriculture to environmental cleanup and pharmaceutical development. By leveraging microbial metabolism and genetics, it offers solutions for pressing global challenges while advancing scientific understanding and driving innovation across various industries.	
Course Outcomes (COs):	**CO1-52BT102.1:** Able to Recognize and evaluate the major groups of microorganisms; classification, diversity, and ubiquity **CO2- 52BT102.2:** Identify and show the structural, physiological, and genetic similarities and differences of the main categories of microorganisms. **CO3-52BT102.3:** Analyze parameters to control microbial growth. **CO4-52BT102.4:** Can able to assess interactions between microbes, hosts, and environment. **CO5-52BT102.5:** Microbial diversity assessment employs culture-dependent and culture-independent methods, each with distinct merits and demerits, including culture-dependent methods' specificity and culture-independent methods' broader	

Scheme of Studies:

Board of Study	CourseCode	Course Title	Scheme of studies (Hours/Week)					Total Credits(C) (L: T: P=3:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Basic Science Course (BSC)	52BT102	Microbial Technology	3	2	1	3	9	3+1=4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);
SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits.
Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
BSC	52BT102	Microbial Technology	**15**	**20**	**10**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
BSC	**52BT152**	Microbial Technology	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	02	01	02	14

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO1-52BT102.1: Able to Recognize and evaluate the major groups of microorganisms; classification, diversity, and ubiquity	**SO1.1** Define Introduction to Microbiology & discovery of the microbial world	**LI1.1** Isolation of microbes from soil	**CI1.1** Introduction to Microbiology & discovery of the microbial world	**SL1.1** Try to visit the microbiology laboratory
	SO1.2 Explain controversy over spontaneous generation		**CI1.2** Controversy over spontaneous generation	
	SO1.3 How the development of microbiology in the twentieth century		**CI1.3** Development of microbiology in the Twentieth Century	
	SO1.4 what are the methods of Microbial life: - prokaryotes, eukaryotes, Archeas & protozoa		**CI1.4** Microbial life: - prokaryotes, eukaryotes, Archeas & protozoa	
	SO1.5 Features and Classification of microorganism- Bacteria		**CI1.5** Classification of microorganism- Bacteria	
	SO1.6 Classification of microorganism- fungi		**CI1.6** Classification of microorganism- fungi	
	SO1.7 Classification of microorganism- cyanobacteria and virus		**CI1.7** Classification of microorganism- cyanobacteria and virus	

	SO1.8 Structure of microbial cell, characteristics of cyanobacteria and actinomycetes		**CI1.8** Structure of microbial cell, characteristics of cyanobacteria and actinomycetes	
	SO1.9 Structure of microbial cell, characteristics of virus, nutrition, metabolism, propagation		**CI1.9** Structure of microbial cell, characteristics of virus, nutrition, metabolism, propagation	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Summarizes classification of microorganism- Bacteria.
	SW1.2 Mini Project	Demonstrate how to isolate microbes from soil.
	SW1.3 Other Activities (Specify)	correlate the structural differences between bacterial cells and viruses.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	02	01	02	14

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO2-52BT102.2: Identify and show the structural, physiological, and genetic similarities and differences of the main categories of microorganisms	**SO2.1** What is Microscopy: light microscope- basic principles	**LI2.1** Discuss how to prepare a permanent slide	**CI2.1** Global and local alignments work	**SL2.1** Practice microscope optimization
	SO2.2 How many types of microscopy 1		**CI2.2** Types of Microscopy	**SL2.2** Recall types of microscopes
	SO2.3 Understanding Electron microscopy – principles, working function		**CI2.3** Electron microscopy – principles, working function	
	SO2.4 electron probe, transmitted electron		**CI2.4** electron probe, transmitted electron	
	SO2.5 image formation, backscattering, secondary electrons.		**CI2.5** image formation, backscattering, secondary electrons.	
	SO2.6 X-ray diffraction		**CI2.6** X-ray diffraction	

	SO2.7 Augur electron and cathode luminescence's		**CI2.7** Augur electron and cathode luminescence's	
	SO2.8 Types of Electron Microscopy TEM & SEM		**CI2.8** Types of Electron Microscopy TEM & SEM	
	SO2.9 STEM-sample preparation for EM analysis		**CI2.9** STEM-sample preparation for EM analysis	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Justify the role of SEM and TEM in biotechnology.
	SW2.2 Mini Project	Differentiate between SEM and TEM.
	SW2.3 Other Activities (Specify)	Incorporate some YouTube videos based on features of how TEM works.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	02	16

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO3-52BT102.3: Analyze parameters to control microbial growth.	**SO3.1** What is Microbial Growth	**LI3.1** Basics of three phases of growth based on OD	**CI3.1** Microbial Growth	**SL3.1** Learn how to culture microbes
	SO3.2 Mathematical expression of growth	**LI3.2** How to cultivate in different media	**CI3.2** Mathematical expression of growth	**SL3.2** Recall growth curve
	SO3.3 Measurement of growth.		**CI3.3** Measurement of growth.	
	SO3.4 Synchronous culture and continuous culture		**CI3.4** Synchronous culture and continuous culture	
	SO3.5 Types of Cultural Media		**CI3.5** Culture media	
	SO3.6 handling pathogens		**CI3.6** handling pathogens	

	SO3.7 sterilization, safety in the microbiology laboratory		**CI3.7** sterilization, safety in the microbiology laboratory	
	SO3.8 Elaborate pure culture technique		**CI3.8** Pure culture technique	
	SO3.9 Culture collection and preservation of microbial culture.		**CI3.9** culture collection and preservation of microbial culture.	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Write about the pure culture technique.
	SW3.2 Mini Project	Make a flow chart of steps of pure culturing
	SW3.3 Other Activities (Specify)	How many types of cultural media are generally found with the help of the internet?

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	02	16

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO4-52BT102.4: Can able to assess interactions between microbes, hosts, and environment.	**SO4.1** Relate Microbiology & Man: - Pathogen	**LI4.1** Basics of pathogenicity	**CI4.1** Microbiology & Man: - Pathogen	
	SO4.2 What is the mode & source of infection- carriers and vectors	**LI4.2** Draw a flow chart of the source of infection.	**CI4.2** Mode & source of infection- carriers and vectors	**SL4.1** Study the source of infection
	SO4.3 Explain congenital infection		**CI4.3** Congenital infection	
	SO4.4 pathogenesis and prophylaxis - Bacterial		**CI4.4** pathogenesis and prophylaxis - Bacterial	**SL4.2** Study the pathogenesis & prophylaxis
	SO4.5 pathogenesis and prophylaxis - fungi		**CI4.5** pathogenesis and prophylaxis - fungi	
	SO4.6 Pathogenesis and prophylaxis – viral and protozoans		**CI4.6** Pathogenesis and prophylaxis – viral and protozoans	

	SO4.7 Antimicrobial agents and their mode of action- antibacterial		**CI4.7** Antimicrobial agents and their mode of action- antibacterial	
	SO4.8 Antimicrobial agents and their mode of action- antiviral		**CI4.8** Antimicrobial agents and their mode of action- antiviral	
	SO4.9 antiviral, antifungal, anti-parasitic agents.		**CI4.9** antiviral, antifungal, anti-parasitic agents.	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Write about antimicrobial agents.
	SW4.2 Mini Project	pathogenesis and prophylaxis – Bacterial, fungi, and virus.
	SW4.3 Other Activities (Specify)	Search and learn via YouTube pathogenesis.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	02	16

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO5-52BT102.5: Microbial diversity assessment employs culture-dependent and culture-independent methods, each with distinct merits and demerits, including culture-dependent methods' specificity and culture-independent methods' broader	**SO5.1** Microbial diversity: Methods to assess microbial diversity	**LI5.1** How to perform CFU in the lab	**CI5.1** Microbial diversity: Methods to assess microbial diversity	**SL5.1** Study the microbial diversity
	SO5.2 What are the merits and demerits of culture-dependent	**LI5.2** Basics of culture-dependent method	**CI5.2** Merits and demerits of culture-dependent.	**SL5.2** Classify different types of independent methods of culturing
	SO5.3 Distinguish merits and demerits of culture-independent		**CI5.3** Merits and demerits of culture-independent	

	SO5.4 & SO5.5 Elaborate molecular analysis of bacterial community		**CI5.4 & CI5.5** Molecular analysis of bacterial community	
	SO5.6 What is gel electrophoresis		**CI5.6** gel electrophoresis	
	SO5.7 How restriction fragment length polymorphism		**CI5.7** Restriction fragment length polymorphism	
	SO5.8 & SO5.9 What is amplified ribosomal DNA and restriction		**CI5.8 & CI5.9** amplified ribosomal DNA and restriction	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Write about RFLP.
	SW5.2 Mini Project	Molecular analysis of bacterial community.
	SW5.3 Other Activities (Specify)	Try to learn and apply gel electrophoresis of the DNA.

Course duration (in hours) to attain Course Outcomes:

Course Title: Microbial Technology **Course Code:** 52BT102

Course Outcomes (COs)	**Class lecture (CI)**	**Laboratory Instruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO1-52BT102.1: Able to Recognize and evaluate the major groups of microorganisms; classification, diversity, and ubiquity	9	2	2	1	**14**
CO2-52BT102.2: Identify and show the structural, physiological, and genetic similarities and differences of the main categories of microorganisms.	9	2	2	1	**14**

CO3-52BT102.3: Analyse parameters to control microbial growth.	9	4	2	1	**16**
CO4-52BT102.4: Can able to assess interactions between microbes, hosts, and environment.	9	4	2	1	**16**
CO5-52BT102.5: Microbial diversity assessment employs culture-dependent and culture-independent methods, each with distinct merits and demerits, including culture-dependent methods' specificity and culture-independent methods' broader	9	4	2	1	**16**
Total Hours	**45**	**16**	**10**	**05**	**76**

End-semester Assessment Scheme for setting up question papers and assessments to evaluate the Course Outcome:

Course Title: Microbial Technology **Course Code:** 52BT102

Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1-52BT102.1: Able to Recognize and evaluate the major groups of microorganisms; classification, diversity, and ubiquity	02	03	04	1	**10**
CO2-52BT102.2: Identify and show the structural, physiological, and genetic similarities and differences of the main categories of microorganisms.	03	04	02	1	**10**
CO3-52BT102.3: Analyze parameters to control microbial growth.	02	05	02	1	**10**
CO4-52BT102.4: Can able to assess interactions between microbes, hosts, and environment.	02	05	02	1	**10**
CO5-52BT102.5: Microbial diversity assessment employs culture-dependent and culture-independent methods, each with distinct merits and demerits, including culture-dependent methods' specificity and culture-independent methods' broader	03	04	02	1	**10**
Total Marks	**12**	**21**	**12**	**05**	**50**

***Legend*: A-** Apply; **An-** Analyze; **E-** Evaluate; **C-** Create

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	Microbiology: Davis, B.D Dulbecco, R., Eiser, H.N. and Ginsberg, H.S. 2014
2	Microbiology: Pelczar, M.T 2023
3	A Textbook of Microbiology: R.C. Dubey and D. K. Maheshwari 2022

(b) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Roleplay
6. Visit to Microbiology lab
7. Demonstration
8. ICT Based Teaching Learning
9. Brainstorming

CO, PO, and PSO Mapping

Program Name: M.Sc. Biotechnology
Semester: Ist Sem
Course Title: Microbial Technology
Course Code: 52BT102

Course Outcome (Cos)	Program Specific Outcomes (PSOs)							
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-52BT102.1: Able to Recognize and evaluate the major groups of microorganisms; classification, diversity, and ubiquity	2	-	-	1	2	2	1	1
CO2-52BT102.2: Identify and show the structural, physiological, and genetic similarities and differences of the main categories of microorganisms.	-	-	-	-	-	1	2	-
CO3-52BT102.3: Analyze parameters to control microbial growth.	-	1	1	1	-	1	1	1
CO4-52BT102.4: Can able to assess interactions between microbes, hosts, and environment.	-	1	1	-	2	2	1	3
CO5-52BT102.5: Microbial diversity assessment employs culture-dependent and culture-independent methods, each with distinct merits and demerits, including culture-dependent methods' specificity and culture-independent methods' broader	1	1	1	-	-	1	3	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2, 3	**CO1-52BT102.1:** Able to Recognize and evaluate the major groups of microorganisms; classification, diversity, and ubiquity	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	**IL 1**	1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8, 1.9	**1SL-1,2**
PO 1,2,3,4,5 PSO 1,2, 3	**CO2-52BT102.2:** Identify and show the structural, physiological, and genetic similarities and differences of the main categories of microorganisms.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO 2.6 SO2.7 SO2.8 SO2.9	**IL 1**	2.1, 2.2, 2.3, 2.4.2.5,2.6,2.7,2.8,2.9	**2SL-1,2**
PO 1,2,3,4,5 PSO 1,2, 3	**CO3-52BT102.3:** Analyze parameters to control microbial growth.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	**IL 1** **IL 2**	3.1,3.2,3.3,3.4,3.5,3.6,3.7 3.8,3.9	**3SL-1,2**
PO 2,3,4,5 PSO 1,2, 3	**CO4-52BT102.4:** Can able to assess interactions between microbes, hosts, and environment.	SO4.1 SO4.2 SO4.3 SO4.4,SO 4.5,SO4.6 SO4.7 SO4.8 SO4.9	**IL 1** **IL 2**	4.1,4.2,4.3,4.4,4.5,4.6,4.7,4.8,4.9	**4SL-1,2**
PO 1,2,3,5 PSO 1, 2, 3	**CO5-52BT102.5:** Microbial diversity assessment employs culture-dependent and culture-independent methods, each with distinct merits and demerits, including culture-dependent methods' specificity and culture-independent methods' broader	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9	**IL 1** **IL 2**	5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8,5.9	**5SL-1,2**

Curriculum Developer Team:
Prof. Kamlesh Choure
Prof. Ashwini A. Waoo

Prof. Deepak Mishra
Dr. Kamlesh Choure
Er. Arpit Srivastava

Program Name	**Masters of Science (M.Sc.)- Biotechnology**	
Semester	I	
Course Code:	52BT103	
Course title:	Advanced Biochemistry	**Curriculum Developer**: Mrs. Keerti Samdariya, Assistant Professor
Pre-requisite:	Student should have basic knowledge of biomolecules, their chemistry and metabolism of biomolecules.	
Rationale:	The paper on Advanced Biochemistry in an MSc Biotechnology program explores the role of biomolecules and their metabolic activity in biological systems. The living systems synthesize four primary types of biomolecules within the body. This study enables Students to learn how biomolecules promote different biological processes, which are necessary for life. They vary in structures and sizes. metabolism is a complex process that is essential for the body to function properly. It is important for students to understand the role of biomolecules and metabolism in maintaining a healthy body and lifestyle.	
Course Outcomes (COs):	**CO1-52BT103.1:** Understand the Structure, classification and the properties of Biomolecules.	
	CO2-52BT103.2: Extend biochemistry of amino acids and protein.	
	CO3-52BT103.3: Understanding of enzyme kinetics and immobilization techniques.	
	CO4-52BT103.4: To become familiar with fundamental Metabolic activity of carbohydrates and lipids.	
	CO5-52BT103.5: Apply the ideas and concept of bioenergetics and metabolism.	

Scheme of Studies:

Board of Study	CourseCode	Course Title	Scheme of studies (Hours/Week)					Total Credits(C) (L: T: P=3:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Basic Science Course (BSC)	52BT103	Advanced Biochemistry	3	2	1	1	7	3+1=4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);
SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits.
Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CAT+CT+SA+AT)		
BSC	52BT103	Advanced Biochemistry	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
BSC	**52BT153**	Advanced Biochemistry	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	02	16

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO1-52BT103.1: Understand the structure, classification, and properties of Biomolecules.	**SO1.1** Clarify the Chemical foundation of biology.	**LI1** Calibration of Ph meter.	**CI 1.1** Clarify the Chemical foundation of biology.	
	SO1.2 & SO1.3 Determine the structure of carbohydrates.	**LI2** Detect the presence of biomolecules in the given sample.	**CI 1.2 & CI1.3** Determine the structure of carbohydrates.	**SL1.1** Understand the role of carbohydrates.

	SO1.4 Explain the physical properties of carbohydrates.		**CI 1.4** Explain the physical properties of carbohydrates.	**SL1.2** Learn the naming system of carbohydrate and lipid
	SO1.5 Explain the chemical properties of carbohydrates.		**CI 1.5** Explain the chemical properties of carbohydrates.	
	SO1.6 & SO1.7 Nomenclature, classification, structure, properties of lipid.		**CI 1.6 & CI1.7** Nomenclature, classification, structure, properties of lipid.	
	SO1.8 Structure and properties of fatty acids		**CI1.8** Structure, and properties of fatty acids	
	SO1.9 Differentiate the use of lipids and carbohydrates in biotechnology		**CI 1.9** Differentiate the use of lipids and carbohydrates in biotechnology	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Differentiate between reducing and non-reducing disaccharides
	SW3.2 Mini Project	Importance of biochemistry and its applications
	SW3.3 Other Activities (Specify)	Find out some you tube videos based on chemical tests for carbohydrates and lipids.

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	03	17

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO52BT103.2: Extend biochemistry of amino acids and protein.	**SO2.1** Clarify the Structure of amino acids.	**LI 1** focusing on Structure and properties of amino acids	**CI 2.1** Clarify the Structure of amino acids.	**SL2.1** Understand the role of amino acids
	SO2.2 Clarify the properties of amino acids.		**CI 2.2** Clarify the properties of amino acids.	
	SO2.3 Elucidation of primary and higher order structures of protein	**LI 2** To study chemical reaction of protein and	**CI 2.3** Elucidation of primary and higher order structures of protein	

		amino acids		
	SO2.4 & SO2.5 Understand Ramachandran plot, structure & function relationship in model proteins like ribonuclease A, myoglobin, and hemoglobin.	.	**CI2.4 & CI2.5** Understand Ramachandran plot, structure & function relationship in model proteins like ribonuclease A, myoglobin, and hemoglobin.	**SL2.2** Learn the Ramachandran plot and structure & function of ribonuclease A, myoglobin, and hemoglobin.
	SO2.6 Classify Plant hormone and animal hormone		**CI 2.6** Classify Plant hormone and animal hormone	
	SO2.7 Explaining fat-soluble Vitamin- types and structure.		**CI 2.7** Explaining fat soluble Vitamin- types and structure.	**SL2.3** Discriminate Vitamin- types and structure.
	SO2.8 & SO2.9 Explaining water-soluble Vitamin- types and structure.		**CI 2.8 & CI2.9** explaining water-soluble Vitamin- types, and structure.	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Differentiate between fat- and water-soluble vitamins.
	SW2.2 Mini Project	Draw ray diagram of classification of amino-acid classification
	SW2.3 Other Activities (Specify)	Find out some you tube videos based on the elucidation of primary and higher-order structures of protein.

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	02	16

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO-3 52BT103.3: Understanding of enzyme kinetics and immobilization techniques.	**SO3.1** Illustrating General Characteristics of Enzymes.	**LI3.1** Chemical test for enzymes.	**CI 3.1** Illustrating General Characteristics of Enzymes.	**SL3.1** Read in detail the enzymes.

	SO3.2 Explain classification, and of enzymes.		**CI3.2** Explain classification, and of enzymes.	
	SO3.3 Explain nomenclature of enzymes.	**LI3.2** To study immobilization techniques.	**CI3.3** Explain nomenclature of enzymes.	
	SO3.4 & SO3.5 Explaining Kinetics of Single Substrate Reaction	.	**CI 3.4 & CI3.5** Explaining Kinetics of Single Substrate Reaction	.
	SO3.6 Differentiate enzyme inhibition and its types,		**CI 3.6** Differentiate enzyme inhibition and its types	
	SO3.7 Explain Coenzymes and their role.		**CI 3.7** Explain Coenzymes and their role.	
	SO3.8 & SO3.9 Explain Immobilization of enzyme, technique and applications		**CI 3.8 & CI3.9** Explain Immobilization of enzyme, technique and applications	**SL3.2** Study the enzyme immobilization

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail on Classification and nomenclature of enzymes
	SW3.2 Mini Project	Describe Isolation and purification of enzyme.
	SW3.3 other activity	Find out some you tube videos based on enzyme activity

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	02	16

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**

CO-4 52BT103.4: To become familiar with fundamental Metabolic activity of carbohydrates and lipids.	**SO4.1** Illustrating Principles of bioenergetics.	**LI4.1** To analyze the Immobilization process.	**Unit-4** **CI 4.1** Principles of bioenergetics	**SL 4.1** Understand the metabolic role of ATP
	SO4.2 Illustrating Principles of biological oxidation-reduction reaction.	**LI4.2** To study metabolic roles of ATP-phosphoryl group transfer	**CI 4.2** Principles of Biological oxidation-reduction reaction.	
	SO4.3 Explaining metabolic roles of ATP-phosphoryl group transfer, and nucleotidyl group transfer.		**CI4.3** Explaining metabolic roles of ATP-phosphoryl group transfer, nucleotidyl group transfer	.
	SO4.4 & SO4.5 Differentiate glycolysis, gluconeogenesis		**CI4.4 & CI4.5** Explain glycolysis, gluconeogenesis	**SL 4.2** Learn the Differentiation glycolysis, gluconeogenesis
	SO4.6 Explain TCA cycle.		**CI4.6** Explain TCA cycle.	
	SO4.7 Explain glycogen synthesis.		**CI4.7** explain the pathway of glycogen synthesis.	
	SO4.8 Explain glycogenolysis.		**CI4.8** explains the pathway of glycogenolysis.	
	SO4.9 Explain oxidative phosphorylation.		**CI4.9** explains the pathway of oxidative phosphorylation.	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	llustrating Principles of bioenergetics, biological oxidation-reduction reaction.
	SW4.2 Mini Project	Describe the glycogen synthesis
	SW4.3 Other Activities (Specify)	Find out some you tube videos based on metabolic activity of carbohydrates

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	02	16

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)

CO52BT103.5: Explain ideas and concepts of bioenergetics and metabolism.	**SO5.1** Elucidate Biosynthesis of lipids	**LI5.1** Detect the presence of lipids in the given sample.	**Unit-5** **CI5.1** Biosynthetic pathway of lipids.	**SL5.1** Understand the metabolic role of lipids
	SO5.2 Explain the beta oxidation pathway of lipids.	**LI5.2** Detect the presence of amino acid in the given sample.	**CI5.2** Explain the beta oxidation pathway of lipids.	**SL5.2** Learn the Differentiation between Disorder associated with defect in carbohydrate, amino acid and lipid metabolism
	SO5.3 Explain the alfa oxidation pathway of amino acids.		**CI5.3** Explain the alfa oxidation pathway of amino acids.	
	SO5.4 & SO5.5 Disorder associated with defect in carbohydrate, amino acid and lipid metabolism.		**CI5.4 & CI5.5** Disorder associated with defect in carbohydrate, amino acid and lipid metabolism.	
	SO5.6 Explain the degradation of amino acids.		**CI5.6** Explain the degradation of amino acids.	
	SO5.7 Recognize Disorder associated with defects in carbohydrate.		**CI 5.7** Recognize Disorder associated with defects in carbohydrate.	
	SO5.8 Recognize Disorder associated with defect in amino acids .		**CI 5.8** Recognize Disorder associated with defect in amino acids .	
	SO5.9 Recognize Disorder associated with defect in lipid metabolism.		**CI 5.9** Recognize Disorder associated with defect in lipid metabolism.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	llustrating Biosynthesis Degradative pathway of lipids.
	SW5.2 Mini Project	A disorder associated with defects in carbohydrate, amino acid and lipid metabolism
	SW5.3 Other Activities (Specify)	Prepare one article explaining the degradation of amino acid.

Course duration (in hours) to attain Course Outcomes:

Course Title: Advanced Biochemistry **Course Code: 52BT103**

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-52BT103.1: Understand the Structure, classification and the properties of Biomolecules.	9	4	2	1	16
CO2-52BT103.2: Extend biochemistry of amino acids and protein.	9	4	3	1	17
CO3-52BT103.3: Understanding of enzyme kinetics and immobilization techniques.	9	4	2	1	16
CO4-52BT103.4: To become familiar with fundamental Metabolic activity of carbohydrates and lipids.	9	4	2	1	16
CO5-52BT103.5: Apply the ideas and concept of bioenergetics and metabolism.	9	4	2	1	16
Total Hours	45	20	11	05	81

End-semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Advanced Biochemistry **Course Code: 52BT103**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-52BT103.1: Understand the Structure, classification and the properties of Biomolecules.	2	1	1	1	5
CO2-52BT103.2: Extend biochemistry of amino acids and protein.	2	4	2	2	10
CO3-52BT103.3: Understanding of enzyme kinetics and immobilization techniques.	3	5	5	2	15
CO4-52BT103.4: To become familiar with fundamental Metabolic activity of carbohydrates and lipids.	2	3	3	2	10
CO5-52BT103.5: Apply the ideas and concept of bioenergetics and metabolism.	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	Principles of biochemistry David L. Nelson, Michael Cox WH Freeman 7 & 2017

2	Fundamentals of biochemistry j. l. jain; S.chand 6 & 2005
3	U. Satyanarayana Kindle Edition Elsevier India 5 & 2017

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to virology lab (BSL-3)
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: M. Sc. Biotechnology
Semester: I Semester
Course Title: Advanced Biochemistry
Course Code: 52BT103

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-52BT103.1: Understand the Structure, classification and the properties of Biomolecules.	1	2	2	3	1	2	2	1
CO2-52BT103.2: Extend biochemistry of amino acids and protein.	1	2	3	2	1	1	1	2
CO3-52BT103.3: Understanding of enzyme kinetics and immobilization techniques.	1	2	3	2	1	1	1	1
CO4-52BT103.4: To become familiar with fundamental Metabolic activity of carbohydrates and lipids.	-	1	1	-	2	1	1	3
CO5-52BT103.5: Apply the ideas and concept of bioenergetics and metabolism.	1	1	1	-	-	1	3	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2,3	**CO1-52BT103.1:** Understand the Structure, classification and the properties of Biomolecules.	SO1.1 SO1.2 SO1.3, SO1.4 SO1.5, SO1.6, SO1.7, SO1.8 SO1.9	**LI 1** **LI 2**	1.1,1.2,1.3,1.4,1.5,1.6,1.7, 1.8,1.9	**1SL-1,2**
PO 1,2,3,4,5 PSO 1,2,3	**CO2-52BT103.2:** Extend biochemistry of amino acids and protein.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5, SO2.6, SO2.7, SO2.8 SO2.9	**LI 1** **LI 2**	2.1, 2.2, 2.3, 2.4,2.5,2.6,2.7,2.8,2.9	**2SL-1,2**
PO 1,2,3,4,5 PSO 1,2,3	**CO3-52BT103.3:** Understanding of enzyme kinetics and immobilization techniques.	SO3.1 SO3.2 SO3.3 SO3.4, SO3.5, SO3.6, SO3.7, SO3.8 SO3.9	**LI 1** **LI 2**	3.1,3.2,3.3,3.4,3.5,3.6,3.7,3.8,3.9	**3SL-1,2**
PO 1,2,3,4,5 PSO 1,2,3	**CO4-52BT103.4:** To become familiar with fundamental Metabolic activity of carbohydrates and lipids.	SO4.1 SO4.2 SO4.3 SO4.4, SO4.5, SO4.6, SO4.7, SO4.8 SO4.9	**LI 1** **LI 2**	4.1,4.2,4.3,4.4,4.5,4.6,4.7,4.8,4.9	**4SL-1,2**
PO 1,2,3,4,5 PSO 1,2,3	**CO5-52BT103.5:** Apply the ideas and concept of bioenergetics and metabolism.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5, SO5.6, SO5.7, SO5.8 SO5.9	**LI 1** **LI2**	5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8,5.9	**5SL-1,2**

Curriculum Developer Team:
Prof. Kamlesh Choure
Prof. Ashwini A. Waoo
Prof. Deepak Mishra
Dr. Monika Soni
Er. Arpit Srivastava

Program Name	**Master of Science (M. Sc)- Biotechnology**	
Semester	I	
CourseCode:	52BT104	
Coursetitle:	Biostatistics and Computer Application	**Curriculum Developer**: Dr. Deepak Mishra And Er. Vinay Shrivastava
Pre-requisite:	Student should have basic knowledge of Mathematical concepts i.e. Mean, Median, Mode, Correlation etc. and computer such as Input devices, central processing unit and output devices. Student should aware of how to power on computer and how to shut down computer.	
Rationale:	The subject of Biostatistics and Computer Application in M.Sc. Biotechnology programme. Biostatistics serves as the cornerstone of evidence-based decision-making in the fields of biotechnology by providing rigorous methods for data analysis, study design, and interpretation. It enables researchers and practitioners to extract meaningful insights from complex biological and health-related data, facilitating advancements in disease prevention, diagnosis, and treatment. Computer Application software much like the suite of tools offered by Microsoft Office, is an indispensable resource in today's digital era. Just as Microsoft Office applications streamline and enhance productivity in various office tasks, this subject empowers individuals and organizations to make informed decisions about their computing resources, resulting in increased productivity and cost-efficiency. Much like Word helps craft documents, Excel crunches numbers, and PowerPoint delivers impactful presentations, our subject equips students with the knowledge and skills needed to navigate the dynamic world of personal computing. It's a bit like having the right software for the job, where understanding the right PC package configuration and customization is key to achieving desired outcomes.	
Course Outcomes (COs):	**CO1-52BT104.1:** Acquire proficiency in fundamental statistical concepts, methods, and techniques relevant to biostatistics, **CO1-52BT104.2: A**pply statistical methods to analyze biological data sets, interpret results, and draw meaningful conclusions **CO1-52BT104.3:** Acquire the basic and advances knowledge of COMPUTER and its characteristics. **CO1-52BT104.4:** Acquire the basic and advances knowledge of C programming, and HTML programming. **CO1-52BT104.5:** Acquire the basic and advances knowledge of MS WORD, MS EXCEL, MS POWERPOINT.	

Scheme of Studies:

Board ofStudy	CourseCode	CourseTitle	Scheme ofstudies (Hours/Week)					Total Credits(C) (L:T:P=2:1:1)
			Cl	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
Discipline Specific Course (DSC)	52BT104	Biostatistics and Computer Application	3	2	1	5	11	2+1+1=4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);
SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits.
Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
DSC	52BT104	Biostatistics and Computer Application	**15**	**20**	**10**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
DSC	**52BT154**	Biostatistics & Computer Application	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	04	01	05	19

Course outcome (CO)	**Session Outcomes(SOs)**	**Laboratory Instruction(LI)**	**Class room Instruction(CI)**	**Self-Learning(SL)**
CO1-52BT104.1: Acquire proficiency in fundamental	**SO1.1** Define and Describe concept of		**Unit 1** **CI1.1** Statistical	**SL1.1** Search various reference

statistical concepts, methods, and techniques relevant to biostatistics	statistical population and basic terminology used		population	books and study material to start the learning
	SO1.2 Describe about different sampling methods		**CI1.2** sampling methods	**SL1.2** Check the application of sampling in biological problems
	SO1.3 Explain about Tabulation of Data & its graphical representation.	**LI1.1** Graphical Representation of Data	**CI1.3** tabulation of data & its graphical representation.	**SL1.3** Learn about various categories of data presentation
	SO1.4 Study the different measures of central Tendency	**LI1.2** Solve the numerical Problems related to Central Tendency	**CI1.4** Measures of central tendency– Mean,	**SL1.4** Study the biological problems by application of measure of central tendency
	SO1.5 Study of median		**CI1.5** Median,	
	SO1.6 Describe concept of Mode		CI1.6 Mode	
	SO1.7 Assess the concept of measures of Dispersion		**CI1.7** Measures of dispersion – range,	**SL1.5** Study the biological problems by application of measure of dispersion
	SO1.8 Describe concept of Standard deviation		**CI1.8** Standard deviation	
	SO1.9 Describe concept of variance		**CI1.9** variance	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Explain various types of data and its presentation techniques
	SW1.2 Mini Project	Describe the concept and application of measures of central tendency
	SW1.3 Other Activities (Specify)	Find out examples of measures of central tendency in different biological processes and experiments.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	05	19

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self Learning (SL)**
CO1-52BT104.2: Apply statistical methods to analyze biological data sets, interpret results, and draw meaningful conclusions	**SO2.1** Simple and linear regression	**LI2.1** Find out regression equation X on Y	**Unit-II** **CI2.1** Simple and linear regression	**SL2.1** Enlist the different biological problem related for statistical analysis.
	SO2.2 Explain about concept and methods of correlation	**LI2.2** Problems related to correlation.	**CI2.2** correlation	**SL2.2** Assess role of regression and correlation
	SO2.3 Explain about concept of hypothesis		**CI2.3** Explain about concept of hypothesis	**SL2.3** Learn about different types of hypothesis
	SO2.4 Explain about T-test		**CI2.4** T-test	**SL2.4** Learn about application of test of significance.
	SO2.5 Describe about F Test		**CI2.5** F test	**SL2.5** Learn about different parametric tests.
	SO2.6 Describe significance of Chi-Square Test		**CI2.6** Chi-Square Test	
	SO2.7 Describe about ANOVA		**CI2.7** one & two way analysis of variance (ANVOA)	

	SO2.8 Assess the concept of block designs		**CI2.8** randomization, randomized block design	
	SO2.9 Explain about data mining		**CI2.9** Introduction of data mining	

Suggested Sessional Work (SW):*anyone*	**SW2.1** Assignments	Describe various techniques used for testing hypothesis
	SW2.2 Mini Project	Select any biological problems and investigate it statistically.
	SW2.3 Other Activities (Specify)	Prepare list of application of parametric test.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	04	01	05	19

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction(LI)**	**Class room Instruction (CI)**	Self-Learning(SL)
CO1-52BT104.3: Acquire the basic and advances knowledge of COMPUTER and its characteristics	**SO3.1** Understanding fundamentals of computer	**LI3.1** Computer start and operating.	**Unit-III** **CI3.1** Introduction of computer: Definition	**SL 3.1** Search various reference books and study material to start the learning in computer
	SO3.2 & SO3.3 study different characteristics of computer	**LI3.2** Computer software and hardware types.	**CI3.2 & CI3.3** Characteristics, hardware, Software, Types of computer	**SL3.2** Check the application of computer
	SO3.4 & SO3.5 learning flowchart ,and binary number system and others		**CI3.4 & CI3.5** flow chart, number systems.	**SL3.3** Learn about various characteristics of computer.
	SO3.6 & SO3.7 criticizing OSI-model		**CI3.6 & CI3.7** OSI Model	**SL3.4.** Learn internet model
	SO3.8 & SO3.9 understanding internet, its growth and application		**CI3.8 & CI3.9** Internet & its application, E-mail concept PNS.	**SL3.5** Study internet and its uses

Suggested Sessional Work (SW):*anyone*	**SW3.1** Assignments	Describe Characteristics, hardware, Software, and Types of computer
	SW3.2 Mini Project	Describe Internet & its application, E-mail concept PNS.
	SW3.3 Other Activities (Specify)	criticizing OSI-model

Items	CI	LI	SW	SL	TOTAL
Approax hrs	09	04	01	05	19

Course Outcome (CO)	**Session Outcomes(SOs)**	**Laboratory Instruction(LI)**	**Classroom Instruction(CI)**	**Self-Learning(SL)**
CO1-52BT104.4: Acquire the basic and advances knowledge of C programming, and HTML programming.	**SO4.1**Introduction to MS-DOS	**LI4.1** Computer start MS-DOS operating.	**CI4.1** Introduction to MS-DOS	**SL4.1** Search study material to learn MS-DOS
	SO4.2 Introduction to C programming	**LI4.2** MS-DOS commands	**CI4.2** internal ms-dos commands	**SL4.2**Learn about external commands
	SO4.3 Introduction to HTML AND ITS TAGS		**CI4.3** external ms-dos commands	
	SO4.4 Introduction to Database		**CI4.4** introduction to C language	**SL4.3**Learn c language
	SO4.5 understanding advantages of DBMS		**CI4.5** programming in c	
	SO4.6 & SO4.7 introduction to HTML and its tags		**CI4.6 & CI4.7** introduction to HTML and its tags	**SL4.4**Study the html and its tags
	SO4.8 & SO4.9 introduction to Database		**CI4.8 & CI4.9** introduction to Database	**SL4.5** Study database

Suggested Sessional Work (SW):*anyone*	**SW4.1** Assignments	Describe internal, and external ms-dos commands.
	SW4.2 Mini Project	Describe C language and its programming.
	SW4.3 Other Activities (Specify)	Introduction to database.

Item	CI	LI	SW	SL	TOTAL
Approx .Hrs	09	02	01	04	16

Course Outcome (CO)	**Session Outcomes(SOs)**	**Laboratory Instruction(LI)**	**Classroom Instruction(CI)**	**Self-Learning(SL)**
CO1-52BT104.5: Acquire the basic and advances knowledge of MS WORD, MS EXCEL, MS POWERPOINT.	**SO5.1** Introduction to MS Word and Document Creation & editing	**LI5.1** Start MS-office operating & MS-word documents and editing.	**Unit-V** **CI5.1** 1Introduction to MS office, MS WORD and Document Creation & editing	**SL5.1** learn all latest applications of internet and ms-office
	SO5.2 Introduction to Excel and Data Entry		**CI5.2** Introduction to Excel and Data Entry & Working with numbers and formula	
	SO5.3 introduction of ms-excel, features of excel		**CI5.3** introduction of ms-excel, features of excel	**SL5.2** use MS EXCEL
	SO5.4 cell formatting, uses of function & formula		**CI5.4** cell formatting, uses of function & formula	
	SO5.5 sorting & filtering & working with graph in excel		**CI5.5** sorting & filtering & working with graph in excel	
	SO5.6 introduction to ms-powerpoint, feature of powerpoint		**CI5.6** introduction to ms-powerpoint, feature of powerpoint	**SL5.3** Study the MS-powerpoint
	SO5.7 inserting slide, working with slide		**CI5.7** inserting slide, working with slide	
	SO5.8 working with slide animation & transaction		**CI5.8** working with slide animation & transaction	

	SO5.9 prepare a desired presentation in POWERPOINT		**CI5.9** prepare a desired presentation in POWERPOINT	**SL5.4** Learning presentation

Suggested Sessional Work (SW):*anyone*	**SW5.1** Assignments	Describe MS WORD and Document Creation, editing.
	SW5.2 Mini Project	Describe ms-excel, features of excel, cell formatting, uses of function & formula.
	SW5.3 Other Activities (Specify)	prepare a desired presentation in POWERPOINT

Course duration (in hours) to attain Course Outcomes:

Course Title: Animal Biotechnology **Course Code: 52BT104**

Course Outcomes(COs)	**Class lecture (CI)**	**Laboratory Instruction(LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (LI+CI+SL+SW)**
CO1-52BT104.1: Acquire proficiency in fundamental statistical concepts, methods, and techniques relevant to biostatistics	09	4	5	1	19
CO1-52BT104.2: Apply statistical methods to analyze biological data sets, interpret results, and draw meaningful conclusions	09	4	5	1	19
CO1-52BT104.3: Acquire the basic and advances knowledge of COMPUTER and its characteristics	09	4	5	1	19
CO1-52BT104.4: Acquire the basic and advances knowledge of C programming, and HTML programming.	09	4	5	1	19
CO1-52BT104.5: Acquire the basic and advances knowledge of MS WORD, MS EXCEL, MS POWERPOINT.	09	2	4	1	16
Total Hours	45	18	24	5	92

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Biostatistics and Computer Application **Course Code: 52BT104**

Course Outcomes					
	A	**A**	**E**	**C**	**Total Marks**
CO1-52BT104.1: Acquire proficiency in fundamental statistical concepts, methods, and techniques relevant to biostatistics	03	02	02	03	10
CO1-52BT104.2: Apply statistical methods to analyze biological data sets, interpret results, and draw meaningful conclusions	03	02	02	03	10
CO1-52BT104.3: Acquire the basic and advances knowledge of COMPUTER and its characteristics	03	03	03	01	10
CO1-52BT104.4: Acquire the basic and advances knowledge of C programming, and HTML programming.	02	03	05	00	10
CO1-52BT104.5: Acquire the basic and advances knowledge of MS WORD, MS EXCEL, MS POWERPOINT.	05	04	00	01	10
Total Marks	**16**	**14**	**12**	**8**	**50**

Legend: A: Apply, A: Analyze E: Evaluate, C: Create

Suggested learning Resources:

(a) Books:

S. No.	**Title**
1	fundamentals of computers by E balagurusamy
2	fundamentals of computers by Pk sinha
3	fundamentals of computers by Rajaraman
4	Biostatistics, P.N.Arora, P.K.Malhan, Himalaya Publishing House,Edition2 & 2005
5	Fundamentals of biostatistics, Khan and Khanam, Ukaaz Publication 2 & 2004
6	Elements Of Biostatistics, Prasad Rastogi Publication, edition, 3& 2009

(b) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to virology lab (BSL-3)
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Title: M. Sc. Biotechnology
Semester: I
Course Code: 52BT104
Course Title: Biostatistics and Computer Application

Course Outcome	Program Outcomes (POs)					Program Specific Outcomes (PSOs)		
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-52BT104.1: Acquire proficiency in fundamental statistical concepts, methods, and techniques relevant to biostatistics	**1**	**2**	**2**	**2**	**3**	**2**	**2**	**2**
CO1-52BT104.2: Apply statistical methods to analyze biological data sets, interpret results, and draw meaningful conclusions	**2**	**3**	**2**	**3**	**3**	**1**	**1**	**2**
CO1-52BT104.3: Acquire the basic and advances knowledge of COMPUTER and its characteristics	**1**	**2**	**1**	**1**	**3**	**2**	**2**	**1**
CO1-52BT104.4: Acquire the basic and advances knowledge of C programming, and HTML programming	**2**	**3**	**1**	**3**	**3**	**1**	**1**	**1**
CO1-52BT104.5: Acquire the basic and advances knowledge of MS WORD, MS EXCEL,MS POWERPOINT	**3**	**1**	**1**	**3**	**2**	**2**	**2**	**1**

Legend: **(1) Low (2) Medium (3) High**

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2,3	**CO1-52BT104.1:** Acquire proficiency in fundamental statistical concepts, methods, and techniques relevant to biostatistics	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	LI1.1,1.2	1.1,1.2,1.3,1.4,1.5, 1.6, 1.7, 1.8, 1.9	1SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO1-52BT104.2: A**pply statistical methods to analyze biological data sets, interpret results, and draw meaningful conclusions	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	LI2.1, 2.2	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9	2SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO1-52BT104.3:** Acquire the basic and advances knowledge of COMPUTER and its characteristics	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	LI3.1,3.2	3.1,3.2,3.3,3.4,3.5,3.6,3.7,3.8,3.9	3SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO1-52BT104.4:** Acquire the basic and advances knowledge of C programming, and HTML programming	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9	LI4.1,4.2	4.1,4.2,4.3,4.4,4.5,4.6,4.7,4.8.4.9	4SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO1-52BT104.5:** Acquire the basic and advances knowledge of MS WORD, MS EXCEL,MS POWERPOINT	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9	LI5.1	5.1,5.2,5.3,5.4,5.5, 5.6,5.7,5.8,5.9	5SL-1,2,3,4

Curriculum Developer Team:
Prof. Kamlesh Choure
Prof. Ashwini A. Waoo

Prof. Deepak Mishra
Dr. Monika Soni
Er. Arpit Srivastava

Program Name	**Masters of Science (M.Sc.)- Biotechnology**	
Semester	I	
Course Code:	52BT105	
Course itle:	Molecular Biology	Developer: Mrs. Shaily Mishra, Assistant Professor
Pre-requisite:	Student should have basic knowledge of biology, biological activity and related processes in living organisms.	
Rationale:	The paper on Molecular Biology in an M.Sc Biotechnology program aims to introduce and elaborate the students with the detailed understanding of structure and functional organization of gene with respect to molecular architecture and comparative analysis of both prokaryotic and eukaryotic organism. The course enlightens the students about the various processes such as DNA replication, transcription, translation, regulation, repair and advances in the topics in recent research.	
Course Outcomes (COs):	**CO1-52BT105.1** Understand molecular phenomena of DNA copying and transmission of information, its damage and repair mechanism. **CO2-52BT105.**2 Students are being able to understand mechanism of synthesis of RNA molecules from DNA and its processing. **CO3-52BT105.3** Molecular basis of biological activity in and between cells including protein synthesis, modification and interaction. **CO4-52BT105.4** The regulation of gene function, respond to environment and associated phenomena. **CO5-52BT105.5** Recognize various transposable element in DNA, advances in molecular activity such as antisense technology, genome mapping.	

Scheme of Studies:

Board ofStudy	CourseCode	CourseTitle	Scheme ofstudies (Hours/Week)					Total Credits(C) (L:T:P=3:0:1)
			Cl	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
Basic Science Course (BSC)	52BT105	Molecular Biology	3	2	1	3	9	3+1=4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);
SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits.
Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
BSC	52BT105	Molecular Biology	**15**	**20**	**10**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
BSC	**52BT155**	Molecular Biology	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

ApproximateHours

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	04	01	04	18

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-52BT105.1 Understand molecular phenomena of DNA copying and transmission of information, its damage and repair mechanism.	**SO1.1** Understand organization and structure of prokaryotic and eukaryotic organization.	**LI1.1** Isolation of genomic DNA from bacteria.	**Unit 1** **CI1.1** Organization of prokaryotic & eukaryotic genomes.	**SL1.1** Chemical structure of DNA and RNA
	SO1.2 Understand the Machinery involved in DNA replication.	**LI1.2** Isolation of plasmid DNA from bacteria	**CI1.2** Unit of replication, replication machinery in prokaryotes and eukaryotes.	**SL1.2** Types of DNA
	SO1.3 Learn about the role of different enzymes in DNA replication.		**CI1.3** Enzymology of DNA replication.	**SL1.3** Experiments to prove DNA as genetic Material

	SO1.4 Learn the mechanism of DNA replication.		**CI1.4** Steps involved in DNA replication.	**SL1.4** Cell Division
	SO1.5 Various causes of DNA damage.		**CI1.5** Causes of DNA damage	
	SO1.6 Understand the mechanism that involves repair of damaged DNA.		**CI1.6** Repair mechanism for DNA damage.	
	SO1.7 Genetic recombination process in prokaryotic		**CI1.7** Genetic Recombination: Homologous and non - homologous recombination.	
	SO1.8 Study the process of site specific mechanism		**CI1.8** Site specific recombination.	
	SO1.9 Genetic recombination process in eukaryotic organism.		**CI1.9** Genetic recombination process in eukaryotic organism.	

Suggested Sessional Work (SW):*anyone*	**SW1.1** Assignments	Watson and Crick double helical model, machinery involved in DNA replication, causes of DNA damage and process of recombination.
	SW1.2 Mini Project	Diagrammatic representation of various processes you studied with neat labelling.
	SW1.3 Other Activities (Specify)	Find out some you tube videos based on working model of biological activity associated with DNA.

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

ApproximateHours

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	02	01	01	13

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**

CO2-52BT105.2 Students are being able to understand mechanism of synthesis of RNA molecules from DNA and its processing.	**SO2.1** Understand the process involved in synthesis of RNA molecules from DNA.		**Unit-II** **CI2.1** Prokaryotic and eukaryotic transcription mechanism.	**SL2.1** Structure of different types of RNA.
	SO2.2 & SO2.3 Enzymes involved in RNA synthesis.	**LI2.1** Restriction digestion analysis.	**CI2.2 & CI2.3** Enzymes involved in RNA synthesis.	**SL2.2** DNA binding proteins and their interaction with DNA.
	SO2.4 Role of different transcription factors in process of transcription.		**CI2.4** General and specific transcription factors, promoter.	
	SO2.5 Mechanism of RNA synthesis in prokaryotes.		**CI2.5** Mechanism of RNA synthesis in prokaryotes.	
	SO2.6 Mechanism of RNA synthesis in eukaryotes.		**CI2.6** Mechanism of RNA synthesis in eukaryotes.	
	SO2.7 Post transcriptional modification in synthesized RNA.		**CI2.7** RNA processing of pre mRNA, tRNA and rRNA.	
	SO2.8 RNA processing of mRNA.		**CI2.8** 5'cap formation and 3'end processing and polyadenylation.	
	SO2.9 Learn the function of RNA splicing in regulation of gene expression.		**CI2.9** Importance of RNA splicing.	**SL2.3** Functions of regulatory proteins.

Suggested Sessional Work (SW):*anyone*	**SW1.1** Assignments	Describe mechanism of transcription in prokaryotes and eukaryotes.
	SW1.2 Mini Project	Diagrammatic representation of process of RNA processing in different types of RNAs.
	SW1.3 Other Activities (Specify)	Write the role of various proteins and enzyme involved in transcription process and RNA processing.

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of

ApproximateHours

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	02	01	02	14

Course Outcomes (COs) upon the course's conclusion.	

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO3-52BT105.3 Molecular basis of biological activity in and between cells including protein synthesis, modification and interaction.	**SO3.1** Role of various proteins in translation process in prokaryotes.	**LI3.1** Determination of molecular weight of DNA/RNA	**Unit-III** **CI3.1** Translation machinery in prokaryotes.	**SL3.1** Study the translation.
	SO3.2 Role of various proteins in translation process in eukaryotes.		**CI.3.2** Translation machinery in eukaryotes.	
	SO3.3 Study of genetic code and wobble hypothesis.		**CI3.2** Genetic code and wobble hypothesis	
	SO3.4 Steps involved in process of protein synthesis in prokaryotes.		**CI3.4** Mechanism of translation initiation, elongation and termination in prokaryotes.	
	SO3.5 Steps involved in process of protein synthesis in eukaryotes.		**CI3.5** Mechanism of translation initiation, elongation and termination in eukaryotes.	
	SO3.6 Post translational modifications.		**CI3.6** Co and post translation modification of protein,	
	SO3.7 Role of molecular chaperones.		**CI3.7** Molecular chaperones	
	SO3.8 & SO3.9 Learn about protein turnover and degradation.		**CI3.8 & CI3.9** Protein turnover and degradation.	**SL3.2** Study the protein turnover and degradation.

Suggested Sessional Work (SW):*anyone*	**SW3.1** Assignments	Describe the importance of post translation modification.
	SW3.2 Mini Project	Describe role of molecular chaperones in protein degradation.
	SW3.3 Other Activities (Specify)	Draw a chart of genetic code and watch you tube videos of models of protein structures.

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**ApproximateHours** **Item** | Cl | LI | SW | SL | Total **Approx.Hrs** | 09 | 02 | 01 | 02 | 14

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO4-52BT105.4 The regulation of gene function, respond to environment and associated phenomena.	**SO4.1** Positive and negative regulation of transcription.		**Unit-4** **CI4.1** Transcriptional regulation-positive & negative.	
	SO4.2 Understand the operon concept.		**CI4.2** Operon concept	
	SO4.3 To study different types of operon in prokaryotes		**CI4.3** Lactose, tryptophan and histidine operons.	
	SO4.4 Role of activator and repressor in control of gene expression.	**LI4.1** Cloning & Transformation	**CI4.4** Activator and repressor control of gene expression.	**SL4.1** Concept of gene and unit of gene.
	SO4.5 Understand the regulation mechanism in lambda phage.		**CI4.5** Transcriptional control in λ phage.	**SL4.2** Gene expression in phage
	SO4.6 Regulation control at transcription.		**CI4.6** Control of gene expression at transcription.	
	SO4.7 Regulation control at RNA processing level.		**CI4.7** Regulation control at RNA processing level.	
	SO4.8 & SO4.9 Regulation control at translation level.		**CI4.8 & CI4.9** Regulation control at translation level.	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Describe mechanism of gene regulation in prokaryotic and eukaryotic organism.
	SW4.2 Mini Project	Diagrammatic representation of gene regulation control at transcription, translation and processing level.
	SW4.3 Other Activities (Specify)	Prepare list of proteins and their functions involved in regulation and control of gene expression.

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**ApproximateHours** **Item** | Cl | LI | SW | SL | Total **Approx.Hrs** | 09 | 02 | 01 | 02 | 14

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO5-52BT105.5: Recognize various transposable element in DNA, advances in molecular activity such as antisense technology, genome mapping.	**SO5.1** Understand the function and structure of transposable elements in prokaryotes.		**Unit-5** **CI5.1**Transposable element in prokaryotes. Insertion sequences, transposons.	**SL5.1** Study about mobile genetic elements.
	SO5.2 Understand the function and structure of transposable elements in eukaryotes.		**CI5.2** Transposable element in eukaryotes. DNA and retrotransposons.	
	SO5.3 Study the mechanism of transposable elements in prokaryotes.		**CI5.3** Mechanism of transposition in prokaryotes.	
	SO5.4 Study the mechanism of transposable elements in eukaryotes.		**CI5.4** Mechanism of transposition in eukaryotes.	
	SO5.5 Understand the molecular mechanism of antisense and ribozyme technology.		**CI5.5** Antisense & ribozyme technology-molecular mechanism of antisense technology, ribozymes.	
	SO5.6 Understand concept and importance of genome mapping.		**CI5.6** Introduction to genome mapping.	**SL5.2** Study the Human Genome Project.
	SO5.7 Understand the genetic and physical map and		**CI5.7** Genetic & physical map.	
	SO5.8 Applications of molecular markers.	**LI5.1** PCR amplification study using thermal cycler.	**CI5.8** Molecular marker in genome analysis-RFLP, RAPD & AFLP analysis.	

Suggested Sessional	**SW5.1** Assignments	Write the mechanism of transposition in prokaryotes and eukaryotes.

Work (SW): *anyone*	**SW5.2** Mini Project	Draw and describe human genome project.
	SW5.3 Other Activities (Specify)	Find out some you tube videos of completed genome maps of various organisms.

Course duration (in hours) to attain Course Outcomes:

Course Title: Molecular Biology **Course Code: 52BT105**

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-52BT105.1: Understand molecular phenomena of DNA copying and transmission of information, its damage and repair mechanism.	09	4	4	1	18
CO2-52BT105.2 Students are being able to understand mechanism of synthesis of RNA molecules from DNA and its processing.	09	2	1	1	13
CO3-52BT105.3 Molecular basis of biological activity in and between cells including protein synthesis, modification and interaction.	09	2	2	1	14
CO4-52BT105.4 The regulation of gene function, respond to environment and associated phenomena.	09	2	2	1	14
CO5-52BT105.5: Recognize various transposable element in DNA, advances in molecular activity such as antisense technology, genome mapping.	09	2	2	1	14
Total Hours	45	12	11	05	73

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Molecular Biology **Course Code: 52BT105**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-52BT105.1: Understand molecular phenomena of DNA copying and transmission of information, its damage and repair mechanism.	02	01	01	01	05
CO2-52BT105.2 Students are being able to understand mechanism of synthesis of RNA	02	04	02	02	10

molecules from DNA and its processing.					
CO3-52BT105.3 Molecular basis of biological activity in and between cells including protein synthesis, modification and interaction.	03	05	05	02	15
CO4-52BT105.4 The regulation of gene function, respond to environment and associated phenomena.	03	03	03	01	10
CO5-52BT105.5: Recognize various transposable element in DNA, advances in molecular activity such as antisense technology, genome mapping.	05	04	01	00	10
Total Marks	15	17	12	06	50

***Legend*:A,** Apply;**An,** Analyze;**E,** Evaluate;**C,** Create

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	Genes V by Benjamin Lewin, Oxford University Press, New York,1994.
2	Gene IX, Benjamin Lewin Oxford University Press, New York,2006.
3	Principles of Genetics, Snustad and Simmons, Seventh Edition, John Wiley and Sons, Inc.,2015.
4	Molecular Cell Biology, Lodish et.al., W. H. Freeman and Company,Eighth Edition,2016.
5	Genomes 5 by T.A. Brown, John Wiley and sons (Asia)PTE LTD, New York, Fifth Edition2023

(b) Online Resources: Research papers and Google articles.

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to virology lab (BSL-3)
7. Demonstration
8. ICT Based teaching L

CO, PO and PSO Mapping

Program Name: M. Sc. biotechnology
Semester: I
Course Title: Molecular Biology
Course Code: 52BT105

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-52BT105.1: Understand molecular phenomena of DNA copying and transmission of information, its damage and repair mechanism.	**2**	**2**	**-**	**-**	**1**	**2**	**2**	**1**
CO2-52BT105.2 Students are being able to understand mechanism of synthesis of RNA molecules from DNA and its processing.	**3**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
CO3-52BT105.3 Molecular basis of biological activity in and between cells including protein synthesis, modification and interaction.	**2**	**2**	**-**	**1**	**-**	**1**	**1**	**3**
CO4-52BT105.4 The regulation of gene function, respond to environment and associated phenomena.	**2**	**2**	**1**	**1**	**1**	**1**	**1**	**3**
CO5-52BT105.5: Recognize various transposable element in DNA, advances in molecular activity such as antisense technology, genome mapping.	**1**	**1**	**1**	**-**	**1**	**1**	**3**	**2**

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2,3	**CO1-52BT105.1:** Understand molecular phenomena of DNA copying and transmission of information, its damage and repair mechanism.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	LI 1 LI 2	1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8,1.9	**1SL-1,2,3,4**
PO 1,2,3,4,5 PSO 1,2,3	**CO2-52BT105.**2 Students are being able to understand mechanism of synthesis of RNA molecules from DNA and its processing.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	LI 1	2.1, 2.2, 2.3, 2.4,2.5,2.6,2.7,2.8,2.9	**2SL-1**
PO 1,2,3,4,5 PSO 1,2,3	**CO3-52BT105.3** Molecular basis of biological activity in and between cells including protein synthesis, modification and interaction.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO2.9	LI 1	3.1,3.2,3.3,3.4,3.5,3.6,3.7,3.8,3.9	**3SL-1,2**
PO 1,2,3,4,5 PSO 1,2,3	**CO4-52BT105.4** The regulation of gene function, respond to environment and associated phenomena.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO2.9	LI 1	4.1,4.2,4.3,4.4,4.5,4.6,4.7,4.8,4.9	**4SL-1,2**
PO 1,2,3,4,5 PSO 1,2,3	**CO5-52BT105.5:** Recognize various transposable element in DNA, advances in molecular activity such as antisense technology, genome mapping.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO2.9	LI 1	5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8,5.9	**5SL-1,2**

Curriculum Developer Team:
Prof. Kamlesh Choure
Prof. Ashwini A. Waoo
Prof. Deepak Mishra
Dr. Monika Soni
Er. Arpit Srivastava

Program name	**Master of Science (M.Sc.)- Biotechnology**	
Semester	I	
Course Code:	52BT106	
Course title:	Bioanalytical Tools and Techniques	Developer: Dr. Kamlesh Kumar Soni, Assistant Professor
Pre-requisite:	Student should have basic knowledge of physics, chemistry and analytical techniques	
Rationale:	The paper on "Bioanalytical Tools and Techniques" in MSc Biotechnology program give the opportunity to understand the working principle and application of numerous tools like spectroscopy, chromatography, gel electrophoresis. The techniques like DNA microarray will advance the knowledge of research related to molecular biology, gene regulation	
Course Outcomes (COs):	**CO1-52BT106.1:** Recognize the finer points of microscopy. **CO2-52BT106.2:** Recognize the differences between colorimetry, fluorescence, and UV visible spectroscopy. **CO3-52BT106.3:** Calculate the Rf value from a chromatogram to study paper, ion exchange, and affinity chromatography apart. **CO4-52BT106.4**: Understand the working principle and application of electrophoresis **CO5-52BT106.5:** Learn the essential ideas behind centrifugation and electrophoresis and use them in real-world situations	

Scheme of Studies:

Board of Study	CourseCode	Course Title	Scheme of studies (Hours/Week)					Total Credits(C) (L:T:P=3:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Discipline Specific Course (DSC)	52BT106	Bioanalytical Tools & Techniques	3	2	1	3	9	3+1=4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);
SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits.
Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+SA+CAT+AT)		
DSC	52BT106	Bioanalytical Tools & Techniques	15	20	5	5	5	50	50	100

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	**Scheme of Assessment (Marks)**						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
DSC	**52BT156**	Bioanalytical Tools & Techniques	35	5	5	5	50	50	50

Unit-I: Introduction to Analysis	
Course-Curriculum: This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	Approximate Hours Item | Cl | LI | SW | SL | Total Approx. Hrs | 09 | 04 | 01 | 02 | 16

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-52BT106.1: Understand the essential ideas and immune system cells	1.1: Attain Good Laboratory Practice	1.1: Demonstration of working in the lab	1.1: Introduction to Analysis: Concept of Good Laboratory Practice and Quality Management	1.1: Study the various instructions of working in the labs
	1.2 &1.3: Discuss the Working principle and instrumentation of different instruments used in biotechnology laboratory		1.2 & 1.3: Working principle and instrumentation of different instruments used in biotechnology laboratory	
	1.4: Understand the Spectroscopy: Lambert Beer's Law, principle, instrumentation	1.2: Use and practices of Spectrophotometer	1.4: Spectroscopy: Lambert Beer's Law, principle, instrumentation	1.2: Principle of different spectroscopy
	1.5: Application of UV spectrophotometer		1.5: Application of UV spectrophotometer	
	1.6: Application of visible spectrophotometer		1.6: Application of visible spectrophotometer	
	1.7: Application of IR spectrophotometer		1.7: Application of IR spectrophotometer	
	1.8 & 1.9: NMR Spectroscopy		1.8 & 1.9: NMR Spectroscopy	

Suggested Sessional Work (SW): *anyone*	SW1.1 Assignments	Explain in details about good laboratory practices
	SW1.2 Mini Project	Ray diagram of all microscope you studied with neat labelling. And their applications
	SW1.3 Other Activities (Specify)	Find out the literature discussing about the advancement of spectrophotometer.

Unit-II: Different Techniques of Molecular Biology

Course-Curriculum:
This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	02	16

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO2-52BT106.2: Recognize the differences between colorimetry, fluorescence, and UV visible spectroscopy	2.1: Learn about the chemical important for DNA and RNA. isolation	2.1: DNA isolation from bacteria/plant/animal blood cells	2.1: Isolation of DNA and RNA	2.1: DNA precipitation and storage
	2.2: Advance the knowledge of protein isolation		2.2: Isolation of protein	
	2.3: Detail knowledge about DNA fingerprinting,		2.3: DNA fingerprinting	
	2.4 DNA foot printing & Imprinting		2..4: DNA foot printing, DNA imprinting,	
	2.5 DNA microarray- fundamental understanding		2.5: DNA microarray	
	2.6: DNA sequencing: learn various methods		2.6: DNA sequencing	
	2.7: know the blotting techniques principle		2.7: Blotting techniques- Introduction	
	2.8 & 2.9 : Understand difference among the southern blotting, northern blotting and western blotting and their applications	2.2: Demonstration of Western blotting	2.8 & 2.9: Southern blotting, northern blotting and western blotting.	2.2: Read in details about the blotting techniques

Suggested Sessional Work (SW): *anyone*	SW1.1 Assignments	Important precautions while working with RNA
	SW1.2 Mini Project	Prepare the poster evaluating different DNA sequencing m,ethods
	SW1.3 Other Activities (Specify)	Find out the videos discussing about the different blot techniques

Unit-III: Separation & Identification of Material

Course-Curriculum:
This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	02	16

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO3-52BT106.3: Calculate the Rf value from a chromatogram to study paper, ion exchange, and affinity chromatography apart	3.1: Read the principle behind the various chromatographic techniques	3.1: Thin layer chromatography	3.1: Concept of chromatography	3.1: Study the fundamentals of various chromatography
	3.2: Know the working principle of chromatography		3.2: Principle of chromatography	
	3.3 & 3.4: Paper chromatography, thin layer chromatography	3.2: Paper chromatography	3.3 & 3.4: Paper chromatography, thin layer chromatography	
	3.5: Column chromatography,		3.5: Column chromatography,	
	3.6: Understand about adsorption vs absorption and role in chromatography		3.6: Adsorption chromatography	
	3.7: Gas liquid chromatography,		3.7: Gas liquid chromatography,	3.2: Boost your knowledge for application of chromatographic techniques
	3.8: Affinity chromatography,		3.8: Affinity chromatography,	
	3.9: Gel permeation chromatography		3.9: Gel permeation chromatography	

Suggested Sessional Work (SW): *anyone*	Assignments:	What are the materials used as bead in different chromatography machine; explain in details
	Mini Project:	Make a poster explaining the principle of separation of ion exchange chromatography
	Other Activities (Specify):	Watch animation on explaining the functionality of HPLS and Gas chromatography

Unit IV: Electrophoresis

Course-Curriculum:
This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	03	17

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO4-52BT106.4: Understand the working principle and application of electrophoresis in real world	4.1: Understanding the basic concept of electrophoresis	4.1: DNA gel electrophoresis and DNA separation	4.1: Concept and basic principle of electrophoresis	4.1: Enhance your knowledge about the agar gel electrophoresis and polyacrylamide gel electrophoresis
	4.2: Fundamental knowledge of key factors affecting the mobility	4.2: PAGE for the separation of protein	4.2: Factors affecting electrophoretic mobility	4.2: Understand the basis of separation of protein in PAGE
	4.3: Learning of movement of DNA freely on electrophoresis		4.3: Free electrophoresis	4.3: learn the difference in DNA and RNA gel electrophoresis
	4.4: Moving boundary electrophoresis		4.4: Moving boundary electrophoresis	
	4.5: learn how zones are created in electrophoresis		4.5: Zone electrophoresis	
	4.6: Paper electrophoresis		4.6: Paper electrophoresis	
	4.7: Understanding of capillary electrophoresis and its application		4.7: Gel electrophoresis, capillary electrophoresis	
	4.8: Immune-electrophoresis,		4.8: Immune-electrophoresis,	
	4.9: Isoelectric-focusing		4.9: Isoelectric-focusing	

Suggested Sessional Work (SW): *anyone*	Assignments:	Working principle of Gel electrophoresis
	Mini Project:	Application of DNA-Protein Interaction analysis
	Other Activities (Specify):	Find out the videos discussing about the various types of electrophoresis techniques.

Unit-V: Centrifugation & Imaging Techniques	
Course-Curriculum: This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	Approximate Hours Item | Cl | LI | SW | SL | Total Approx. Hrs | 09 | 02 | 01 | 04 | 16

Course outcome (COs)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO5-52BT106.5: Learn the essential ideas behind centrifugation and use them in real-world situations	5.1: Abstract he working principle of centrifugation	5.1: Separation of protein from given sample	5.1: Introduction & basic principle of centrifugation	5.1: Understand the centripetal and centrifugal forces
	5.2: Understand the major factors affecting the centrifugation		5.2: Factors affecting sedimentation	5.2: Understand the concept of centrifugation
	5.3: Learn how ultracentrifugation is different to that of centrifugation		5.3: Ultracentrifuge, analytical centrifuge,	5.3: Learnt the ultracentrifugation
	5.4: Gain a skill of gradient centrifugation		5.4: Density gradient centrifugation	
	5.5: Acquire a knowledge of differential centrifugation		5.5: Differential centrifugation,	
	5.6: Physical methods of imaging intact biological structures		5.6: Physical methods of imaging intact biological structures	
	5.7: Gain advance knowledge of X-Ray, CAT-Scan		5.7: X-ray, CAT-Scan	5.4: Discuss the different types of rays and applications in medical biotechnology
	5.8 & 5.9: Get to know about ECG and EEG		5.8 & 5.9: ECG and EEG	

Suggested Sessional Work (SW): Anyone	Assignments:	Working principle of Centrifugation
	Mini Project:	Image development and application of x-rays
	Other Activities (Specify):	Ultracentrifugation: Application in isolation of different cell organelles

Course duration (in hours) to attain Course Outcomes **(Course title:** Bioanalytical Tools and Techniques**) (Course code: 52BT106)**					
Course Outcomes (COs)	**Class lecture (CI)**	**Laboratory Instruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO1-52BT106.1: Understand the essential ideas and immune system cells	9	4	2	1	16
CO2-52BT106.2: Recognize the differences between colorimetry, fluorescence, and UV visible spectroscopy	9	4	2	1	16
CO3-52BT106.3: Calculate the Rf value from a chromatogram to study paper, ion exchange, and affinity chromatography apart	9	4	2	1	16
CO4-52BT106.4: Understand the working principle and application of electrophoresis in real world	9	4	3	1	17
CO5-52BT106.5: Learn the essential ideas behind centrifugation and use them in real-world situations	9	2	4	1	16
Total Hours	45	18	13	05	81

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome: **(Course title:** Bioanalytical Tools and Techniques**) (Course code: 52BT106)**					
Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1-52BT106.1: Understand the essential ideas and immune system cells	2	1	1	1	5
CO2-52BT106.2: Recognize the differences between colorimetry, fluorescence, and UV visible spectroscopy	2	4	2	2	10
CO3-52BT106.3: Calculate the Rf value from a chromatogram to study paper, ion exchange, and affinity chromatography apart	3	5	5	2	15
CO4-52BT106.4: Understand the working principle and application of electrophoresis in real world	2	3	3	2	10
CO5-52BT106.5: Learn the essential ideas behind centrifugation and use them in real-world situations	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**
Legend: A-Apply, A- Analyze, E- Evaluate, C- Create					

Suggested learning Resources:

S.no.	Title	Author	Publisher	Edition & Year
1	Principles and Techniques of Biochemistry and Molecular Biology	Keith Wilson and John Walker	Cambridge University Press	3 & 2018
2	Principles of Physical Biochemistry	K.E. Van Holde, Prentice Hall	Pearson Prentice Hall	2 & 2005
3	Principles and Practice of Bioanalysis	Richard F. Venn	CRC Press Inc	2 & 2008

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Cement Plant
7. Demonstration
8. ICT Based teaching Learning (Video Demonstration/Tutorials CBT, Blog, Facebook, Twitter, WhatsApp, Mobile, Online sources)
9. Brainstorming

CO, PO and PSO Mapping

Program Title: M. Sc. Biotechnology, 1st Sem
Course Code: **52BT106**
Course Title: Bioanalytical Tools & Techniques

CO/PO Mapping (Range 1: Low, 2: Medium, 3:High)								
Course Outcomes	Program Outcomes (POs)					Program Specific Outcomes (PSOs)		
COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3
CO1-52BT106.1: Understand the essential ideas and immune system cells	**2**	**2**	-	-	**1**	**2**	**2**	**1**
CO2-52BT106.2: Recognize the differences between colorimetry, fluorescence, and UV visible spectroscopy	**3**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
CO3-52BT106.3: Calculate the Rf value from a chromatogram to study paper, ion exchange, and affinity chromatography apart	**2**	**2**	-	**1**	-	**1**	**1**	**3**
CO4-52BT106.4: Understand the working principle and application of electrophoresis in real world	**2**	**2**	**1**	**1**	**1**	**1**	**1**	**3**
CO5-52BT106.5: Learn the essential ideas behind centrifugation and use them in real-world situations	**1**	**1**	**1**	-	**1**	**1**	**3**	**2**

Course Curriculum Map:					
POs & PSOs No.	COs No	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2,3	**CO1-52BT106.1:** Understand the essential ideas and immune system cells	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9	LI 1 LI 2	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9	1 SL-1,2
PO 1,2,3,4,5 PSO 1,2,3	**CO2-52BT106.2:** Recognize the differences between colorimetry, fluorescence, and UV visible spectroscopy	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9	LI 1 LI 2	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9	2 SL-1,2
PO 1,2,3,4,5 PSO 1,2,3	**CO3-52BT106.3:** Calculate the Rf value from a chromatogram to study paper, ion exchange, and affinity chromatography apart	3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9	LI 1 LI 2	3.1,3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9	3 SL-1,2
PO 1,2,3,4,5 PSO 1,2,3	**CO4-52BT106.4**: Understand the working principle and application of electrophoresis in real world	4.1,4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9	LI 1 LI 2	4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9	4 SL-1,2,3
PO 1,2,3,4,5 PSO 1,2,3	**CO5-52BT106.5:** Learn the essential ideas behind centrifugation and use them in real-world situations	5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9	LI 1	5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9	5 SL-1,2,3,4

Curriculum Developer Team:
Prof. Kamlesh Choure
Prof. Ashwini A. Waoo
Prof. Deepak Mishra
Dr. Monika Soni
Er. Arpit Srivastava

Semester 2

Program name	**Master of Science (M.Sc.)- Biotechnology**	
Semester	II	
Course Code:	52BT201	
Course title:	Immunology	Developer: Mrs. Keerti Samdariya, Assistant Professor
Pre-requisite:	Student should have basic knowledge about immunology.	
Rationale:	The paper on "Immunology and Immune Technology" in M.Sc. Biotechnology program allow predicting the working principle and application of numerous cells involved in defense responses. This subject will build up the basic and advanced mechanism of immune responses during the different stresses. This subject offers the students the opportunity to advance their knowledge of immunology.	
Course Outcomes (COs):	**CO1-52BT201.1-** The immune system, including its organs, cells, and receptors, will be covered in class. **CO2-52BT201.2-** comprehensive understanding of innate immunity and the cell types involved. **CO3-52BT201.3-** Understand the structure and operation of antibodies. **CO4-52BT201.4-** The molecular foundations of antigen recognition, hypersensitivity reactions, and antigen-antibody interactions will be thoroughly understood by the students. **CO5-52BT201.5-** The student gains an understanding of the fundamentals of immunology and how it can be used to treat diseases of humans as a result of the course.	

Scheme of Studies:

Board of Study	CourseCode	Course Title	Scheme of studies (Hours/Week)					Total Credits(C) (L: T: P=3:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Basic Science Course (BSC)	52BT201	Immunology	3	2	1	2	8	3+1=4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);
SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits.
Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CAT+CT+SA+AT)		
BSC	52BT201	Immunology	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
BSC	**52BT251**	Immunology	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	02	01	04	16

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-52BT201.1- Understand the essential of immune system cells to the organism	SO 1.1: Able to define the immune system	LI 1.1: Demonstration of T-cell mediated immunity diagrammatically and with the help of animation.	CI 1.1: Able to define the immune system	SL 1.1: Study about the basic of immune systems
	SO 1.2: History and major milestones of Immunology		CI 1.2: History and Major Milestones of Immunology	SL 1.2: Learn about defense mechanism in lower organism
	SO 1.3: Understanding fundamental of immune system		CI 1.3: General concepts of the immune system	

	SO 1.4: In depth study about the specific immune systems		CI 1.4: In depth study about the specific immune systems	
	SO 1.5: In depth study about the non-specific immune systems		CI 1.5: In depth study about the non-specific immune systems	SL 1.3: Read the working principle of the non-specific immune system
	SO 1.6 & CI 1.7 Categorizing the primary and secondary responses, Haematopoiesis		CI 1.6 & CI 1.7: Primary and Secondary immune response, Haematopoiesis	
	SO 1.8: Basic and advanced understanding of B cells.		CI 1.8: Basic and advanced understanding of B cells.	SL 1.4: Compare the B-cells and T-cells
	SO 1.9: Basic and advanced understanding of T cells		CI 1.9: Basic and advanced understanding of T cells	

Suggested Sessional Work (SW): *anyone*	SW1.1 Assignments	Describe in details the action of B-cells on defence system
	SW1.2 Mini Project	Draw well labelled diagram of different lymphoid organs
	SW1.3 Other Activities (Specify)	Watch animation on mode of action of first line of defence

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	02	01	02	14

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO 2-52BT201.2- Know the fundamentals of immunoglobulins, antigens, and their classifications	SO2.1: Discuss the properties of antigens	LI 2.1: Demonstration of Antibody-antigen interaction	CI 2.1: Antigens: Properties and types, Haptens and Adjuvants	
	SO2.2: Discuss the types of antigens, Haptens		CI 2.2: Antigens: Properties and types, Haptens	
	SO2.3 explain the Adjuvants		CI 2.3: Adjuvants	
	SO 2.4: Build up the concept about the antibody's structures and classes-Immunoglobulins		CI 2.4: Antibodies: Types, Molecular structure of Immuno-globulins	SL 2.1: Fundamental structure of immunoglobins

	SO 2.5: Build up the concept about the antibody's structures and classes-allotypes & idiotypes		CI 2.5: Antibodies: Types, Molecular structure of allotypes & idiotypes	
	SO 2.6: Humoral & Cellular immune responses		CI 2.6: Humoral & Cellular immune responses	
	SO 2.7: Complement System, and Introduction to cytokines.		CI 2.7: Complement System, and Introduction to cytokines.	
	SO 2.8 & CI2.9: learn about Hybridoma secreting monoclonal antibodies		CI 2.8 & CI2.9: Hybridoma secreting monoclonal antibodies	SL 2.2: Read in details about the monoclonal and polyclonal antibody

Suggested Sessional Work (SW): *anyone*	SW1.1 Assignments	Discuss about cytokines and their role in immune responses
	SW1.2 Mini Project	Draw well labelled diagram of immunoglobin and mention their types
	SW1.3 Other Activities (Specify)	Watch animation on Antibody-antigen interaction mechanism

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	02	01	02	14

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO3-52BT201.3- In-depth study about action of immune responses and their genetic regulations	SO3.1: generation of humoral and cell-mediated immune system		CI 3.1: generation of humoral and cell-mediated immune system	SL3.1: Figure out the fundamental differences between humoral and cell-mediated immune responses
	SO 3.2: Activation of B & T lymphocytes		CI 3.2: Activation of B & T lymphocytes	SL 3.2: Advance the knowledge of the regulation of B & T cells on exposure to the antigens
	SO 3.3: cytokines and their function		CI 3.3: cytokines and their function	
	SO 3.4 & SO 3.5: regulation of B & T cell	LI3.1 To perform the preparation of B & T cells	CI 3.4 & CI 3.5: regulation of B & T cell	
	SO 3.6 & SO 3.7: Learn the structure and function of class 1 MHC molecules.		CI 3.6 & CI 3.7: structure and function of 1 MHC molecules.	
	SO 3.8 & SO 3.9: Learn the structure and function of class 2 MHC molecules.		CI 3.8 & CI 3.9: structure and function of 2 MHC molecules.	

Suggested Sessional Work (SW): *anyone*	Assignments:	Describe in hybridoma technology
	Mini Project:	Draw structure of different types of antibodies
	Other Activities (Specify):	Watch animation on explaining the functionality of cell mediated immune system.

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	02	01	03	15

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO4-52BT201.4- Elaborate the various immunodeficiency related diseases and functionality of immune system	SO 4.1: Discuss about Hypersensitivity- Delayed hypersensitivity	LI 4.1 To perform a skin prick test (SPT) to diagnose immediate hypersensitivity reactions (Type I hypersensitivity) to common allergens.	CI 4.1: Hypersensitivity-Delayed hypersensitivity	SL 4.1: Study the hypersensitivity
	SO 4.2: Discuss about Hypersensitivity- immediate hypersensitivity		CI 4.2: Hypersensitivity-immediate hypersensitivity	
	SO 4.3: Discus Autoimmunity-types of autoimmune diseases		CI 4.3: Autoimmunity-types of autoimmune diseases	
	SO 4.4: Explain the mechanism of CD-4+ T-cell		CI 4.4: mechanism of CD-4+ T-cell	SL 4.2: Learn what are the CD4 & CD8
	SO 4.5: Discuss MHC and TCR in autoimmunity		CI 4.5: MHC and TCR in autoimmunity	
	SO 4.6: Discuss AIDS and immuno deficiency disorder		CI 4.6: Autoimmune diseases, Immunodeficiency-AIDS	SL 4.3: Study the nature of HIV and why is it not curable so far

Suggested Sessional Work (SW): *anyone*	Assignments:	Elaborate the function of MHCs
	Mini Project:	Describe the AIDS in details
	Other Activities (Specify):	Make a poster explaining how pathogen make fool and escape from host immune machineries

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	02	01	02	14

Course outcome (COs)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO5-52BT201.5- Basic principles and applications of various immunization techniques as well as the various vaccinations	SO 5.1: Explain Vaccinology- Active immunization		CI 5.1: active immunization	SL 5.1: Apply the idea of Infection to suppress the immunity to human health
	SO 5.2: Explain Vaccinology- passive immunization		CI 5.2: Passive immunization	
	SO 5.3: Illustrate the vaccine technology and application		CI 5.3: Vaccines & Vaccination	
	SO 5.4 explain the types of vaccines		CI 5.4: Vaccines & Vaccination – adjuvants, cytokines, DNA vaccines, recombinant vaccines, bacterial vaccines, viral vaccines, vaccines to other infectious agents	
	SO 5.6: Immuno assay- RIA, ELISA, ELISPOT assay, western blotting and immunofluoroscense	LI 5.1: Demonstration of ELISA	CI 5.6: Immuno assay- RIA, ELISA, ELISPOT assay, western blotting and immunofluoroscense	SL 5.2: Revise the ELSIA for several diseases' diagnosis

Suggested Sessional Work (SW): Anyone	Assignments:	Detail explanation of principle of vaccine production
	Mini Project:	Discuss about the western blotting techniques and it application in infection detection
	Other Activities (Specify):	How ELISA functioning differs from RIA.

Course duration (in hours) to attain Course Outcomes:

Course Title: Immunology **Course Code: 52BT201**

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-52BT201.1- The immune system, including its organs, cells, and receptors, will be covered in class.	9	2	4	1	16
CO2-52BT201.2- comprehensive understanding of innate immunity and the cell types involved.	9	2	2	1	14
CO3-52BT201.3- Understand the structure and operation of antibodies.	9	2	2	1	14
CO4-52BT201.4- The molecular foundations of antigen recognition, hypersensitivity reactions, and antigen-antibody interactions will be thoroughly understood by the students.	9	2	3	1	15
CO5-52BT201.5- The student gains an understanding of the fundamentals of immunology and how it can be used to treat diseases of humans as a result of the course.	9	2	2	1	14
Total Hours	45	10	13	05	73

End-semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Immunology **Course Code: 52BT201**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-52BT201.1- The immune system, including its organs, cells, and receptors, will be covered in class.	2	1	1	1	5
CO2-52BT201.2- comprehensive understanding of innate immunity and the cell types involved.	2	4	2	2	10
CO3-52BT201.3- Understand the structure and operation of antibodies.	3	5	5	2	15

CO4-52BT201.4- The molecular foundations of antigen recognition, hypersensitivity reactions, and antigen-antibody interactions will be thoroughly understood by the students.	2	3	3	2	10
CO5-52BT201.5- The student gains an understanding of the fundamentals of immunology and how it can be used to treat diseases of humans as a result of the course.	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	Roitt I.M, Brostoff, J., Male D.K., Immunology (Illustrated Publisher, Mosby).
2	T. J. Kindt, R.A. G. B. A. Osborne, J. Kuby. Immunology (W.H. Freeman and Company, New York).
3	Paul, W.E. (2008). Fundamental immunology (Lippincott Williams & Wilkins).
4	T.G. Parslow, D.P. Stites, A.I. Terr. Medical immunology (Lange Medical Books/McGraw-Hill).

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to virology lab (BSL-3)
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: M. Sc. Biotechnology
Semester: II Semester
Course Title: Immunology
Course Code: 52BT201

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-52BT201.1- The immune system, including its organs, cells, and receptors, will be covered in class.	1	2	2	3	1	2	2	1
CO2-52BT201.2- comprehensive understanding of innate immunity and the cell types involved.	1	2	3	2	1	1	1	2
CO3-52BT201.3- Understand the structure and operation of antibodies.	1	2	3	2	1	1	1	1
CO4-52BT201.4- The molecular foundations of antigen recognition, hypersensitivity reactions, and antigen-antibody interactions will be thoroughly understood by the students.	-	1	1	-	2	1	1	3
CO5-52BT201.5- The student gains an understanding of the fundamentals of immunology and how it can be used to treat diseases of humans as a result of the course.	1	1	1	-	-	1	3	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2,3	**CO1-52BT201.1-** The immune system, including its organs, cells, and receptors, will be covered in class.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	LI 1	1.1,1.2,1.3,1.4, 1.5,1.6,1.7,1.8,1.9	1SL-1,2,3,4
PO 1,2,3,4,5 PSO 1,2,3	**CO2-52BT201.2-** comprehensive understanding of innate immunity and the cell types involved.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	LI 1	2.1, 2.2, 2.3, 2.4,2.5, 2.6,2.7,2.8,2.9	2SL-1,2
PO 1,2,3,4,5 PSO 1,2,3	**CO3-52BT201.3-** Understand the structure and operation of antibodies.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	LI 1	3.1,3.2,3.3,3.4,3.5,3.6,3.7.3.8,3.9	3SL-1,2
PO 1,2,3,4,5 PSO 1,2,3	**CO4-52BT201.4-** The molecular foundations of antigen recognition, hypersensitivity reactions, and antigen-antibody interactions will be thoroughly understood by the students.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9	LI 1	4.1,4.2,4.3,4.4,4.5,4.5,4.6,4.7,4.8,4.9	4SL-1,2,3
PO 1,2,3,4,5 PSO 1,2,3	**CO5-52BT201.5-** The student gains an understanding of the fundamentals of immunology and how it can be used to treat diseases of humans as a result of the course.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9	LI 1	5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8,5.9	5SL-1,2

Curriculum Developer Team:
Prof. Kamlesh Choure
Prof. Ashwini A. Waoo
Prof. Deepak Mishra
Dr. Monika Soni
Er. Arpit Srivastava

Program Name	**M.Sc. BIOTECHNOLOGY**	
Semester	II[nd]	
Course Code:	52BT202	
Course title:	Computational Biology & Bioinformatics	**Curriculum Developer**: Mr. Piyush Kant Rai, Assistant Professor
Pre-requisite:	To excel in Computational Biology & Bioinformatics, a strong foundation in molecular biology, genetics, is essential. Understanding algorithms, especially dynamic programming, and familiarity with bioinformatics tools like NCBI databases are advantageous. Exposure to structural biology and molecular modeling concepts, sequence analysis, alignment methods, and phylogenetics is valuable. Skills in molecular modeling software and techniques further enhance comprehension of advanced topics.	
Rationale:	The proposed syllabus are critical for students embarking on a Computational Biology & Bioinformatics course due to its interdisciplinary nature. Proficiency in molecular biology, genetics, programming, and statistical analysis is fundamental for effective biological data interpretation and computational analysis. Familiarity with bioinformatics tools and databases enables efficient data handling and retrieval, while understanding algorithms enhances students' ability to develop and optimize bioinformatics algorithms. Exposure to structural biology concepts provides insights into molecular modeling techniques, essential for drug discovery and protein structure prediction. Overall, these prerequisites equip students with the necessary knowledge and skills to tackle complex biological problems using computational approaches.	
Course Outcomes (COs):	**CO1-52BT202.1-** Acquire knowledge about a strong foundation in interdisciplinary sciences such as Computer Sciences and Biological Sciences. **CO2-52BT202.2-** Address the challenges arising from the huge amount of genomic data. **CO3-52BT202.3-** Analyze the corresponding drug responses towards appropriate drug specified dosages. **CO4-52BT202.4-** Explore the EST database and protein databases to acquire knowledge about the protein structure. **CO5-52BT202.5-** To gain information about biochemical and molecular mechanics information regards to proteins.	

Scheme of Studies:

Board of Study	CourseCode	Course Title	Scheme of studies (Hours/Week)					Total Credits(C) (L:T:P=3:1:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Discipline Specific Course (DSC)	52BT202	Computational Biology and Bioinformatics	3	2	1	2	8	3+1+1=5

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);
SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits.
Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
DSC	52BT202	Computational Biology and Bioinformatics	15	20	5	10	50	50	100

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
DSC	**52BT252**	Computational Biology & Bioinformatics	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours** **Item** | Cl | LI | SW | SL | Total **Approx. Hrs** | 12 | 02 | 01 | 02 | 17

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-52BT202.1- Acquire knowledge about a strong foundation in interdisciplinary sciences such as Computer Sciences and Biological Sciences	**SO1.1 & SO1.2** Understand the NCBI data model	**LI1.1** Learn how to use databases	**CI1.1 & CI1.2** Introduction to the NCBI data model	**SL1.1** Explore NCBI website
	SO1.3 & SO1.4 EMBL		**CI1.3 & CI1.4** EMBL	**SL1.2** Visit EMBL database site
	SO1.5 & SO1.6 DDBJ, Swissprot		**CI1.5 & CI1.6** DDBJ, Swissprot	
	SO1.7 & SO1.8 GENBANK		**CI1.7 & CI1.8** GENBANK	
	SO1.9 & SO1.10 Entrez, Unigene .		**CI1.9 & CI1.10** Entrez, Unigene	
	SO1.11 & SO1.12 Understanding the Databases and rapid sequence analysis		**CI1.11 & CI1.12** Understanding the Databases and rapid sequence analysis	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Summarizes the GenBank, EMBL and DDBJ
	SW1.2 Mini Project	Demonstrate how to retrieve data from EMBL
	SW1.3 Other Activities (Specify)	correlate the data redundancy among INSDC databases

Item	Cl	LI	SW	SL	Total
Approx. Hrs	12	02	01	02	17

Course Outcome (CO)	Session Outcomes (SOs)	LaboratoryInstruction (LI)	Class room Instruction (CI)	Self Learning (SL)
CO2-52BT202.2- Address the challenges arising from the huge amount of genomic data	**SO2.1 & SO2.2** How Global and local alignments works	**LI2.1** Discuss how to analyze raw reads of DNA/RNA.	**CI2.1 & CI2.2** Global and local alignments works	**SL2.1** Practice sequence alignment
	SO2.3 & SO2.4 What is Pairwise and multiple alignment		**CI2.3 & CI2.4** Pairwise and multiple alignment	

	SO2.5 & SO2.6 How dynamic programming algorithms, alignment by hidden Markov models		**CI2.5 & CI2.6** Dynamic programming algorithms, alignment by hidden Markov models	**SL2.2** Recall Dynamic programming
	SO2.7 & SO2.8 Understanding consensus word analysis		**CI2.7 & CI2.8** consensus word analysis	
	SO2.9 & SO2.10 more complex scoring		**CI2.9 & CI2.10** more complex scoring	
	SO2.11 Pattern searching programs		**CI2.11** Pattern searching programs	
	SO2.12 family and superfamily representation		**CI2.12** family and superfamily representation	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Justify the role of dynamic programming in alignment
	SW2.2 Mini Project	Interpret the MSA result concerning the DNA
	SW2.3 Other Activities (Specify)	Incorporate some youtube videos based on features of how to do MSA

Item	Cl	LI	SW	SL	Total
Approx. Hrs	12	04	01	02	19

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO3-52BT202.3- Analyze the corresponding drug responses towards appropriate drug specified dosages	**SO3.1 & SO3.2** Show Trees-splits and metrices on trees, tree interpretation	**LI3.1** Basics of tree metrices and tree splits	**CI3.1 & CI3.2** Trees-splits and metrices on trees, tree interpretation	**SL3.1** Learn steps of phylogenetic tree generation
	SO3.3 & SO3.4 Learn the , Distance – additive, ultrameric and nonadditive distances, tree building methods		**CI3.3 & CI3.4** Distance – additive, ultrameric and nonadditive distances, tree building methods	**SL3.2** Practice Phylip software
	SO3.5 & SO3.6 How to do phylogenetic analysis, parsimony, tree	**LI3.2** Interpretation of phylogenetic tree	**CI3.5 & CI3.6** phylogenetic analysis, parsimony,	

	evaluation, maximum likelihood trees		tree evaluation, maximum likelihood trees	
	SO3.7 & SO3.8 tree evaluation		**CI3.7 & CI3.8** tree evaluation	
	SO3.9 & SO3.10 Estimating the rate of change		**CI3.9 & CI3.10** Estimating the rate of change	
	SO3.11 Estimate likelihood and trees		**CI3.11** Estimate likelihood and trees	
	SO3.12 analysis software		**CI3.12** analysis software	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Write about distance matrix.
	SW3.2 Mini Project	Make a flow chart of steps of phylogenetic tree generations
	SW3.3 Other Activities (Specify)	Search and find the amrita lab and there find alignment methods.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	12	04	01	02	19

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO4-52BT202.4- Explore the EST database and protein databases to acquire knowledge about the protein structure.	**SO 4.1 & SO4.2** Features of ESTs – databases	**LI4.1** Basics of computer	**CI4.1 & CI4.2** ESTs – databases	
	SO4.3 & SO4.4 What is clustering, gene discovery and identification,	**LI4.2** How to search any phylogenetic tree.	**CI4.3 & CI4.4** clustering, gene discovery and identification	**SL4.1** Learn techniques of gene discovery
	SO4.5 & SO4.6 How to do gene discovery and identification		**CI4.5 & CI4.6** gene discovery and identification	
	SO4.7 & SO4.8 explain methods of Protein identification and its physical properties		**CI4.7 & CI4.8** Protein identification and its physical properties	**SL4.2** remember protein characteristics
	SO4.9 & SO4.10 Describe motifs and patterns, structure, folding classes		**CI4.9 & CI4.10** Motifs and patterns, structure, folding classes	

	SO4.11 & SO4.12 Elaborate structure classification		**CI4.11 & CI4.12** Structure classification	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Write about mathematical associated with phylogenetic analysis.
	SW4.2 Mini Project	explain methods of Protein identification and its physical properties
	SW4.3 Other Activities (Specify)	Search and learn via YouTube how to interpret phylogenetic tree.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	12	06	01	03	22

Course Outcome (CO)	**Session Outcomes (SOs)**	**LaboratoryInstruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO5-52BT202.5- To gain information about biochemical and molecular mechanics information regards to proteins.	**SO5.1** Features of PDB and MMDB	**LI5.1** How to search and download any protein structures	**CI5.1** PDB and MMDB	**SL5.1** Learn how protein functions
	SO5.2 What is advance structure modeling.	**LI5.2** Basics of drug and protein interactions	**CI5.2** advance structure modeling	**SL5.2** Classify different types of modelling techniques
	SO5.3 & SO5.4 Distinguish Internal and external co-ordinate system, cartesian and cylindrical polar co-ordinate system	**LI5.3** How to do homology modelling	**CI5.3 & CI5.4** Internal and external co-ordinate system, cartesian and cylindrical polar co-ordinate system	**SL5.3** How many types of molecular force fields used in the MMDD
	SO5.5 & SO5.6 Convey Potential energy calculations using semiempirical potential energy function		**CI5.5 & CI5.6** Potential energy calculations using semiempirical potential energy function	
	SO5.7 & SO5.8 What is Molecular mechanics and dynamics		**CI5.7 & CI5.8** Molecular mechanics and dynamics	
	SO5.9 & SO5.10 How Docking of Molecules can be done, Knowledge base		**CI5.9 & CI5.10** Docking of Molecules, Knowledge base structure	

	structure prediction		prediction	
	SO5.11 What is Molecular Design, structure similarity searching; Secondary structure prediction in proteins		**CI5.11** Molecular Design, structure similarity searching; Secondary structure prediction in proteins	
	SO5.12 Elaborate Prediction of buried residues in proteins.		**CI5.12** prediction of buried residues in proteins	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Write about Lipinski rule of five
	SW5.2 Mini Project	What is Molecular Design, structure similarity searching; Secondary structure prediction in proteins
	SW5.3 Other Activities (Specify)	Try to learn and apply protein homology modelling using virtual lab.

Course duration (in hours) to attain Course Outcomes:

Course Title: Computational Biology and Bioinformatics **Course Code: 52BT202**

Course Outcomes (COs)	**Class lecture (CI)**	**Laboratory Instruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO1-52BT202.1- Acquire knowledge about a strong foundation in interdisciplinary sciences such as Computer Sciences and Biological Sciences.	12	2	2	1	17
CO2-52BT202.2- Address the challenges arising from the huge amount of genomic data.	12	2	2	1	17
CO3-52BT202.3- Analyze the corresponding drug responses towards appropriate drug specified dosages.	12	4	2	1	19
CO4-52BT202.4- Explore the EST database and protein databases to acquire knowledge about the protein structure.	12	4	2	1	19
CO5-52BT202.5- To gain information about biochemical and molecular mechanics information regards to proteins.	12	6	3	1	22
Total Hours	60	18	11	5	94

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Computational Biology and Bioinformatics **Course Code: 52BT202**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-52BT202.1- Acquire knowledge about a strong foundation in interdisciplinary sciences such as Computer Sciences and Biological Sciences.	02	03	04	1	10
CO2-52BT202.2- Address the challenges arising from the huge amount of genomic data.	03	04	02	1	10
CO3-52BT202.3- Analyze the corresponding drug responses towards appropriate drug specified dosages.	02	05	02	1	10
CO4-52BT202.4- Explore the EST database and protein databases to acquire knowledge about the protein structure.	02	05	02	1	10
CO5-52BT202.5- To gain information about biochemical and molecular mechanics information regards to proteins.	03	03	03	1	10
Total Marks	**12**	**20**	**13**	**05**	**50**

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	Bioinformatics Thomas Dandekar , Meik Kunz Springer-Verlag GmbH Germany, part of Springer Nature 2023
2	Introduction to bioinformatics Arthur Lesk Oxford University Press 2023
3	Essential bioinformatics Jin Xiong Cambridge University Press 2007

(b) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method

4. Group Discussion
5. Role play
6. Visit to bioinformatics lab
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B.Tech. Biotechnology
Semester: III[rd] Sem
Course Title: Computational Biology and Bioinformatics
Course Code: 52BT202

Course Outcome (Cos)	Program Specific Outcomes (PSOs)							
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-52BT202.1- Acquire knowledge about a strong foundation in interdisciplinary sciences such as Computer Sciences and Biological Sciences.	1	2	3	2	1	**3**	**3**	**1**
CO2-52BT202.2- Address the challenges arising from the huge amount of genomic data.	1	1	2	1	1	**1**	**1**	**2**
CO3-52BT202.3- Analyze the corresponding drug responses towards appropriate drug specified dosages.	1	1	1	2	1	**1**	**1**	**1**
CO4-52BT202.4- Explore the EST database and protein databases to acquire knowledge about the protein structure.	-	**1**	**1**	1	**2**	**1**	**2**	**3**
CO5-52BT202.5- To gain information about biochemical and molecular mechanics information regards to proteins.	**1**	**1**	**1**	-	1	**1**	-	**2**

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2, 3	**CO1-52BT202.1-** Acquire knowledge about a strong foundation in interdisciplinary sciences such as Computer Sciences and Biological Sciences.	SO1.1, SO1.2 SO1.3, SO1.4 SO1.5, SO1.6 SO1.7, SO1.8 SO1.9, SO1.10 SO1.11, SO1.12	**IL 1**	1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8,1.9,1.10,1.11,1.12	**1SL-1,2**
PO 1,2,3,4,5 PSO 1,2, 3	**CO2-52BT202.2-** Address the challenges arising from the huge amount of genomic data.	SO2.1, SO2.2 SO2.3, SO2.4 , SO 2.5, SO 2.6, SO2.7, SO2.8 SO2.9, SO2.10 SO2.11, SO2.12	**IL 1**	2.1, 2.2, 2.3, 2.4.2.5,2.6,2.7,2.8,2.9,2.10,2.11,2.12	**2SL-1,2**
PO 1,2,3,4,5 PSO 1,2, 3	**CO3-52BT202.3-** Analyze the corresponding drug responses towards appropriate drug specified dosages.	SO3.1, SO3.2 SO3.3, SO3.4 SO3.5,SO3.6 SO3.7, SO3.8 SO3.9, SO3.10 SO3.11, SO3.12	**IL 1** **IL 2**	3.1,3.2,3.3,3.4,3.5,3.6,3.7,3.8,3.9,3.10,3.11,3.12	**3SL-1,2**
PO 2,3,4,5 PSO 1,2, 3	**CO4-52BT202.4-** Explore the EST database and protein databases to acquire knowledge about the protein structure.	SO4.1, SO4.2 SO4.3, SO4.4 SO 4.5, SO4.6 SO4.7, SO4.8 SO4.9. SO4.10 SO4.11, SO4.12	**IL 1** **IL 2**	4.1,4.2,4.3,4.4,4.5,4.6,4.7,4.8,4.9,4.10,4.11,4.12	**4SL-1,2**
PO 1,2,3,5 PSO 1, 3	**CO5-52BT202.5-** To gain information about biochemical and molecular mechanics information regards to proteins.	SO5.1, SO5.2 SO5.3, SO5.4 SO5.5, SO5.6 SO5.7, SO5.8 SO5.9, SO5.10 SO5.11, SO5.12	**IL 1** **LI 2** **LI 3**	5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8,5.9,5.10,5.11,5.12	**5SL-1,2,3**

Curriculum Developer Team:

Prof. Kamlesh Choure
Prof. Ashwini A. Waoo
Prof. Deepak Mishra
Dr. Monika Soni
Er. Arpit Srivastava

Program name	Master of Science (M. Sc.)- Biotechnology	
Semester	IInd	
Course Code:	52BT203	
Course title:	Stem Cell & Tissue Engineering	**Curriculum Developer**: Dr. Monika Soni, Assistant Professor
Pre-requisite:	Students should have basic knowledge of stem cell & tissue engineering	
Rationale:	The subject aims to provide an overview of stem cell & tissue engineering offer innovative approaches to treating a wide range of medical conditions, with the potential to transform healthcare by providing personalized, regenerative solutions for patients in need.	
Course Outcomes (COs):	**CO1-52BT203.1**- To understand the basics of stem cells. **CO2-52BT203.2**- To discuss the properties of embryonic stem cells, including their various cell types. **CO3-52BT203.3**- To understand the concept of adult stem cells. **CO4-52BT203.4**- To understand the roles of stem cells in drug discovery & tissue engineering including their applications, & cell protection strategies. **CO5-52BT203.5**- To analyze the role of stem cells in gene therapy and cloning & addressing to various diseases.	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits(C) (L:T:P=2:1:1)
			CI	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
Discipline Specific Course (DSC)	52BT203	Stem Cell & Tissue Engineering	3	2	1	2	8	2+1+1=4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);
SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits.
Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+SA+CAT+AT)		
DSC	52BT203	Stem Cell & Tissue Engineering	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
DSC	52BT253	Stem Cell & Tissue Engineering	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Item	CI	LI	SW	SL	Total
Approx. Hours	9	4	1	3	17

Course outcomes (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CIs)	Self-Learning (SL)
CO1-52BT203.1- To understand the basics of stem cells.			**Unit-1**	
	SO1.1 Describe & define the stem cells.		**CI1.1** Brief in detail introduction to stem cells.	**SL1.1** Search various reference books and other study material to start the learning about stem cells & tissue engineering

	SO1.2 Explain in detail the properties of stem cells.	**LI1.1** To observe and compare the properties of embryonic and adult stem cells.	**CI1.2** Describe the properties of stem cells.	**SL1.2** Gain a fundamental understanding of stem cells & their properties.
	SO1.3 Explain in detail the types of stem cells: Embryonic stem cells.		**CI1.3** Explain in detail the types of stem cells: Embryonic stem cells.	
	SO1.4 Explain in detail the types of stem cells: Adult stem cells.		**CI1.4** Explain in detail the types of stem cells: Adult stem cells.	
	SO1.5 Explain in detail the types of stem cells: Umbilical cord stem cells.	**LI1.2** To isolate and culture stem cells from umbilical cord tissue.	**CI1.5** Explain in detail the types of stem cells: Umbilical cord stem cells.	
	SO1.6 Explain in detail the similarities & dissimilarities between embryonic & adult stem cells.		**CI1.6** Study the similarities & dissimilarities between embryonic & adult stem cells.	**SL1.3** Analyse the similarities and differences between embryonic & adult stem cells.
	SO1.7 Explain in detail the application of stem cells.		**CI1.7** Study the applications of stem cells.	
	SO1.8 & SO1.9 Describe & define the conditioned media & other cell culture reagents.		**CI1.8 & CI1.9** Discuss the challenges & ethical considerations to stem cells.	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignment	Explain in detail the various types of stem cells.
	SW1.2 Mini Project	Describe in detail the stem cells.
	SW1.3 Other Activities (Specify)	Explain the challenges & ethical considerations to stem cells.

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Item	CI	LI	SW	SL	Total
Approx. Hours	9	4	1	6	20

Course outcomes (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CIs)	Self-Learning (SL)
CO2-52BT203.2- To discuss the properties of embryonic stem cells, including their various cell types.			**Unit-2**	
	SO2.1 Describe & define the introduction to embryonic stem cells.		**CI2.1** Brief in detail introduction to embryonic stem cells.	**SL2.1** Search various reference books and other study material to start the learning about embryonic stem cells.
	SO2.2 Explain in detail the In- *vitro* fertilization technique using stem cells.		**CI2.2** Explain in detail the In- *vitro* fertilization technique using stem cells.	**SL2.2** Understand the steps involved in IVF and its role in generating embryos for embryonic stem cell research.
	SO2.3 Describe & define the culturing of embryos.	**LI2.1** To understand the process of isolating and culturing embryonic stem cells (ESCs) from blastocysts.	**CI2.3** Describe & define the culturing of embryos.	**SL2.3** Learn about the methods used to culture embryos in laboratory settings for research purposes.
	SO2.4 Explain in detail the isolation of embryonic stem cells.		**CI2.4** Explain in detail the isolation of embryonic stem cells.	**SL2.4** Gain insight into the methods used to isolate embryonic stem cells from early-stage embryos.
	SO2.5 Explain in detail the stimulation of embryonic stem cells for differentiation.	**LI2.2** To understand the process of stimulating ESCs	**CI2.5** Explain in detail the stimulation of embryonic stem cells for differentiation.	**SL2.5** Understand how embryonic stem cells can be induced to differentiate into

		for differentiation into specific cell types.		specialized cell types for various applications.
	SO2.6 Discuss the properties of embryonic stem cells.		**CI2.6** Discuss the properties of embryonic stem cells.	**SL2.6** Explore the unique characteristics and diverse applications of embryonic stem cells in biomedical research and therapy.
	SO2.7 Describe & define the trophoblast stem cells.		**CI2.7** Describe & define the trophoblast stem cells.	
	SO2.8 & SO2.9 Discuss the ethical considerations to embryonic stem cells.		**CI2.8 & CI2.9** Discuss the ethical considerations to embryonic stem cells.	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignment	Describe in detail the embryonic stem cells.
	SW1.2 Mini Project	Explain in detail the stimulation of embryonic stem cells for differentiation.
	SW1.3 Other Activities (Specify)	Write a one review article on trophoblast stem cells.

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Item	CI	LI	SW	SL	Total
Approx. Hours	9	4	1	5	19

Course outcomes (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CIs)	Self-Learning (SL)
CO3-52BT203.3- To understand the concept of adult stem cells.			**Unit-3**	
	SO3.1 Describe & define the adult stem cells.		**CI3.1** Brief in detail to introduction & characterization of adult stem cells.	**SL3.1** Search various reference books and other study material to start the learning about adult stem cells.
	SO3.2 Discuss the somatic stem cells.		**CI3.2** Discuss the somatic stem cells.	
	SO3.3 Explain in detail the adult stem cells differentiation.		**CI3.3** Explain in detail the adult stem cells differentiation.	**SL3.2** Understand the processes and signalling pathways involved in the differentiation of adult stem cells into specialized cell types.
	SO3.4 Discuss the trans-differentiation & plasticity.		**CI3.4** Discuss the trans-differentiation & plasticity.	**SL3.3** Learn about the phenomenon of trans-differentiation and the plasticity of adult stem cells.
	SO3.5 Describe the types of adult stem cells.		**CI3.5** Describe the types of adult stem cells.	**SL3.4** Explore the diverse types of adult stem cells found in various tissues and their roles in tissue maintenance and repair.
	SO3.6 Describe & define the epidermal stem cells.	**LI3.1** To isolate and culture epidermal stem cells from mouse skin tissue.	**CI3.6** Describe & define the epidermal stem cells.	
	SO3.7 Describe & define the liver stem cells.	**LI3.2** To induce differentiation of liver stem cells into hepatocyte-like cells in-*vitro*.	**CI3.7** Describe & define the liver stem cells.	
	SO3.8 Describe & define the pancreatic stem cells.		**CI3.8** Describe & define the pancreatic stem cells.	

	SO3.9 Discuss the experimental techniques & applications to adult stem cells.		**SO3.9** Discuss the experimental techniques & applications to adult stem cells.	**SL3.5** Learn about experimental methods and techniques used in the study of adult stem cells.

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignment	Describe in detail the adult stem cells.
	SW3.2 Mini Project	Explain in detail the adult stem cells differentiation, trans-differentiation, & plasticity.
	SW3.3 Other Activities (Specify)	Prepare one review article on liver & pancreatic stem cells.

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Item	CI	LI	SW	SL	Total
Approx. Hours	9	4	1	5	19

Course outcomes (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CIs)	Self-Learning (SL)
CO4-52BT203.4- To understand the roles of stem cells in drug discovery & tissue engineering including their applications, & cell protection strategies.			**Unit-4**	
	SO4.1 Describe and define the stem cells.		**CI4.1** Brief in detail introduction to stem cells.	**SL4.1** Search various reference books and other study material to start the learning about stem cells in drug discovery & tissue engineering.
	SO4.2 Explain in detail to stem cells in tissue engineering.		**CI4.2** Explain in detail to stem cells in tissue engineering.	

	SO4.3 Understanding the stem cell therapy Vs cell protection.	**LI4.1** To compare the effectiveness of stem cell therapy versus cell protection in promoting cell survival and functionality under stress conditions.	**CI4.3** Understanding the stem cell therapy Vs cell protection.	**SL4.2** Understanding stem cell therapy Vs cell protection.
	SO4.4 Discuss the stem cells in cellular assays for screening.		**CI4.4** Discuss the stem cells in cellular assays for screening.	**SL4.3** Exploring stem cell-based assays for drug screening.
	SO4.5 Describe in detail the stem cells based drug discovery.	**LI4.2** To utilize stem cell-based assays for drug screening and toxicology assessment.	**CI4.5** Describe in detail the stem cells based drug discovery.	**SL4.4** Exploring the stem cells based drug discovery.
	SO4. Discuss the stem cells in toxicology.		**CI4.6** Discuss the stem cells in toxicology.	**SL4.5** Exploring the drug screening & toxicology using stem cells.
	SO4.7 Discuss the ethical considerations with stem cell research.		**CI4.7** Discuss the ethical considerations with stem cell research.	
	SO4.8 Discuss the future directions & challenges in stem cell research.		**CI4.8** Discuss the future directions & challenges in stem cell research.	
	SO4.9 Analyze the case studies related to stem cells based drug discovery & tissue engineering.		**CI4.9** Analyze the case studies related to stem cells based drug discovery & tissue engineering.	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Describe & define the stem cells in cellular assays for screening.
	SW4.2 Mini Project	Explain in detail the stem cells based drug discovery & toxicology.
	SW4.3 Other Activities (Specify)	Analyze the one case study related to stem cells based drug discovery & tissue engineering.

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Item	CI	LI	SW	SL	Total
Approx. Hours	9	4	1	5	19

Course outcomes (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CIs)	Self-Learning (SL)
CO5-52BT203.5- To analyze the role of stem cells in gene therapy and cloning & addressing to various diseases.			**Unit-5**	
	SO5.1 Describe & define the gene therapy.	**LI5.1** To introduce students to gene therapy techniques and their applications in treating genetic and acquired diseases.	**CI5.1** Brief in detail introduction to gene therapy.	**SL5.1** Search various reference books and other study material to start the learning about gene therapy, cloning etc.
	SO5.2 Explain in detail the stem cells in regenerative medicines.		**CI5.2** Explain in detail the stem cells in regenerative medicines.	
	SO5.3 Explain in detail the animal cloning techniques.		**CI5.3** Explain in detail the animal cloning techniques.	**SL5.2** Exploring the animal cloning & transgenic animals: application in biomedical research & biotechnology.
	SO5.4 Discuss the transgenic animals and stem cells.		**CI5.4** Discuss the transgenic animals and stem cells.	
	SO5.5 Discuss the therapeutic applications of gene therapy & stem cells: Parkinson's disease & Alzheimer's disease.	**LI5.2** To explore the potential of stem cells in regenerative medicine and therapeutic applications for various medical conditions.	**CI5.5** Discuss the therapeutic applications of gene therapy & stem cells: Parkinson's disease & Alzheimer's disease	**SL5.3** Exploring the gene therapy in neurological disorders: Parkinson's & Alzheimer's disease.
	SO5.6 Discuss the therapeutic applications of gene therapy & stem cells:		**CI5.6** Discuss the therapeutic applications of gene therapy & stem	**SL5.4** Understanding the stem cell therapies for tissue

	Limb amputation & Heart disease		cells: Limb amputation & Heart disease	regeneration: Limb amputation & Heart disease.
	SO5.7 Discuss the therapeutic applications of gene therapy & stem cells: Spinal cord injuries & Burns		**CI5.7** Discuss the therapeutic applications of gene therapy & stem cells: Spinal cord injuries & Burns	
	SO5.8 Discuss the therapeutic applications of gene therapy & stem cells: Diabetes.		**CI5.8** Discuss the therapeutic applications of gene therapy & stem cells: Diabetes.	
	SO5.9 Explain in detail the HLA typing & transplantation.		**CI5.9** Explain in detail the HLA typing & transplantation.	**SL5.5** HLA typing & its importance in organ transplantation.

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain in detail the gene therapy.
	SW5.2 Mini Project	Discuss the therapeutic applications of gene therapy & stem cells: Parkinson's, & Alzheimer's disease.
	SW5.3 Other Activities (Specify)	Prepare one review article on HLA typing & transplantation.

Course duration (in hours) to attain Course Outcomes:

Course Title: Stem Cells & Tissue Engineering **Course Code:** 52BT203

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-52BT203.1- To understand the basics of stem cells.	9	4	3	1	17
CO2-52BT203.2- To discuss the properties of embryonic stem cells, including their various cell types.	9	4	6	1	20

CO3-52BT203.3- To understand the concept of adult stem cells.	9	4	5	1	19
CO4-52BT203.4- To understand the roles of stem cells in drug discovery & tissue engineering including their applications, & cell protection strategies.	9	4	5	1	19
CO5-52BT203.5- To analyze the role of stem cells in gene therapy and cloning & addressing to various diseases.	9	4	5	1	19
Total Hours	**45**	**20**	**24**	**05**	**94**

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcomes:

Course Title: Stem Cells & Tissue Engineering **Course Code:** 52BT203

***Legend*: R,** Remember; **U,** Understand; **A,** Apply; **A,** Analyze; **E,** Evaluate; **C,** Create

Course Outcomes	**Marks Distribution**						**Total Marks**
	R	**U**	**A**	**A**	**E**	**C**	
CO1-52BT203.1- To understand the basics of stem cells.	1	1	3	2	2	1	10
CO2-52BT203.2- To discuss the properties of embryonic stem cells, including their various cell types.	1	1	2	3	2	1	10
CO3-52BT203.3- To understand the concept of adult stem cells.	1	1	3	2	2	1	10
CO4-52BT203.4- To understand the roles of stem cells in drug discovery & tissue engineering including their applications, & cell protection strategies.	1	1	2	3	2	1	10
CO5-52BT203.5- To analyze the role of stem cells in gene therapy and cloning & addressing to various diseases.	1	1	2	3	2	1	10
Total Marks	**05**	**05**	**12**	**13**	**10**	**05**	**50**

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1.	Stewart Sell, Stem Cells Handbook: Human Press, 2010.
2.	Asok Mukhopadyay, Animal Cell Technology, IK Intl. Ltd, Text Book.
3.	S. Indumathi, Stem cell therapy for organ failures, Springer Verlag, 2015.
4.	Stem cell and future of regenerative medicine by committee on the biological and biomedical applications of stem cell Research, National Academic Press.

(b) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Stem cells & Tissue engineering lab
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: M. Sc. Biotechnology

Semester: II[nd] Semester

Course Title: Stem Cells & Tissue Engineering

Course Code: 52BT203

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-52BT203.1- To understand the basics of stem cells.	1	1	3	2	1	1	1	1
CO2-52BT203.2- To discuss the properties of embryonic stem cells, including their various cell types.	1	2	3	2	1	1	1	-
CO3-52BT203.3- To understand the concept of adult stem cells.	1	1	2	1	1	1	1	1
CO4-52BT203.4- To understand the roles of stem cells in drug discovery & tissue engineering including their applications, & cell protection strategies.	1	2	1	1	1	1	2	3
CO5-52BT203.5- To analyze the role of stem cells in gene therapy and cloning & addressing to various diseases.	1	1	2	2	1	1	2	3

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO1,2,3,4,5 PSO 1,2,3	**CO1-52BT203.1**- To understand the basics of stem cells.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	LI 1 LI 2	1.1,1.2,1.3,1.4,1.5, 1.6,1.7,1.8,1.9	1SL-1,2,3
PO1,2,3,4,5 PSO 1,2,3	**CO2-52BT203.2**- To discuss the properties of embryonic stem cells, including their various cell types.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	LI 1 LI 2	2.1, 2.2, 2.3, 2.4, 2.5,2.6,2.7,2.8,2.9	2SL-1,2,3,4,5,6
PO1,2,3,4,5 PSO 1,2,3	**CO3-52BT203.3**- To understand the concept of adult stem cells.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	LI 1 LI 2	3.1,3.2,3.3,3.4,3.5, 3.6,3.7,3.8,3.9	3SL-1,2,3,4,5
PO1,2,3,4,5 PSO 1,2,3	**CO4-52BT203.4**- To understand the roles of stem cells in drug discovery & tissue engineering including their applications, & cell protection strategies.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9	LI 1 LI 2	4.1,4.2,4.3,4.4,4.5, 4.6,4.7,4.8,4.9	4SL-1,2,3,4,5
PO1,2,3,4,5 PSO 1,2,3	**CO5-52BT203.5**- To analyze the role of stem cells in gene therapy and cloning & addressing to various diseases.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9	LI 1 LI2	5.1,5.2,5.3,5.4,5.5, 5.6,5.7,5.8,5.9	5SL-1,2,3,4,5

Curriculum Developer Team:
Prof. Kamlesh Choure
Prof. Ashwini A. Waoo
Prof. Deepak Mishra
Dr. Monika Soni

Program Name	**Master of Science (M. Sc)- Biotechnology**	
Semester	II	
Course Code:	52BT204	
Course title:	Animal Biotechnology	**Curriculum Developer**: Dr. Ashwini A. Waoo, Professor
Pre-requisite:	Student should have strong foundations in genetics, cellular biology, and hands-on laboratory experience for pursuing animal biotechnology courses at the post graduate level.	
Rationale:	Genetic engineering and bio nanotechnology offer unprecedented avenues to manipulate biological systems at the molecular level, revolutionizing medicine, agriculture, and environmental sustainability. By harnessing genetic modification and nanoscale tools, these fields pave the way for tailored therapies, enhanced crop resilience, and novel solutions to global challenges, driving innovation across diverse scientific domains.	
Course Outcomes (COs):	**CO1-52BT204.1-** Recognize and understand the basics of animal cell culture **CO1-52BT204.2-** Have a thorough understanding of the organ culture, tissue engineering and monoclonal antibodies **CO1-52BT204.3-** Establish professional abilities in cell cloning and transgenic technologies **CO1-52BT204.4-** Apply and analyze use of animal husbandry, aqua culture for commercial purpose **CO1-52BT204.5-** Evaluate applications and ethical concern in animal biotechnology	

Scheme of Studies:

Board of Study	CourseCode	Course Title	Scheme of studies (Hours/Week)					Total Credits(C) (L:T:P=3:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Core (PCC)	52BT204	Animal Biotechnology	3	2	1	1	7	3+1=4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);
SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits.
Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
Program Core (PCC)	52BT204	Animal Biotechnology	**15**	**20**	**10**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
PCC	52BT254	Animal Biotechnology	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	06	01	05	21

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-52BT204.1- Recognize and understand the basics of animal cell culture	**SO1.1** Understand structure of animal cell	**LI1.1** Microscopic examination of animal cell	**Unit-1** **CI1.1** Structure and organisation of animal cell.	**SL1.1** Study and draw structure of animal cell
	SO1.2 Categorize various equipment for animal cell culture.	**LI1.2** Study of equipment used for animal cell culture.	**CI1.2** Equipment for animal cell culture.	**SL1.2** What are various equipment and their company used in animal cell culture lab
	SO1.3 Understand types and composition of culture media	**LI1.3** Prepare Hank's basal salt solution	**CI1.3** Culture media,	**SL1.3** Write composition of different media used in animal cell culture
	SO1.4 types and mode of action of DNA modifying enzymes		**CI1.4** Primary cell culture	**SL1.4** Differentiate between primary and secondary cell culture
	SO1.5 Describe secondary cell culture.		**CI1.5** and secondary cell culture	
	SO1.6 Illustrate the biology and characterisation of cultured cells		**CI1.6** Biology and characterisation of cultured cells.	
	SO1.7 & SO1.8 Evaluate various factors for Maintenance of animal cell culture		**CI1.7 & CI1.8** Maintenance of animal cell culture.	
	SO1.9 Knowledge about Measuring parameters of growth		**CI1.9** Measuring parameters of growth.	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Explain various types of culture media used for animal cell culture
	SW1.2 Mini Project	Describe lab set up and instruments required for ani animal cell culture
	SW1.3 Other Activities (Specify)	Find out differences between primary and secondary cell culture.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	02	01	04	16

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-52BT204.2- Have a thorough understanding of the organ culture, tissue engineering and monoclonal antibodies	**SO2.1** Illustration of techniques of organ culture		**Unit-II** **CI2.1** Organ culture,	**SL2.1** Learn types of organ culture and applications
	SO2.2 & SO2.3 Illustration of three-dimensional culture and scaffolds		**CI2.2 & CI2.3** three-dimensional culture and scaffolds	**SL2.2** Describe examples of 3 D culture and implantation in patient
	SO2.4 & SO2.5 Understand use of tissue engineering in disease treatment		**CI2.4 & CI2.5** tissue engineering.	**SL2.3** Learn about tissue engineering
	SO2.6 & SO2.7 Describe hybridoma technology-production of monoclonal antibody	**LI2.1** To perform the monoclonal antibody	**CI2.6 & CI2.7** Hybridoma technology-production of monoclonal antibody,	**SL2.4** Discuss the production of monoclonal antibodies
	SO2.8 & SO2.9 application of monoclonal antibodies.		**CI2.8 & CI2.9** application of monoclonal antibodies.	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe various techniques of organ culture with diagram.
	SW2.2 Mini Project	Explain the tissue engineering and its advantages.
	SW2.3 Other Activities (Specify)	Prepare list of applications of monoclonal antibodies

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	02	01	05	17

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-52BT204.3- Establish professional abilities in cell cloning and transgenic technologies	**SO3.1** Demonstrate the different cell cloning techniques		**Unit-III** **CI3.1** Cell cloning	**SL3.1** Read about cell cloning
	SO3.2 Illustration of micromanipulator	**LI3.1** Demonstration of micromanipulator	**CI3.2** micromanipulations	**SL3.2** Draw a diagram of micro manipulator
	SO3.3 invitro fertilization and embryo transfer,		**CI3.3** invitro fertilization and embryo transfer,	**SL3.3** Describe invitro fertilization and embryo transfer
	SO3.4 Artificial insemination,		**CI3.4** Artificial insemination,	
	SO3.5 scaling up of animal cell culture.		**CI3.5** scaling up of animal cell culture.	
	SO3.6 & SO3.7 Transgenic animals: vector, selectable markers,		**CI3.6 & CI3.7** Transgenic animals: vector, selectable markers,	**SL3.4** Write a note on transgenic animals
	SO3.8 transfection methods, their applications		**CI3.8** transfection methods, their applications	**SL3.5** Describe gene delivery methods and their applications
	SO3.9 examples of transgenic animals.		**CI3.9** examples of transgenic animals. .	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe Micromanipulator
	SW3.2 Mini Project	Describe the significance of IVF
	SW3.3 Other Activities (Specify)	Prepare list of transgenic animals their production and application.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	02	01	05	17

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO1-52BT204.4- Apply and analyze use of animal husbandry, aqua culture for commercial purpose	**SO4.1** Develop understanding of aquaculture		**Unit-IV** **CI4.1** Aquaculture: fresh water fish culture techniques,	**SL4.1** Learn about Aquaculture
	SO4.2 seri culture: production of silk.		**CI4.2** seri culture: production of silk.	**SL4.2** Discuss challenges of seri culture
	SO4.3 Ananlyze key requirements of animal husbandry		**CI4.3** Animal husbndry,	**SL4.3** Video for animal husbandry
	SO4.4 Understand livestock imrovement		**CI4.4** livestock improvement.	**SL4.4** Studies related livestock management
	SO4.5 Techniques: microarray,		**CI4.5** Techniques: microarray,	
	SO4.6 Evaluate the need of DNA Fingerprinting		**CI4.6** DNA fingerprinting,	**SL4.5** Explain technique of DNA fingerprinting and its applications
	SO4.7 Apply FISH in clinical purpose		**CI4.7** Flurecsent insitu hybridization	
	SO4.8 & SO4.9 FACS, chromosome mapping,	**LI4.1** Demonstration of FACS	**CI4.8 & CI4.9** FACS, chromosome mapping	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Describe requirements and maintenance of animal husbandry
	SW4.2 Mini Project	Describe the the technique of DNA fingerprinting
	SW4.3 Other Activities (Specify)	Write short notes on FACS.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	02	01	05	17

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO1-52BT204.5- Evaluate applications and ethical concern in animal biotechnology	**SO5.1** Describe applications of animal cell culture		**Unit-V** **CI5.1** Application of animal cell culture,	**SL5.1** learn all latest applications
	SO5.2 Illustrate the production of biopharmaceuticals		**CI5.2** production of biopharmaceuticals,	**SL5.2** Prepare list of biopharmaceuticals produced by animal cell culture
	SO5.3 Evaluate the need of cell culture based vaccines,	**LI5.1** To demonstrate the preparation of vaccine	**CI5.3** cell culture based vaccines	**SL5.3** Give role of cell culture based vaccine
	SO5.4 & SO5.5 Describe strategies of gene therapy		**CI5.4 & CI5.5** gene therapy	**SL5.4** Learn about gene therapy and gene disorders
	SO5.6 & SO5.7 Analyze the Bio hazard and Biosecurity in animal biotechnology work		**CI5.6 & CI5.7** hazard and Biosecurity in Animal Biotechnology,	**SL5.5** Give example of biohazards
	SO5.8 & SO5.9 Describe ethical concerns in animal biotechnology		**CI5.8 & CI5.9** Ethical aspects in Animal Biotechnology.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Describe applications of animal cell culture
	SW5.2 Mini Project	Describe the production of biopharmaceuticals
	SW5.3 Other Activities (Specify)	Prepare list of hazards occurred and biosecurity measures in animal biotech lab

Course duration (in hours) to attain Course Outcomes:

Course Title: Animal Biotechnology **Course Code: 52BT204**

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-52BT204.1- Recognize and understand the basics of animal cell culture	9	6	5	1	21
CO1-52BT204.2- Have a thorough understanding of the organ culture, tissue engineering and monoclonal antibodies	9	2	4	1	16
CO1-52BT204.3- Establish professional abilities in cell cloning and transgenic technologies	9	2	5	1	17
CO1-52BT204.4- Apply and analyze use of animal husbandry, aqua culture for commercial purpose	9	2	5	1	17
CO1-52BT204.5- Evaluate applications and ethical concern in animal biotechnology	9	2	5	1	17
Total Hours	45	14	24	05	88

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Animal Biotechnology **Course Code: 52BT204**

Course Outcomes					
	A	**A**	**E**	**C**	**Total Marks**
CO1-52BT204.1- Recognize and understand the basics of animal cell culture	03	01	01	01	06
CO1-52BT204.2- Have a thorough understanding of the organ culture, tissue engineering and monoclonal antibodies	02	04	02	02	10
CO1-52BT204.3- Establish professional abilities in cell cloning and transgenic technologies	03	05	05	01	14
CO1-52BT204.4- Apply and analyze use of animal husbandry, aqua culture for commercial purpose	02	03	05	00	10
CO1-52BT204.5- Evaluate applications and ethical concern in animal biotechnology	05	04	00	01	10
Total Marks	15	17	13	05	50

Legend: A: Apply, A: Analyze E: Evaluate, C: Create

Suggested learning Resources:

(a) Books:

S. No.	Title
1	Animal Biotechnology, M.M. Ranga, (2007).
2	Culture of Animal Cells (3rd Edition),R.lan Froshney,Wiley-Liss.
3	Instant Notes in Animal Biology, Richard D. Turd, (2003).

(b) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to virology lab (BSL-3)
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Title: M. Sc. Biotechnology
Semester: II
Course Code: 52BT204
Course Title: Genetic Engineering & Bionanotechnology

Course Outcome	Program Outcomes (POs)					Program Specific Outcomes (PSOs)		
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-52BT204.1- Recognize and understand the basics of animal cell culture	**1**	**1**	**-**	**3**	**3**	**2**	**1**	**-**
CO1-52BT204.2- Have a thorough understanding of the organ culture, tissue engineering and monoclonal antibodies	**2**	**1**	**2**	**2**	**3**	**2**	**1**	**1**
CO1-52BT204.3- Establish professional abilities in cell cloning and transgenic technologies	**-**	**3**	**-**	**1**	**2**	**1**	**2**	**-**
CO1-52BT204.4- Apply and analyze use of animal husbandry, aqua culture for commercial purpose	**2**	**2**	**1**	**3**	**3**	**2**	**-**	**-**
CO1-52BT204.5- Evaluate applications and ethical concern in animal biotechnology	**3**	**1**	**1**	**3**	**2**	**2**	**2**	**-**

Legend: **(1) Low (2) Medium (3) High**

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2,3	**CO1-52BT204.1-** Recognize and understand the basics of animal cell culture	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	LI1, LI2, LI3	1.1,1.2,1.3,1.4,1.5, 1.6, 1.7, 1.8, 1.9	1SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO1-52BT204.2-** Have a thorough understanding of the organ culture, tissue engineering and monoclonal antibodies	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	LI1	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9	2SL-1,2,3,4
PO 1,2,3,4,5 PSO 1,2,3	**CO1-52BT204.3-** Establish professional abilities in cell cloning and transgenic technologies	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	LI1,	3.1,3.2,3.3,3.4,3.5, 3.6, 3.7, 3.8, 3.9	3SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO1-52BT204.4-** Apply and analyze use of animal husbandry, aqua culture for commercial purpose	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9	LI1,	4.1,4.2,4.3,4.4, 4.5, 4.6, 4.7, 4.8, 4.9	4SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO1-52BT204.5-** Evaluate applications and ethical concern in animal biotechnology	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9	LI1	5.1,5.2,5.3,5.4,5.5, 5.6, 5.7, 5.8, 5.9	5SL-1,2,3,4,5

Curriculum Developer Team:
Prof. Kamlesh Choure
Prof. Ashwini A. Waoo
Prof. Deepak Mishra
Dr. Monika Soni
Er. Arpit Srivastava

Program Name	**Masters of Science (M.Sc.)- Biotechnology**	
Semester	II	
Course Code:	52BT205	
Course title:	Industrial Microbiology	**Curriculum Developer**: Er. Arpit Srivastava, Assistant Professor
Pre-requisite:	Students should have basic knowledge of microbiology and fermentation	
Rationale:	Industrial microbiology assists industrial production processes using variety of microbial strains. They may examine microbial growth found in the pipes of a chemical factory, monitor the impact industrial waste has on the local ecosystem, or oversee the microbial activities used in cheese production to ensure quality. Fermentation is frequently used for the cultivation of biomass and in the production of enzymes, pharmaceuticals, energy, food and feedstock, bioactive compounds, biopolymers, etc., in which different microorganisms, and including filamentous fungi, are involved. The overall objective of this subject is to make student more relative about their best career opportunity in this field.	
Course Outcomes (COs):	**CO1-52BT205.1-** Describe the fundamentals of Industrial Microbiology and Fermentation Technology **CO2-52BT205.2-** Define the role of microbiology for the production of desired bioproducts **CO3-52BT205.3-** Derive the working mechanism of upstream and downstream processing **CO4-52BT205.4-** Interpretate the mechanism of fermentation process in industry **CO5-52BT205.5-** Examine the mechanism of biological product development using microbes	

Scheme of Studies:

Board of Study	CourseCode	Course Title	Scheme of studies (Hours/Week)					Total Credits(C) (L:T:P=3:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Discipline Specific Course (DSC)	52BT205	Industrial Microbiology	3	2	1	3	9	3+1=4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);
SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits.
Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
DSC	52BT205	Industrial Microbiology	**15**	**20**	**10**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
DSC	52BT255	Industrial Microbiology	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	05	19

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-52BT205.1- Describe the fundamentals of Industrial Microbiology and Fermentation Technology	**SO1.1** Explain the concept of Fermentation	**LI1.1** To Demonstrate the working of a Bench Top bioreactor	**Unit-1** **CI1.1** Introduction, fermentation and fermenters	**SL1.1** Search various reference books and study material to start the learning of microorganisms
	SO1.2 Elaborate the historical perspective of fermentation	**LI1.2** To perform the isolation of microorganisms from different kinds of samples	**CI1.2** Brief history and developments in industrial microbiology	**SL1.2** Find out the literature showing use of fermentation technology in ancient India

	SO1.3 Differentiate between Solid-state and liquid-state (stationary and submerged) fermentations		**CI1.3** Solid-state and liquid-state (stationary and submerged) fermentations	**SL1.3** Derive the equation representing various mode of fermentations
	SO1.4 & SO1.5 Derive the equations based on Batch, fed-batch and continuous fermentations		**CI1.4 & CI1.5** Batch, fed-batch and continuous fermentations	**SL1.4** Explore different bioproducts manufacture in laboratory
	SO1.6 & SO1.7 Explain & compare the components of a typical bioreactor, types of bioreactors-Laboratories, pilot- scale and production fermenters		**CI1.6 & CI1.7** Components of a typical bioreactor, types of bioreactors-Laboratories, pilot- scale and production fermenters	**SL1.5** Draw a well labelled diagram of a bioreactor
	SO1.8 & SO1.9 Continuous stirred tank fermenter, tower fermenter, fixed bed, fluidized bed bioreactors and air-lift fermenter		**CI1.8 & CI1.9** Continuous stirred tank fermenter, tower fermenter, fixed bed, fluidized bed bioreactors and air-lift fermenter	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail "Applications of Microorganisms in various Sectors"
	SW1.2 Mini Project	Draw various types of Fermenters with specifications
	SW1.3 Other Activities (Specify)	List down the tables of different domains of microorganisms which are industrially important

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	05	19

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-52BT205.2- Define the role of microbiology for the production of desired bioproducts	**SO2.1** Explain the role of industrial scope of fermentation		**Unit-1** **CI2.1** Overview on industrial fermentation- measurement of parameters	**SL2.1** Search various reference books and study material to start the learning of microorganisms

	SO2.2 Derive the roles of Isolation of strains, media and ingredients: pH, temperature, dissolved oxygen, foaming and aeration	**LI2.1** To Demonstrate the working of a pH electrode	**CI2.2** Isolation of strains, media and ingredients: pH, temperature, dissolved oxygen, foaming and aeration	**SL2.2** Find out the literature showing use of fermentation technology in ancient India
	SO2.3 Compare different identification, screening & preservation techniques		**CI2.3** Primary and secondary screening, strain development, preservation and maintenance of industrial strains	**SL2.3** Derive the equation representing various mode of fermentations
	SO2.4 Differentiate among different kinds of media used in industrial microbiology	**LI2.3** To prepare the different kinds of nutrient media for microbial culture	**CI2.4** Crude and synthetic media; molasses, corn-steep liquor, sulphite waste liquor, whey and yeast extract	**SL2.4** Explore different bioproducts manufacture in laboratory
	SO2.5 Describe the Downstream processing: Filtration, centrifugation		**CI2.5** Downstream processing: Filtration, centrifugation	**SL2.5** Draw a well labelled diagram of a bioreactor
	SO2.6 & SO2.7 Cell disruption, solvent extraction, precipitation and ultrafiltration		**CI2.6 & CI2.7** Cell disruption, solvent extraction, precipitation and ultrafiltration	
	SO2.8 & SO2.9 Analyse the difference between Lyophilization and Spray Drying		**CI2.8 & CI2.9** Lyophilization and Spray drying	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Write down any 5 kinds of Unit Operations used in Downstream Processing
	SW1.2 Mini Project	Draw a well labelled diagram of Bacterial Cell Wall showing gram+/- staining
	SW1.3 Other Activities (Specify)	Watch animation related to working of different kinds of bioreactor used in various industries

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	05	19

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-52BT205.3- Derive the working mechanism of upstream and downstream processing	**SO3.1** Explain the role of Metabolic pathways		**Unit-3** **CI3.1** Metabolic pathways and metabolic control mechanisms	**SL3.1** Search various reference books and study material to start the learning of microorganisms
	SO3.2 & SO3.3 Define the concept of biological product production	**LI3.1**To perform the citric acid production by given sample	**CI3.2 & CI3.3** Industrial production of citric acid, lactic acid	**SL3.2** Find out the literature showing use of Lactic Acid in industries
	SO3.4 & SO3.5 Industrial production of Enzymes (alpha-amylase, lipase, xylase, pectinases, proteases)	**LI3.2** To check the quantity of alpha-amylase by given sample	**CI3.4 & CI3.5** Industrial production of Enzymes (alpha-amylase, lipase, xylase, pectinases, proteases)	**SL3.3** Derive the mechanism for fermentation of ethanol
	SO3.6 & SO3.7 ABE Fermentation		**CI3.6 & CI3.7** ABE Fermentation	**SL3.4** Write about different bioproducts manufacture in laboratory
	SO3.8 & SO3.9 Microbial Production of Lysine and Glutamic acid		**CI3.8 & CI3.9** Microbial Production of Lysine and Glutamic acid	**SL3.5** Find out the applications of enzymes in industries

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail cultivation of microorganisms
	SW3.2 Mini Project	Prepare a flowchart showing industrial production of biological products using fermentation
	SW3.3 Other Activities (Specify)	Make a Power Point Presentation on "Different Types of Microbial Culture Media"

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	05	19

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO4-52BT205.4 Interpretate the mechanism of fermentation process in industry	**SO4.1** Importance and production of Beta-lactam, aminoglycosides, (Rifamycin)	**LI4.1** To perform the antibiotic production using fungi	**Unit-4** **CI4.1** Importance and production of Beta-lactam, aminoglycosides, (Rifamycin)	**SL4.1** Find out more antibiotics and their production process
	SO4.2 & SO4.3 Understand the production of antibiotics	**LI4.2** To perform the microbial growth kinetics by observing the biomass produced and representation on graph	**CI4.2 & CI4.3** Microbial production of Peptide antibiotics Quinolinones	**SL4.2** List out the role of Antibiotic Resistance Genes
	SO4.4 & SO4.5 Biotransformation of steroids and its microbial production		**CI4.4 & CI4.5** Biotransformation of steroids and its microbial production	**SL4.3** Explore the medical applications of Steroids
	SO4.6 & SO4.7 Vitamin B12 and Riboflavin production through fermentation		**CI4.6 & CI4.7** Vitamin B12 and Riboflavin production through fermentation	**SL4.4** Make a flowchart showing metabolic pathway for Vitamin B_{12} and Vitamin B_2
	SO4.8 & SO4.9 Production of Biogas; Anaerobic digestion		**CI4.8 & CI4.9** Production of Biogas; Anaerobic digestion	**SL4.5** Explore how Biogas is produced in rural areas of India

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Explain the role of Antibiotics and its disadvantages
	SW4.2 Mini Project	Describe how therapeutics being produced in biotech-based industries
	SW4.3 Other Activities (Specify)	Make a list of "Biogas producing centres in India"

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	02	01	05	17

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO5-52BT205.5 Examine the mechanism of biological product development using microbes	**SO5.1** Identify Modern trends in microbial production of bioplastics	**LI5.1** To perform the growth of Algae using a photobioreactor column	**Unit-5** **CI5.1** Modern trends in microbial production of bioplastics (PHA, PHB)	**SL5.1** Explore the various kinds of biopolymers and their applications
	SO5.2 & SO5.3 Recognize the production mechanism of different polymer		**CI5.2 & CI5.3** Production of bioinsectices (Thuricide), Biopolymer (Dextran, Alginate, Xanthan, Pullulan)	**SL5.2** Read research on advancement in production of biofertilizers
	SO5.4 & SO5.5 Explain the role of biofertilizers in agriculture		**CI5.4 & CI5.5** Biofertilizers (Nitrogen fixer Azotobacter, Phosphate solubilizing microorganisms)	**SL5.3** Find out different centres where Single Cell Proteins are used
	SO5.6 & SO5.7 Microbial production of Single Cell Protein		**CI5.6 & CI5.7** Microbial production of Single Cell Protein	
	SO5.8 & SO5.9 Production of biological weapons with reference to anthrax		**CI5.8 & CI5.9** Production of biological weapons with reference to anthrax	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general characteristics of Biopolymers & their applications
	SW5.2 Mini Project	Describe the production process of Single Cell Production
	SW5.3 Other Activities (Specify)	Prepare one article on Applications of Biofertilizers

Course duration (in hours) to attain Course Outcomes:

Course Title: Industrial Microbiology **Course Code:** 52BT205

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-52BT205.1- Describe the fundamentals of Industrial Microbiology and Fermentation Technology	9	4	5	1	19
CO2-52BT205.2- Define the role of microbiology for the production of desired bioproducts	9	4	5	1	19
CO3-52BT205.3- Elaborate the working mechanism of upstream and downstream processing	9	4	5	1	19

CO4-52BT205.4- Interpretate the mechanism of fermentation process in industry	9	4	5	1	19
CO5-52BT205.5- Examine the mechanism of biological product development using microbes	9	2	5	1	17
Total Hours	45	18	25	05	93

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Industrial Microbiology **Course Code:** 52BT205

Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1-52BT205.1- Describe the fundamentals of Industrial Microbiology and Fermentation Technology	2	1	1	1	5
CO2-52BT205.2- Define the role of microbiology for the production of desired bioproducts	2	4	2	2	10
CO3-52BT205.3- Elaborate the working mechanism of upstream and downstream processing	3	5	5	2	15
CO4-52BT205.4- Interpretate the mechanism of fermentation process in industry	2	3	3	2	10
CO5-52BT205.5- Examine the mechanism of biological product development using microbes	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	Textbook of Microbiology by Ananthnarayanan and Paniker's, eighth edition, Universities Press
2	Microbiology; Lansing M Prescott, John P. Harley, Donald A Klein, Sixth edition, Mc Graw Hill Higher education.
3	J.E. Bailey and D.F. Ollis, Biochemical Engineer-ing Fundamentals, McGraw-Hill, New York
4	Industrial Microbiology and Biotechnology, Pradeep Verma, Springer, 2022
5	An Introduction to Industrial Microbiology, Sivakumar, K. Sukesh and Joe, S. Chand Publications, 2010

(b) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method

4. Group Discussion
5. Role play
6. Visit to Industrial plant of Biotech-based organizations
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: M. Sc. Microbiology
Semester: II Semester
Course Title: Industrial Microbiology
Course Code: 52BT205

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-52BT205.1- Describe the fundamentals of Industrial Microbiology and Fermentation Technology	2	-	-	1	2	2	2	1
CO2-52BT205.2- Define the role of microbiology for the production of desired bioproducts	-	1	1	-	-	1	1	2
CO3-52BT205.3- Elaborate the working mechanism of upstream and downstream processing	1	1	1	1	-	1	1	1
CO4-52BT205.4- Interpretate the mechanism of fermentation process in industry	1	1	1	-	2	1	1	3
CO5-52BT205.5- Examine the mechanism of biological product development using microbes	1	1	1	-	-	1	3	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2,3	**CO1-52BT205.1-** Describe the fundamentals of Industrial Microbiology and Fermentation Technology	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	**LI 1** **LI 2**	1.1,1.2,1.3,1.4,1.5 1.6,1.7,1.8,1.9	**1SL-1,2,3,4,5**
PO 1,2,3,4,5 PSO 1,2,3	**CO2-52BT205.2-** Define the role of microbiology for the production of desired bioproducts	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	**LI 1** **LI 2**	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7,2.8,2.9	**2SL-1,2,3,4,5**
PO 1,2,3,4,5 PSO 1,2,3	**CO3-52BT205.3-** Elaborate the working mechanism of upstream and downstream processing	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	**LI 1** **LI 2**	3.1,3.2,3.3,3.4,3.5,3.6,3.7,3.8,3.9	**3SL-1,2,3,4,5**
PO 1,2,3,4,5 PSO 1,2,3	**CO4-52BT205.4-** Interpretate the mechanism of fermentation process in industry	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9	**LI 1** **LI 2**	4.1,4.2,4.3,4.4, 4.5,4.6,4.7,4.8,4.9	**4SL-1,2,3,4,5**
PO 1,2,3,4,5 PSO 1,2,3	**CO5-52BT205.5-** Examine the mechanism of biological product development using microbes	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9	**LI 1**	5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8,5.9	**5SL-1,2,3,4,5**

Curriculum Developer Team:
Prof. Kamlesh Choure
Prof. Ashwini A. Waoo
Prof. Deepak Mishra
Dr. Monika Soni
Er. Arpit Srivastava

Program Name	**Masters of Science (M.Sc.)- Biotechnology**	
Semester	II	
Course Code:	52BT206	
Course title:	Plant Biotechnology	**Curriculum Developer**: Dr. Deepak Mishra, Professor
Pre-requisite:	Student should have basic knowledge of Biotechnology, Genetic Engineering and Botany.	
Rationale:	The paper on Plant Biotechnology in a M.Sc. Biotechnology program explores the concept and techniques used for development and growth of plant tissues in laboratorial conditions. It delves into the use of precise instruments and techniques for micro propagation of plants. The second part of this course will provide precise knowledge of genetic engineering tools for improvement in plant varieties and stable genetic transformation. This study enables students to understand how recombinant DNA technology helps us for development of new plant varieties. It also explore the knowledge of biotechnology for generation of novel characteristics in plants.	
CourseOutcomes (COs):	**CO1-52BT206.1-** Familiarization with the basic needs and lab layout for conducting investigations with plant cell cultures. **CO2-52BT206.2-** Development of critical skills for generation of tissue culture raised plantlets and applies protoplast fusion for production of hybrids. **CO3-52BT206.3-** Acquired Skills of the various methods and processes used to create recombinant plants. **CO4-52BT206.4-** Recognize various methods related to genetic profiling of plants and analyze the techniques for improvement in plants. **CO5-52BT206.5-** Explore application of transgenic plants for improvement and development of novel characters in plants.	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits(C) (L:T:P=2:1:1)
			Cl	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
Program Common Course (PCC)	52BT206	Plant Biotechnology	4	2	1	5	12	2+1+1=4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);
SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits.
Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
PCC	52BT206	Plant Biotechnology	15	20	10	5	50	50	100

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
PCC	52BT256	Plant Biotechnology	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	05	19

Course outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction(CI)	Self-Learning(SL)
CO1-52BT206.1- Familiarization with the basic needs and lab layout for conducting investiga-tions with plant cell cultures.	**1.1** Define and Describe concept of plant tissue culture	**LI1.1** preparation of stock solutions and Plant tissue culture media	**Unit-1** **CI1.1** Introduction to plant tissue culture: Plant tissue culture media	**SL1.1** Search various reference books and study material to start the learning of plant tissue culture
	SO1.2 Describe about method of sterilization & culture initiation	**LI1.2** Perform sterilization and culture initiation	**CI1.2** Sterilization & Culture Initiation,	**SL1.2** Method of sterilization for living and non living articles used in PTC
	SO1.3 Explain about callus culture and suspension culture		**CI1.3** Initiation and maintenance of callus and Suspension culture	**SL1.3** To optimize protocol for callus culture and cell suspension culture for specific plants.
	SO1.4 Describe about plants from single plant cell		**CI1.4** single cell clones	
	SO1.5 Study the concept of totipotency and organogenesis.		**CI1.5** Totipotency, Organoganesis;	**SL1.4** To analyze impact of hormones on totipotency and organogenesis
	SO1.6 Study of somatic embryogenesis.		**CI1.6** somatic embryogenesis	
	SO1.7 Describe concept of hardening		**CI1.7** transfer and establishment of whole plants in soil (hardening).	**SL1.5** To optimize protocols for somatic embryogenesis and hardening of tissue cultured plants
	SO1.8 Study about methods of production of virus free plants.		**CI1.8** production of virus -free plants.	
	SO1.9 Describe the concept of embryo culture		**CI1.9** embryo culture and embryo rescue	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail plant tissue culture methods.
	SW1.2 Mini Project	Standardize the protocols of plant tissue culture for different plant varieties
	SW1.3 Other Activities (Specify)	Collection of explants materials and their culture initiation.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	05	19

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-52BT206.2- Development of critical skills for generation of tissue culture raised plantlets and applies protoplast fusion for production of hybrids.	**SO2.1** Explore the concept and techniques of protoplast isolation and protoplast fusion.	**LI2.1** Isolation of protoplast from given explants.	**Unit-II** **CI2.1** Protoplast isolation and Protoplast fusion	**SL2.1** Search various contents for protoplast isolation and protoplast fusion
	SO2.2 Describe the contents of hybrid cells		**CI2.2** Selection of hybrid cells;	**SL2.2** design the protocol for protoplast fusion
	SO2.3 Reflecting about hybrids and cybrids.		**CI2.3** symmetric and asymmetric hybrids, cybrids	
	SO2.4 & SO2.5 Explain about concept and mechanism of somaclonal variations.		**CI2.4 & CI2.5** somaclonal variations and nuclear cytology of cultured plant cells.	**SL2.3** to learn about mechanism of somaclonal variation.
	SO2.6 & SO2.7 Assessing the role of anther culture for haploid plant production.	**LI2.2** Perform anther culture for haploid plant production.	**CI2.6 & CI2.7** Production of haploid plants	**SL2.4** standardize the protocol for explants sterilization
	SO2.8 Explaining the steps of cryopreservation.		**CI2.8** Cryopreservation	**SL2.5** to learn the methods of cryopreservation.
	SO2.9 Explaining the methods of germplasm conservation		**CI2.9** slow growth for germplasm conservation	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe in detail about different stages of execution of research by using research process.
	SW2.2 Mini Project	Designing of a research thesis.
	SW2.3 Other Activities (Specify)	Take a research problem a select a specific research design for solving it.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	05	19

Course Outcome (CO)	**Session Outcomes(SOs)**	**Laboratory Instruction(LI)**	**Class room Instruction (CI)**	**Self-Learning(SL)**
CO3-52BT206.3- Acquired Skills of the various methods and processes used to create recombinant plants.	**SO3.1** Explain the role of Agrobacterium for cloning in plants.	**LI3.1** Preparation of competent cell and plant cloning.	**Unit-III** **CI3.1** Cloning vector for higher plant transformation: Agrobac terium tumefaciens	**SL3.1** Read about various types of vectors used for cloning in plants.
	SO3.2 Assessing the concept of Ti and Ri plasmid		**CI3.2** Ti and Ri plasmids,	**SL3.2** Study the structure and function of Ti and Ri Plasmid
	SO3.3 T-DNA, mechani-sms of DNA transfer,	**LI3.2** to perform transformation.	**CI3.3** T-DNA, mechani-sms of DNA transfer,	**SL3.3** Illustration about mechanism of TDNA transfer.
	SO3.4 Role of virulence genes.		**CI3.4** Role of virulence genes.	
	SO3.5 Viral vectors and their application:		**CI3.5** Viral vectors and their application:	**SL3.4** Study of different viruses used for cloning in plants.
	SO3.6 direct gene transfer: particle bomba-rdment, electroporation, microinjection:		**CI3.6** direct gene transfer: particle bomba-rdment, electroporation, microinjection:	**SL3.5** Assess role of direct gene transfer methods used for plants
	SO3.7 transformation of monocots;		**CI3.7** transformation of monocots;	
	SO3.8 & SO3.9 transgene stability and gene silencing		**CI3.8 & CI3.9** transgene stability and gene silencing	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail plant cloning vector and mechanism of TDNA transfer in plants.
	SW3.2 Mini Project	Describe the role of different vectors in genetic transformation in plants.
	SW3.3 Other Activities (Specify)	Prepare a list of plant viruses and cloning vectors used for genetic engineering in plants.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	04	01	05	19

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO4-52BT206.4- Recognize various methods related to genetic profiling of plants and analyze the techniques for improvement in plants.	**SO4.1** Exploring the concept of Molecular markers and their types	**LI4.1** Demonstration of RFLP Analysis	**Unit-IV** **CI4.1** Molecular marker-aided breeding RFLP maps.	**SL4.1** Learn about different categories of molecular markers
	SO4.2 Assessing role of RAPD and STS marker in phylogenetic analysis	**LI4.2** Demonstration of RAPD Analysis	**CI4.2** RAPD markers, STS, microsatellites,	**SL4.2** Compare RAPD, RFLP and AFLP markers
	SO4.3 Explaining the concept of SCAR marker		**CI4.3** SCAR (sequence characterized amplified region)	**SL4.3** Learn about various types of arid and semi arid plants
	SO4.4 & SO4.5 Explaining the role of AFLP and QTLs markers in diversity analysis.		**CI4.4 & CI4.5** AFLP and QTLs	**SL4.4** Case studies related to application of biotechnology for plant improvement.
	SO4.6 & SO4.7 Arid and Semi Arid Plant Biotechnology		**CI4.6 & CI4.7** Arid and Semi Arid Plant Biotechnology	**SL4.5** Case studies related to application of molecular markers
	SO4.8 & SO4.9 Green House and Green Home Technology		**CI4.8 & CI4.9** Green House and Green Home Technology	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Explain about different types of PCR and Non PCR based genetic markers
	SW4.2 Mini Project	Describe the various techniques used in development of arid and semi arid plant biotechnology
	SW4.3 Other Activities (Specify)	Prepare one article on green house and green home technology.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	04	01	05	19

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO5-52BT206.5: Explore application of transgenic plants for improvement and development of novel characters in plants.	**SO5.1** Define the concept and objective of chloroplast transformation.	**LI5.1** Demonstration of Chloroplast Transformation	**Unit-V** **CI5.1** Chloroplast transformation: advantages, vectors,	**SL5.1** learn about basic concept & requirement of chloroplast genome
	SO5.2 success with tobacco and potato;		**CI5.2** success with tobacco and potato;	**SL5.2** Review concept of chloroplast transformation
	SO5.3 Application of plant transformation for productivity and performance: herbicide resistance,	**LI5.2** Demonstration of transgenic plant products and varieites	**CI5.3** Application of plant transformation for productivity and performance: herbicide resistance,	**SL5.3** learn how to apply transgenic technology in plants
	SO5.4 insect resistance,		**CI5.4** insect resistance,	
	SO5.5 virus resistance,		**CI5.5** virus resistance,	
	SO5.6 disease resistance,		**CI5.6** disease resistance,	**SL5.4** Learn about novel characters of plants varieties
	SO5.7 Apply the RDT for controlling post harvest loss and abiotic stress		**CI5.7** abiotic stress, post harvest losses,	
	SO5.8 & SO5.9 long shelf life of fruits and flowers, edible vaccine		**CI5.8 & CI5.9** long shelf life of fruits and flowers, edible vaccines	**SL5.5** Learn about application of transgenic technology

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general characteristics and application of chloroplast transformation.
	SW5.2 Mini Project	Describe the role of transgenic technology for improvement in plants.
	SW5.3 Other Activities (Specify)	Prepare a detail document on application of transgenic plants.

Course duration (in hours) to attain Course Outcomes:

Course Title: Plant Biotechnology **Course Code:** 52BT206

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-52BT206.1- Familiarization with the basic needs and lab layout for conducting investigations with plant cell cultures.	9	4	5	1	19
CO2-52BT206.2- Development of critical skills for generation of tissue culture raised plantlets and applies protoplast fusion for production of hybrids.	9	4	5	1	19
CO3-52BT206.3- Acquired Skills of the various methods and processes used to create recombinant plants	9	4	5	1	19
CO4-52BT206.4- Recognize various methods related to genetic profiling of plants and analyze the techniques for improvement in plants.	9	4	5	1	19
CO5-52BT206.5- Explore application of transgenic plants for improvement and development of novel characters in plants.	9	4	5	1	19
Total Hours	45	20	25	05	95

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Plant Biotechnology **Course Code:** 52BT206

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-52BT206.1- Familiarization with the basic needs and lab layout for conducting investigations with plant cell cultures.	2	1	1	1	5
CO2-52BT206.2- Development of critical skills for generation of tissue culture raised plantlets and applies protoplast fusion for production of hybrids.	2	4	2	2	10
CO3-52BT206.3- Acquired Skills of the various methods and processes used to create recombinant plants	2	3	3	2	10
CO4-52BT206.4- Recognize various methods related to genetic profiling of plants and analyze the techniques for improvement in plants.	3	5	5	2	15
CO5-52BT206.5- Explore application of transgenic plants for improvement and development of novel characters in plants.	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	TH.S. Chawla: Biotechnology in Group Improvement, International Book Distributing Company. 1998.
2	P.K. Gupta Elements of Biotechnology. Rastogi and Co. Meerut. 1996.
3	R.J. Henry: Practical Application of Plant Molecular Biotechnology. Chapman and Hall. 1997.
4	K.K. De Plant Tissue Culture- 2000.
5	B.D. Singh, Plant Biotechnology- Kalyani Pulication- 2004.

(b) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to virology lab (BSL-3)
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: M. Sc. Biotechnology
Semester:II Semester
Course Title: Plant Biotechnology
Course Code: 52BT206

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-52BT206.1- Familiarization with the basic needs and lab layout for conducting investigations with plant cell cultures.	1	2	3	2	1	2	2	3
CO2-52BT206.2- Development of critical skills for generation of tissue culture raised plantlets and applies protoplast fusion for production of hybrids.	1	1	2	2	1	2	3	3
CO3-52BT206.3- Acquired Skills of the various methods and processes used to create recombinant plants	1	2	2	3	1	1	2	3
CO4-52BT206.4- Recognize various methods related to genetic profiling of plants and analyze the techniques for improvement in plants.	1	1	3	3	2	1	2	3
CO5-52BT206.5- Explore application of transgenic plants for improvement and development of novel characters in plants.	1	1	3	3	2	1	2	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2,3	**CO1-52BT206.1-** Familiarization with the basic needs and lab layout for conducting investigations with plant cell cultures.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	1.1,1.2	1.1,1.2,1.3,1.4,1.5, 1.6, 1.7, 1.8, 1.9	1SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO2-52BT206.2-** Development of critical skills for generation of tissue culture raised plantlets and applies protoplast fusion for production of hybrids.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	2.1, 2.2	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9	2SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO3-52BT206.3-** Acquired Skills of the various methods and processes used to create recombinant plants	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	3.1,3.2	3.1,3.2,3.3,3.4,3.5, 3.6, 3.7, 3.8, 3.9	3SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO4-52BT206.4-** Recognize various methods related to genetic profiling of plants and analyze the techniques for improvement in plants.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9	4.1,4.2	4.1,4.2,4.3,4.4, 4.5, 4.6, 4.7, 4.8, 4.9	4SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO5-52BT206.5-** Explore application of transgenic plants for improvement and development of novel characters in plants.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9	5.1,5.2	5.1,5.2,5.3,5.4,5.5, 5.6, 5.7, 5.8, 5.9	5SL-1,2,3,4,5

Curriculum Developer Team:
Prof. Kamlesh Choure
Prof. Ashwini A. Waoo
Prof. Deepak Mishra
Dr. Monika Soni
Er. Arpit Srivastava

Semester 3

Program Name	**Masters of Science (M.Sc.)-Biotechnology**	
Semester	III	
Course Code:	52BT301	
Course title:	Environmental Biotechnology	**Curriculum Developer**: Mr. Paras Koshe, Assistant Professor
Pre-requisite:	Student should have basic knowledge of Environmental science and Biotechnology	
Rationale:	The Environmental Biotechnology course aims to introduce and elaborate the fundamental concepts and applications of biotechnology in all aspects of environment including its protection, restoration and sustainability. Considering the rising challenges of climate change, energy and environmental crisis, this course will emphasize upon the recent development of biotechnology for harnessing microbial potential in environmental applications. The course is structured to provide the students with fundamental concepts of environmental biotechnology, highlighting the importance of microbial ecology, their metabolism, and methods for their characterization and scopes for implementation. Bioremediation and biodegradation principles, processes and applications will be discussed along with advanced applications in wastewater, oil recovery, biohydrometallurgy, biofuel, carbon storage and capture, etc. This course will offer the students a broad sense of understanding on how modern biotechnology is developed to achieve better environmental protection and sustainability through the use of microbes and microbial communities in pollution abatement to mitigation of climate change, bioenergy, biomaterial to enzyme discovery	
Course Outcomes (COs):	**CO1-52BT301.1.** Explain basic concepts and components of environment **CO2-52BT301.2.** Explain waste treatment and recycling of waste **CO3-52BT301.3** Understand the role of bioremediation in cleaning of waste from environment and know about monitoring environment **CO4-52BT301.4** Interpretate the mechanism of biodegradation and energy production **CO5-52BT301.5** Learn about environmental protection acts and examine various global environmental problems	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits(C) (L:T:P=3:0:1)
			CI	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
Program Core Course (PCC)	52BT301	Environmental Biotechnology	3	2	1	3	9	3+1=4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);
SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits;
Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
PCC	52BT301	Environmental Biotechnology	15	20	10	5	50	50	100

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
PCC	52BT351	Environmental Biotechnology	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	CI	LI	SW	SL	Total
Approx. Hrs	09	04	01	05	19

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-52BT301.1- Explain basic concepts and components of environment.	**SO1.1** Introduction to Environmental Biotechnology		**Unit 1 Environment** **CI1.1** Introduction to Environmental Biotechnology	**SL1.1** Role of Biotechnology in environment
	SO1.2 Define various components of environment.		**CI1.2** Basic concepts and components of environment.	
	SO13 Define Conventional energy sources		**CI 1.3** Conventional energy sources	**SL1.2** Types of energy sources used in your locality (Area)
	SO1.4 Define Nonconventional energy sources		**CI 1.4** Nonconventional energy sources	

	SO 1.5 Modern fuels and their impact		**CI 1.5** Modern fuels and their impact	**SL1.3** Learn some recent modern fuels produced by biotech and compare cost
	SO.1.6 Focus on Methane producing bacteria.	**LI1.1** To understand the role of methanogenic bacteria in biogas production and observe the process of biogas generation from organic waste.	**CI1.6** Methanogenic bacteria	
	SO 1.7 Illustrate the process of Biogas production.		**CI1.7** Biogas Production	**SL1.4** visit any biogas production plant and try to learn it practically
	SO1.8 Evaluate the production of hydrogen by microorganism.		**CI1.8** Microbial hydrogen production	
	SO1.9 Describe the steps and mechanism of conversion of sugar to ethanol.	**LI1.2** To demonstrate the fermentation process for converting sugars to ethanol using yeast and to measure the ethanol yield.	**CI1.9** Conversion of sugars to ethanol.	**SL1.5** Use of ethanol as energy source and try to find out limitation of ethanol production

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	1. Write about the Environmental biotechnology and its role in human welfare. 2. Write about modern fuels and latest technology and their impact on environment.
	SW1.2 Mini Project	2. Which types of energy sources are more used .in your area? Visit any fermentation plant and make a rough sketch of ethanol production
	SW1.3 Other Activities (Specify)	3. visit any fermentation plant and make a rough sketch of ethanol production

Item	CI	LI	SW	SL	Total
Approx. Hrs	09	04	01	04	18

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self Learning (SL)
CO2-52BT301.2- Explain waste treatment and recycling of waste	**SO2.1** Understand Concept of waste water treatment	**LI2.1** To understand and observe the primary, secondary, and final treatment processes in wastewater treatment.	**Unit-II Waste water treatment** **CI2.1** Primary, Secondary and final treatment of water.	**SL2.1** Observing the physical and chemical properties of water. And focus on save water.
	SO2.2 Understand Concept of solid waste Management		**CI2.2** Solid Waste: Sources and Management.	**SL2.2** Observe different types of solid waste. And their impacts.
	. **SO2.3** Composting		**CI2.3** Composting	**SL2.3** Gain knowledge about some other method such as landfills, incineration etc.
	SO2.4 Vermiculture		**CI2.4** Vermiculture	
	SO2.5 Methane production		**CI2.5** Methane production	
	SO2.6 Elucidate the process of disposal of waste		**CI2.6** Disposal of medical waste	
	SO2.7 Illustrate the process of recycling of waste(5R'S)		**CI2.7** Recycling of waste	
	SO2.8 Define types and importance of biofertilizers	**LI2.2** To explore the preparation and application of biofertilizers and biopesticides.	**CI2.8** Biofertilizers	**SL2.4** Understanding the role bio fertilizers and bio pesticides in crop improvement.
	SO2.9 Describe types and importance of biopesticides.		**CI2.9** Biopesticides	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Comparative study between chemical and biofertilizer
	SW2.2 Mini Project	Try to find out the earthworm varies found in your area and find most variety used in vermicomposting
	SW2.3 Other Activities (Specify)	Visit some of the dumping sites and see types of solid waste generated and suggest some method of energy generation.

Item	CI	LI	SW	SL	Total
Approx. Hrs	09	04	01	03	17

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO3-52BT301.3- Understand the role of bioremediation in cleaning of waste from environment and know about monitoring environment.	**SO3.1** Explain the role of Bioremediation in environmental cleaning.		**Unit-3 Bioremediation** **CI3.1** In -situ bioremediation techniques	**SL3.1** Explore the basic concepts of bioremediation and its types correlate with unit 1 and energy generation from bioremediation
	SO3.2 Learn about the utility of Bioremediation.		**CI3.2** Ex -situ bioremediation techniques**.**	
	SO3.3 Bioremediation of soil contaminated with oil spills		**CI3.3**. Bioremediation of soil contaminated with oil spills	**SL3.2** Learn different other techniques used in bioremediation of soil and water.
	SO3.4 Analyze the role of Plants in bioremediation		**CI3.4** Bioremediation of water contaminated with oil spills	
	SO3.5 To learn how bioremediation methods are useful in removing heavy metal from water.	**LI3.1** To study the bioremediation of water contaminated with heavy metals and detergents using microbial cultures.	**CI3.5** Removal of heavy metals from water by bioremediation methods	

	SO3.6 Outline the steps of removing detergents from water by bioremediation methods.		**CI3.6** Removal of detergents from water by bioremediation methods	
	SO3.7 Define phytoremediation and its role in reducing pollution	**LI3.2** To explore different types of phytoremediation techniques and their applications in cleaning up contaminated soil and water.	**CI3.7** Phytoremediation: Types and its applications	
	SO3.8 Analyze the role of living (Bio things in environmental monitoring.		**CI3.8** Environmental monitoring:	
	SO3.9 Describe various types of Bioindicators.		**CI3.9** Bioindicators	**SL3.3** Understand the role of bioindicators in aspects of farmer's life.

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	• Explain diagrammatically about in situ and ex situ bioremediation techniques with examples. • Write about different types of Bio indicators.
	SW3.2 Mini Project	How bioreactors are used in bioremediation. Explain different types of bioreactors used.
	SW3.3 Other Activities (Specify)	Find out some Bioremediation sites in your area or nearby cities, and also find microorganism and plant species found in your lab or area which can be used as bio indicators.

Item	CI	LI	SW	SL	Total
Approx. Hrs	09	04	01	02	16

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO4-52BT301.4- Interpretate the mechanism of biodegradation and energy production	**SO4.1**. To study the concept of Biodegradation		**Unit-IV** **CI 4.1** Biodegradation	**SL4.1** Understand the basic knowledge of biodegradation and correlate with bioremediation.
	SO4.2 To learn the biodegradation of various compounds		**CI 4.2** Biodegradation of chlorinated hydrocarbons compounds	
	SO4.3 To learn the biodegradation of various compounds		**CI 4.3** Biodegradation of xenobiotic compounds	
	SO4.4 Elucidate the process of Bioleaching and its steps.		**CI 4.4** Bioleaching	**SL4.2** Learn the steps of bioleaching Identify strain of microorganism used for bioleaching and try to culture and extract.
	SO4.5 Analyze bioleaching of important metals and role of microorganism in bioleaching		**CI 4.5** Leaching of ores by microorganisms (bioleaching of Gold)	
	SO4.6 To study about bioleaching		**CI 4.6** Leaching of ores by microorganisms (leaching of copper)	
	SO4.7 Understand the role of microorganism in leaching of uranium		**CI 4.7** Leaching of ores by microorganisms (uranium)	

	SO4.8 Describe the role of microorganism in cellulose degradation to use as fuel	**LI4.1** To study the degradation of cellulose by microorganisms and the production of combustible fuel (ethanol).	**CI 4.8** Cellulose degradation for combustible fuel	
	SO4.9 Elucidate the production of petroleum from biological materials.	**LI4.2** To explore the production of biopetroleum using algae or other microorganisms.	**CI 4.9** Biopetroleum Production	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	1. Explain biodegradation in detail. 2. Describe the process of Bioleaching.
	SW4.2 Mini Project	Try to produce ethanol in laboratory.
	SW4.3 Other Activities (Specify)	Prepare one article on the bioleaching and also focus on diamond mining.

Item	CI	LI	SW	SL	Total
Approx. Hrs	09	04	01	01	15

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction(LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO5-52BT301.5- Learn about environmental protection act and examine various global environmental problems.	**SO5.1**Over viewing of various environmental protection act and different Environmental laws		**Unit-V** **CI5.1** Environment protection Act: Environmental laws	**SL 5.1** Learn about different agencies and pollution board and their location of head offices.
	SO5.2 To know about environmental policies		**CI5.2** Environmental policies	
	SO5.3 Explain about environmental ethics		**CI5.3** Environmental ethics	
	SO5.4 To study the environmental impact and assessment		**CI5.4** Environmental Impact Assessment	

	SO5.5 Describe the importance of ecoplanning		**CI5.5** Ecoplanning	
	SO5.6 Elucidate the role of sustainable development in conservation of energy**.**	**LI5.1** To explore the principles of ecoplanning and sustainable development through a practical project.	**CI5.6** Sustainable Development	
	SO5.7 To learn about global environmental problems and its impact.	**LI5.2** To understand the causes, effects, and mitigation strategies of global environmental problems such as ozone depletion, the greenhouse effect, and acid rain.	**CI5.7** Global environmental problems	
	SO5.8 Elaborate the causes and impact of Green House effect.		**CI5.8** Green house effect	
	SO5.9 Explain acid rain and its effects on environment.		**CI5.9** Acid rain	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignment	Describe in detail about Global environment problems.
	SW5.2 Assignment	Write a brief note on Sustainable Development Goals.
	SW5.2 Mini Project	Try to find out environmental problems of your Locality or area.
	SW5.3 Other Activities (Specify)	• Find out the water level of your area and compare it with water table. • Identify Major pollutant of your area and suggest steps to reduce them.

Course duration (in hours) to attain Course Outcomes:

Course Title: Environmental Biotechnology **Course Code:** 52BT301

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-52BT301.1- Explain basic concepts and components of environment.	9	4	5	1	19
CO2-52BT301.2- Explain waste treatment and recycling of waste .	9	4	4	1	18
CO3-52BT301.3- Understand the role of bioremediation in cleaning of waste from environment and know about monitoring environment.	9	4	3	1	17
CO4-52BT301.4- Interpretate the mechanism of biodegradation and energy production	9	4	2	1	16
CO5-52BT301.5- Learn about environmental protection act and examine various global environmental problems.	9	4	1	1	15
Total Hours	45	20	15	05	85

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-52BT301.1- Explain basic concepts and components of environment.	2	1	1	1	5
CO2-52BT301.2- Explain waste treatment and recycling of waste .	2	4	2	2	10
CO3-52BT301.3- Understand the role of bioremediation in cleaning of waste from environment and know about monitoring environment.	3	5	5	2	15
CO4-52BT301.4- Interpretate the mechanism of biodegradation and energy production	2	3	3	2	10
CO5-52BT301.5- Learn about environmental protection acts and examine various global environmental problems.	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	• Environmental Microbiology, W.D. Grant & P.E. Long, Blakie, Glassgow and London.
2	• Environmental Biotechnology by Bruce Rittmann and Perry McCarty
3	• Environmental biotechnology, 1995 S.N.Jogdand. Himalaya Publishing House, Bombay, Delhi, Nagpur.
4	• Bioremediation 1994 Baker, K.H.and Herson, D.S. McGraw Hill, Inc.New York.
5	• Environmental Microbiology, W.D. Grant & P.E. Long, Blakie, Glassgow and London.

(b) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to virology lab (BSL-3)
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: M.Sc. Biotechnology
Semester: III Semester
Course Title: Environmental Biotechnology
Course Code: 52BT301

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-52BT301.1- Explain basic concepts and components of environment.	2	-	-	1	2	2	2	1
CO2-52BT301.2- Explain waste treatment and recycling of waste .	-	-	-	-	-	1	1	2
CO3- 52BT301.3- Understand the role of bioremediation in cleaning of waste from environment and know about monitoring environment.	-	1	1	1	-	1	1	1
CO4-52BT301.4- Interpretate the mechanism of biodegradation and energy production	-	1	1	-	2	1	1	3
CO5-52BT301.5- Learn about environmental protection act and examine various global environmental problems.	1	1	1	-	-	1	3	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2,3	**CO1-52BT301.1-** Explain basic concepts and components of environment.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	**LI 1** **LI 2**	1.1,1.2,1.3,1.4,1.5 1.6,1.7,1.8,1.9	**1SL-1,2,3,4,5**
PO 1,2,3,4,5 PSO 1,2,3	**CO2-52BT301.2-** Explain waste treatment and recycling of waste .	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	**LI 1** **LI 2**	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7,2.8,2.9	**2SL-1,2,3,4**
PO 1,2,3,4,5 PSO 1,2,3	**CO3-52BT301.3-** Understand the role of bioremediation in cleaning of waste from environment and know about monitoring environment.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	**LI 1** **LI 2**	3.1,3.2,3.3,3.4,3.5,3.6,3.7,3.8,3.9	**3SL-1,2,3**
PO 1,2,3,4,5 PSO 1,2,3	**CO4-52BT301.4-** Interpretate the mechanism of biodegradation and energy production	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9	**LI 1** **LI 2**	4.1,4.2,4.3,4.4,4.5,4.6,4.7,4.8,4.9	**4SL-1,2**
PO 1,2,3,4,5 PSO 1,2,3	**CO5-52BT301.5-** Learn about environmental protection act and examine various global environmental problems.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9	**LI 1** **LI 2**	5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8,5.9	**5SL-1**

Curriculum Developer Team:

Prof. Kamlesh Choure
Prof. Ashwini A. Waoo
Prof. Deepak Mishra
Dr. Monika Soni
Er. Arpit Srivastava

Program Name	**Master of Science (M. Sc.)- Biotechnology**	
Semester	III	
Course Code:	52BT302	
Course title:	Genetic Engineering & Bionanotechnology	**Curriculum Developer**: Dr. Ashwini A. Waoo, Professor
Pre-requisite:	Student should have basic knowledge of gene, vector, cloning	
Rationale:	Genetic engineering and bio nanotechnology offer unprecedented avenues to manipulate biological systems at the molecular level, revolutionizing medicine, agriculture, and environmental sustainability. By harnessing genetic modification and nanoscale tools, these fields pave the way for tailored therapies, enhanced crop resilience, and novel solutions to global challenges, driving innovation across diverse scientific domains.	
Course Outcomes (COs):	**CO1-52BT302.1:** Understanding the basic steps of gene cloning and the role of enzymes and vectors responsible for gene manipulation, transformation and genetic engineering. **CO1-52BT302.2:** Selection of expression strategies for heterologous gene- expression in bacteria, yeast, insects, and in mammalian cells. **CO1-52BT302.3:** Acquiring theoretical knowledge in the techniques, tools, application and safety measures of genetic engineering and gene therapy. **CO1-52BT302.4:** Studying the basics of nanotechnology, synthesis, characterization of nanoparticles. **CO1-52BT302.5:** Applications of bionanotechnology in medicine, agriculture and the environment.	

Scheme of Studies:

Board of Study	CourseCode	Course Title	Scheme of studies (Hours/Week)					Total Credits(C) (L:T:P=3:1:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Core Course (PCC)	52BT302	Genetic Engineering & Bionanotechnology	3	2	1	1	7	3+1+1=5

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);
SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits;
Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
(PCC)	52BT302	Genetic Engineering & Bionanotechnology	15	20	10	5	50	50	100

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
PCC	52BT352	Genetic Engineering & Bionanotechnology	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	12	04	01	05	22

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI) 98BT155	Class room Instruction (CI)	Self-Learning (SL)
CO1-52BT302.1: Understanding the basic steps of gene cloning and the role of enzymes and vectors responsible for gene manipulation, transformation and genetic engineering.	**SO1.1** Understand history and scope of genetic engineering		**Unit-1** **CI1.1** Scope of genetic engineering,	**SL1.1** Study of history and introduction of genetic engineering
	SL1.2 Molecular tools & their application		**CI1.2** Molecular tools & their application	**SL1.3** What are molecular tools
	SO1.3 & SO1.4 Understand types and mechanisms of restriction endonucleases		**CI1.3 & CI1.4** restriction endonuclease,	**SL1.3** Write mechanism of type II restriction endonuclease
	SO1.5 & SO1.6 Understand types and mode of action of DNA modifying enzymes		**CI1.5 & CI1.6** DNA modifying enzymes,	**SL1.4** Differentiate between all DNA modifying enzymes
	SO1.7 & SO1.8 Describe different methods of DNA extraction.	**LI1.1** Isolation of DNA from plant and bacteria	**CI1.7 & CI1.8** Isolation and purification of DNA from bacteria, plant & animal cell,	
	SO1.9 & SO1.10 Illustrate the technique of c DNA Synthesis	**LI1.2** Electrophoresis of separated DNA.	**CI1.9 & CI1.10** cDNA synthesis and cloning- mRNA enrichment, reverse transcription, DNA primers	
	SO1.11 & SO1.12 Evaluate and apply the linkers and adaptors according to need		**CI1.11 & CI1.12** linker adaptors and their chemical synthesis,	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	What are restriction endonucleases? Give nomenclature, classification, applications and mode of action.
	SW1.2 Mini Project	Describe mode of action of alkaline phosphatases and their applications in genetic engineering.
	SW1.3 Other Activities (Specify)	Find out DNA extraction protocol for insect cell.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	12	02	01	05	20

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-52BT302.2: Selection of expression strategies for heterologous gene-expression in bacteria, yeast, insects, and in mammalian cells.	**SO2.1** Illustration of types of cloning vectors for E coli and their properties	**LI2.1** Preparation of competent cells	**Unit-II** **CI2.1** Cloning vector for E.coli, cloning vector for eukaryotes,	**SL2.1** Learn types cloning vectors for E coli
	SO2.2 Illustration of plant-based vectors		**CI2.2** plant-based vector,	**SL2.2** List out plant based vectors
	SO2.3 Understand use of yeast vectors		**CI2.3** yeast vector	**SL2.3** Learn about yeast vector
	SO2.4 Determine the selection strategies for recombinants		**CI2.4** Method for selection and screening of recombinant clone,	**SL2.3** Discuss the screening of recombinants
	SO2.5 & SO2.6 Assessing the need of heterologous gene- expression in bacteria		**CI2.5 & CI2.6** Expression strategies for heterologous gene- expression in bacteria,	
	SO2.7 & SO2.8 Explaining the expression in yeast		**CI2.7 & CI2.8** expression in yeast	
	SO2.9 & SO2.10 Explaining expression in insect cell		**CI2.9 & CI2.10** Expression in insects	**SL2.5** Give baculovirus expression system
	SO2.11 & SO2.12 Understand expression in mammalian cells		**CI2.11 & CI2.12** expression in mammalian cells.	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe various expression strategies of heterologous gene.
	SW2.2 Mini Project	Explain the extraction of DNA from blood sample.
	SW2.3 Other Activities (Specify)	Prepare list of properties of good cloning vector.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	12	02	01	02	17

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-52BT302.3: Acquiring theoretical knowledge in the techniques, tools, application and safety measures of genetic engineering and gene therapy.	**SO3.1** Demonstrate the production of DNA RNA probe		**Unit-III** **CI3.1** labeling of DNA and RNA probes	**SL3.1** Read about electrophoresis
	SO3.2 Illustration of agarose gel electrophoresis		**CI3.2** gel retardation technique	**SL3.2** Draw a diagram of electrophoretic appartus
	SO3.3 Apply the reporter assay for specific purpose		**CI3.3** reporter assays,	
	SO3.4 Evaluate and apply the PCR for specific purpose	**LI3.1** Demonstration of PCR	**CI3.4** Polymerase chain reaction and its application,	
	SO3.5 & SO3.6 Describe production of recombinant pharmaceuticals,		**CI3.5 & CI3.6** Application of genetic engineering-production of recombinant pharmaceuticals,	
	SO3.7 & SO3.8 Demonstrate the use of Gene therapy.		**CI3.7 & CI3.8** gene therapy,	
	SO3.9 & SO3.10 Describe disease diagnosis via genetic engineering		**CI3.9 & CI3.10** disease diagnosis,	
	SO3.11 & SO3.12 Analyze biohazards and enlist biosafety regulation		**CI3.11 & CI3.12** Biosafety regulation-biological and physical containment.	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe principles and types of PCR
	SW3.2 Mini Project	Describe the significance of PCR in forensics.
	SW3.3 Other Activities (Specify)	Prepare list of compounds produced by Biotech industries and their raw materials with production process.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	12	02	01	05	20

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO-52BT302.4: Studying the basics of nanotechnology, synthesis, characterization of nanoparticles.	**SO4.1** Develop understanding of bio nanotechnology	**LI4.1** Demonstration of nanoparticle synthesis (virtual)	**Unit-IV** **CI4.1** Introduction to Bionanotechnology	**SL4.1** Learn about bio nanotechnology
	SO4.2 Illustrate opportunities & challenges of Bionanotechnology.		**CI4.2** Opportunities & challenges of Bionanotechnology.	**SL4.2** Discuss challenges of bio nanotechnology
	SO4.3 & SO4.4 Ananlyze key features of nanoparticles		**CI4.3 & CI4.4** Key features of Nano-size,	**SL4.1** Video for nanoparticle producation
	SO4.5 & SO4.6 Understand properties nanosize to macro size.		**CI4.5 & CI4.6** Comparison of particle behavior at nanosize to macrosize.	**SL4.4** Studies related properties of nanoparticles
	SO4.7 & SO4.8 Evaluate strategies of nanoarchitecture		**CI4.7 & CI4.8** Strategies for Nanoarchitecture (top down & bottom up approaches).	
	SO4.9 & SO4.10 Evaluate the need of biomolecular design		**CI4.9 & CI4.10** Biomolecular design and	**SL4.5** Evaluate the technique of biomolecular design
	SO4.11 & SO4.12 Apply bionanomachines for various purposes.		**CI4.11 & CI4.12** Bionanomachines in action.	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Describe principles and strategies of bionanotechnogy
	SW4.2 Mini Project	Describe the properties of nanoparticle sand their applications
	SW4.3 Other Activities (Specify)	Prepare list of nanoparticles and their production process.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	12	02	01	05	20

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO-52BT302.5: Applications of bio nanotechnology in medicine, agriculture and the environment.	**SO5.1** Demonstrate microarray technology		**Unit-V** **CI5.1** Microarray technology.	**SL5.1** learn about principle of centrifuge
	SO5.2 Illustrate the basics of bionanoimaging		**CI5.2** Principle, types and Applications of Bionanoimaging,	**SL5.2** learn about analytical centrifuge
	SO5.3 Evaluate the need of Nanobiosensors,		**CI5.3** Nanobiosensors	**SL5.3** Give role of rotors its capacity range and applications
	SO5.4 Evaluate the need of, Biochips, Biorobotics		**CI5.4** Biochips, Biorobotics,	**SL5.4** Learn about properties of radioisotopes
	SO5.5 & SO5.6 Analyze the advantages of biomolecular motars		**CI5.5 & CI5.6** Biomolecular motors; ATP Synthase, flagellar motors;	**SL5.5** Give example of biomolecular designs
	SO5.7 & SO5.8 Describe Traffic across membranes- K channels		**CI5.7 & CI5.8** Traffic across membranes- K channels	
	SO5.9 & SO5.10 Apply the DNA computers.		**CI5.9 & CI5.10** DNA computers.	
	SO5.11 & SO5.12 Evaluate the need of Nano drug delivery	**LI5.1** In-Silico analysis of nano-drug delivery by using software	**CI5.11 & CI5.12** Nano drug delivery.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Describe principles of microarray technology
	SW5.2 Mini Project	Describe the applications of bionanoimaging in clinical field
	SW5.3 Other Activities (Specify)	Prepare list of hazards occurred due to improper use and dispose of radioisotopes.

Course duration (in hours) to attain Course Outcomes:

Course Title: Genetic Engineering & Bionanotechnology **Course Code: 52BT302**

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO-52BT302.1: Understanding the basic steps of gene cloning and the role of enzymes and vectors responsible for gene manipulation, transformation and genetic engineering.	12	4	5	1	22
CO-52BT302.2: Selection of expression strategies for heterologous gene- expression in bacteria, yeast, insects, and in mammalian cells.	12	2	5	1	20
CO-52BT302.3: Acquiring theoretical knowledge in the techniques, tools, application and safety measures of genetic engineering and gene therapy.	12	2	2	1	17
CO-52BT302.4: Studying the basics of nanotechnology, synthesis, characterization of nanoparticles.	12	2	5	1	20
CO-52BT302.5: Applications of bionanotechnology in medicine, agriculture and the environment.	12	2	5	1	20
Total Hours	60	12	22	05	99

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Genetic Engineering & Bionanotechnology **Course Code: 52BT302**

Course Outcomes					
	A	**A**	**E**	**C**	**Total Marks**
CO-52BT302.1: Understanding the basic steps of gene cloning and the role of enzymes and vectors responsible for gene manipulation, transformation and genetic engineering.	03	01	01	01	06
CO-52BT302.2: Selection of expression strategies for heterologous gene- expression in bacteria, yeast, insects, and in mammalian cells.	02	04	02	02	10
CO-52BT302.3: Acquiring theoretical knowledge in the techniques, tools, application and safety measures of genetic engineering and gene therapy.	03	05	05	01	14
CO-52BT302.4: Studying the basics of nanotechnology, synthesis, characterization of nanoparticles.	02	03	05	00	10
CO-52BT302.5: Applications of bionanotechnology in medicine, agriculture and the environment.	05	04	00	01	10
Total Marks	15	17	13	05	50

Legend: A: Apply, A: Analyze E: Evaluate, C: Create

Suggested learning Resources:

(a) Books:

S. No.	Title	Author	Publisher	Edition &Year
1	• Introduction to Genomics .	Arthur Lesk.	Oxford University Press,	2008
2	• Genomes,	T.A. Brown	Garland Science,.	3rd Edition, 2006
3	• Molecular Cloning, A laboratory Manual.	Sambrook, J., Fritsch, E.F., Mariatis.	Cold Spring Harbor Laboratory, USA.	2001, 3rd edition.
4	• Gene Cloning by	T.A. Brown		
5	• Nanotribology and Nanomechanics - An introduction, Springer.	Bharat Bhushan.,		
	• Nanobiotechnology- next big idea.	Mark, Ratner Daniel Ratner		

(b) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to virology lab (BSL-3)
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Title: M. Sc. Biotechnology
Semester: III
Course Code: 52BT302
Course Title: Genetic Engineering & Bionanotechnology

Course Outcome	Program Outcomes (POs)					Program Specific Outcomes (PSOs)		
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO-52BT302.1: Understanding the basic steps of gene cloning and the role of enzymes and vectors responsible for gene manipulation, transformation and genetic engineering.	**2**	**1**	**-**	**3**	**2**	**2**	**1**	**-**
CO-52BT302.2: Selection of expression strategies for heterologous gene- expression in bacteria, yeast, insects, and in mammalian cells.	**2**		**-**	**-**	**3**	**2**	**1**	**1**
CO-52BT302.3: Acquiring theoretical knowledge in the techniques, tools, application and safety measures of genetic engineering and gene therapy.	**2**	**1**	**-**	**3**	**-**	**1**	**1**	**-**
CO-52BT302.4: Studying the basics of nanotechnology, synthesis, characterization of nanoparticles.	**2**		**-**	**3**	**3**	**2**	**-**	**-**
CO-52BT302.5: Applications of bionanotechnology in medicine, agriculture and the environment.	**2**	**1**	**-**	**3**	**2**	**2**	**2**	**-**

Legend: **(1) Low (2) Medium (3) High**

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2,3	**CO-52BT302.1:** Understanding the basic steps of gene cloning and the role of enzymes and vectors responsible for gene manipulation, transformation and genetic engineering.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9 SO1.10 SO1.11 SO1.12	LI1 LI2	1.1,1.2,1.3,1.4,1.5, 1.6, 1.7,1.8,1.9,1.10,1.11,1.12	1SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO-52BT302.2:** Selection of expression strategies for heterologous gene-expression in bacteria, yeast, insects, and in mammalian cells.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9 SO2.10 SO2.11 SO2.12	LI1	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10,2.11,2.12	2SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO-52BT302.3:** Acquiring theoretical knowledge in the techniques, tools, application and safety measures of genetic engineering and gene therapy.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9 SO3.10 SO3.11 SO3.12	LI1	3.1,3.2,3.3,3.4,3.5,3.6,3.7, 3.8,3.9,3.10,3.11,3.12	3SL-1,2
PO 1,2,3,4,5 PSO 1,2,3	**CO-52BT302.4:** Studying the basics of nanotechnology, synthesis, characterization of nanoparticles.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9 SO4.10 SO4.11 SO4.12	LI1	4.1,4.2,4.3,4.4,4.5,4.6, 4.7,4.8,4.9,4.10,4.11,4.12	4SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO-52BT302.5:** Applications of bionanotechnology in medicine, agriculture and the environment.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9 SO5.10 SO5.11 SO5.12	LI1	5.1,5.2,5.3,5.4,5.5,5.6,5.7, 5.8,5.9,5.10,5.11,5.12	5SL-1,2,3,4,5

Curriculum Developer Team:
Prof. Kamlesh Choure
Prof. Ashwini A. Waoo
Prof. Deepak Mishra
Dr. Monika Soni
Er. Arpit Srivastava

Program Name	**Master of Science in Biotechnology (M.Sc. (BT)**	
Semester	III	
Course Code:	52BT303	
Course title:	Agriculture Biotechnology	**Curriculum Developer**: Chahana Desai, Teaching Associate
Pre-requisite:	Students should have basic knowledge and understanding about traditional agricultural practices and concept of genetic engineering.	
Rationale:	• The objectives of the Agricultural Biotech course are to provide students with a comprehensive understanding of the principles and applications of biotechnology in the field of agriculture. • The course aims to equip students with the knowledge and skills necessary to utilize biotechnological tools and techniques for enhancing crop productivity, improving plant genetics, and developing sustainable agricultural practices. • Additionally, the course seeks to foster critical thinking and ethical awareness among students regarding the potential benefits, risks, and societal implications associated with agricultural biotechnology.	
Course Outcomes (COs):	**CO1-52BT303.1-** An overview of Biotechnology in agriculture. **CO2-52BT303.2-** Acquire knowledge regarding transgenesis and genetic engineering. **CO3-52BT303.3-** Gain an understanding of herbicide resistance crops and different types of biofertilizers and its importance and characteristics. **CO4-52BT303.4-** Elucidate the detailed role of various microbes in the field of agriculture. **CO5-52BT303.5-** Elaborate the mechanism of metabolic engineering in plants.	

Scheme of Studies:

Board of Study	CourseCode	Course Title	Scheme of studies (Hours/Week)					Total Credits(C) (L:T:P=3:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Core Course (PCC)	52BT303	Agriculture Biotechnology	3	2	1	1	7	3+1=4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);
SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits.
Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class act any one (CAT)	Class Attendance	Total Marks (CA+CT+CAT+SA+AT)		
PCC	52BT303	Agriculture Biotechnology	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
PCC	52BT353	Agriculture Biotechnology	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	02	01	02	14

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-52BT303.1- An overview of Biotechnology in agriculture.	**SO1.1** Elaborate the risk and challenges in agriculture biotechnology.	**LI1.1** The physiological changes in fruit during ripening process	**Unit-1 Biotechnology in Agriculture** **CI1.1** Historical perspective. Risk and challenges in Agricultural Biotechnology	**SL1.1** Basic idea about traditional agricultural practices.
	SO1.2 Concept of possible improvement techniques for major crop plants.		**CI1.2** Major crop plants and their improvement.	
	SO1.3		**CI1.3**	**SL1.2**

	Understanding the impact of chemical fertilizers and its possible alternatives.		Impact of fertilizers and possible alternatives.	Chemical fertilizers and its effects.
	SO1.4 Elucidate the losses due to biotic and abiotic stresses.		**CI1.4** Losses due to biotic and abiotic stresses.	
	SO1.5 Explanation about the importance of plant growth regulators		**CI1.5** Plant growth regulators: auxin, gibberlins, cytokinins, abscicic acid, etylene.	
	SO1.6 To learn about the biosynthesis, transport and physiological effects of Auxin.		**CI1.6** To learn about the biosynthesis, transport and physiological effects of Auxin.	
	SO1.7 To learn about the biosynthesis, transport and physiological effects of gibberlins, cytokinins		**CI1.7** To learn about the biosynthesis, transport and physiological effects of gibberlins, cytokinins	
	SO1.8 & SO1.9 To learn about the biosynthesis, transport and physiological effects of abscicic acid, ethylene		**CI1.8 & CI1.9** To learn about the biosynthesis, transport and physiological effects of abscicic acid, ethylene	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	1. Biosynthetic pathways for Auxin. 2. Possible alternatives of chemical fertilizers.
	SW1.2 Mini Project	Ray Diagram of Ethylene biosynthetic pathway
	SW1.3 Other Activities (Specify)	Find out the Visual aspects of how plant stressors affect the plant

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	01	15

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-52BT303.2- Acquire knowledge regarding transgenesis and genetic engineering.	**SO2.1** Elaborate the detailed mechanism of transgenesis.	**LI2.1** Isolation of plant cell DNA using CTAB method.	**Unit-2 Transgenesis and genetic engineering:** **CI2.1** Transgenic plants.	
	SO2.2 To learn about the resistance against biotic and abiotic stresses	**LI2.2** To perform agarose gel electrophoresis for DNA identification.	**CI2.2** Engineering for resistance against salinity, drought, herbicide, frost ant pest.	**SL2.1** Differences between Biotic stress and abiotic stress.
	SO2.3 Elucidate the Mechanisms of genetic engineering for the gene transfer in plants for nitrogen fixation.		**CI2.3** transfer of nif gene to transgenic plant	
	SO2.4 To learn about the how therapeutic molecules produced by the plants**.**		**CI2.4** Production of therapeutic molecule in plants	
	SO2.5 Explanation about production and importance of edible vaccines		**CI2.5** edible vaccines	
	SO2.6 Explanation about production and importance of golden rice		**CI2.6** Golden rice.	
	SO2.7 Elucidate the mechanism of flower color modification.		**CI2.7** flower and color modification	
	SO2.8 Explanation about the mechanism of delaying fruit ripening**.**		**CI2.8** Delaying fruit ripening.	
	SO2.9 Elaborate the ethical issues		**CI2.9** Ethical issues associated	

	associated with GM crops and GM food.		with GM crops and GM food.	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	1. Diagram of how the nif gene transfer to plant. 2. Strategies for delaying fruit ripening technology.
	SW2.2 Mini Project	Detailed explanation about different types of gene transfer method with diagram.
	SW2.3 Other Activities (Specify)	Show some visual content how transgenesis takes place in plants.

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	02	16

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO3-52BT303.3- Gain an understanding of herbicide resistance crops and different types of biofertilizers and its importance and characteristics.	**SO3.1** Various effects of herbicide resistance crops to the environment and human health.		**Unit-3 environmental impact of transgenic plant and Biofertilizers:** **CI3.1** Environmental impact of herbicide resistance crops and superweeds.	
	SO3.2 Mechanisms and importance of biological nitrogen fixation.	**LI3.1** To perform isolation and identification of rhizobium/azotobacter species from soil.	**CI3.2** Biological nitrogen fixation: importance and mechanism	**SL3.1** Basics of nitrogen fixation process.
	SO3.3 Elucidate the regulation of biological nitrogen fixation	**LI3.2** Testing of nodulation ability by rhizobia.	**CI3.3** Elucidate the regulation of biological nitrogen fixation	
	SO3.4 Elucidate the mode of action and production of VAM biofertilizer.		**CI3.4** Biofertilizers: types, production, VAM	**SL3.2** Basic idea about chemical and biofertilizers and its effect.
	SO3.5 Explanation about the mode of action and production of		**CI3.5** Biofertilizers: types, production of Rhizobium	

	Rhizobium			
	SO3.6 Explanation about the mode of action and production of Azotobacter		**CI3.6** Biofertilizers: types, production of Azotobacter	
	SO3.7 Elucidate the mode of action and production of Mycorhiza.		**CI3.7** Biofertilizers: types, production of Mycorhiza,	
	SO3.8 Explanation about the mode of action and production of Actinorhiza.		**CI3.8** Biofertilizers: types, production of Actinorhiza.	
	SO3.9 Elaborate the methods, types and applications of vermicomposting technology		**CI3.9** Vermicomposting technology.	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	1. Mechanism of nitrogen fixation. 2. Methods of vermicomposting technology.
	SW3.2 Mini Project	Phases of vermicomposting production with required diagram.
	SW3.3 Other Activities (Specify)	Get the practical knowledge about the nodulation by the symbiotic bacteria in plants for nitrogen fixation.

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	03	17

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO4-52BT303.4- Elucidate the detailed role of various microbes in the field of agriculture.	**SO4.1** Understanding about the Basic concept and Mechanism of plant diseases	**LI4.1** To observe, identify, and document the general symptoms of plant diseases in a variety of plant specimens.	**Unit-4 Role of microbes in agriculture** **CI4.1** General symptoms of plant diseases.	

	SO4.2 Knowledge about how the plant infected by plant pathogen.		**CI4.2** Mode of infection.	
	SO4.3 Understanding about the plant pathogen id dispersed and the control measures.		**CI4.3** Dispersal of plant pathogens and control of pathogens.	**SL4.1** Knowledge about plant pathogen.
	SO4.4 Basic concept about Integrated Pest management.		**CI4.4** Integrated pest management	
	SO4.5 Elucidate the concept of Terminator gene technology.		**CI4.5** Concept of terminator gene technology	
	SO4.6 Elaborate the mechanism of Terminator gene technology.		**CI4.6** Mechanism of Terminator gene technology.	
	SO4.7 Detailed understanding about role and importance of Biopesticides.	**LI4.2** To prepare a neem-based biopesticide and test its effectiveness against common garden pests.	**CI4.7** Biopesticides	**SL4.2** Basic idea about pesticides.
	SO4.8 Knowledge about how Germplasm conservation can be done.		**CI4.8** Germplasm conservation	**SL4.3** Characteristics of germplasm.
	SO4.9 Understanding about the Mechanism of how the seed Bank is developed.		**CI4.9** seed bank	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	1. Write mode of action of different biopesticides. 2. Describe briefly the terminator gene technology.
	SW4.2 Mini Project	Draw a ray diagram of how plant pathogens are controlled
	SW4.3 Other Activities (Specify)	1. Observe symptoms of plant diseases. 2. Power point presentation of dispersal of plant pathogen.

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	02	01	02	14

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO5-52BT303.5- Elaborate the mechanism of metabolic engineering in plants	**SO5.1** Explanation about plant cell culture.	**LI5.1** Separation of plant pigments using different plant samples by paper chromatography	**Unit-5 Metabolic engineering of plants** **CI5.1** Plant cell culture for the production of useful chemicals and secondary metabolites (Hairy root culture, Biotransformation, Elicitation.	**SL5.1** Basic knowledge of plant tissue culture.
	SO5.2 Elucidate about the production of useful chemicals		**CI5.2** Production of useful chemicals	
	SO5.3 Detailed knowledge about plant pigments and pathways for the flavonoid production		**CI5.3** Production of pigments, flavonoids	**SL5.2** Basic knowledge about plant pigments.
	SO5.4 Elucidate the mechanism and importance of alkaloid production		**CI5.4** Production of pigments, alkaloids	
	SO5.5 Explain the detailed mechanism and manipulation of the pathway which is responsible for synthesis of aromatic amino acids.		**CI5.5** Mechanism and manipulation of shikimate pathway.	
	SO5.6 Elucidate the mechanism about production of industrial enzymes.		**CI5.6** Production of Industrial enzymes.	

	SO5.7 Understanding about biodegradable plastics and its importance.		**CI5.7** Biodegradable plastics.	
	SO5.8 Explanation about production of therapeutic protein.		**CI5.8** Production of therapeutic protein	
	SO5.9 Elucidate the role of therapeutic protein.		**CI5.9** Role of therapeutic protein.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	1. Production of flavonoid and alkaloids plant pigments. 2. Ray diagram of Shikimate pathway.
	SW5.2 Mini Project	Detailed diagram of industrial enzyme production.
	SW5.3 Other Activities (Specify)	Acquire knowledge about how bioplastics are made.

Course duration (in hours) to attain Course Outcomes:

Course Title: Agriculture biotechnology **Course Code:** 52BT303

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-52BT303.1- An overview of Biotechnology in agriculture.	09	2	2	1	14
CO2-52BT303.2- Acquire knowledge regarding transgenesis and genetic engineering.	09	4	1	1	15
CO3-52BT303.3- Gain an understanding of herbicide resistance crops and different types of biofertilizers and its importance and characteristics.	09	4	2	1	16
CO4-52BT303.4- Elucidate the detailed role of various microbes in the field of agriculture.	09	4	3	1	17
CO5-52BT303.5- Elaborate the mechanism of metabolic engineering in plants	09	2	2	1	14
Total Hours	45	16	10	05	76

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Agriculture Biotechnology **Course Code:** 52BT303

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-52BT303.1- An overview of Biotechnology in agriculture.	2	1	1	1	5
CO2-52BT303.2- Acquire knowledge regarding transgenesis and genetic engineering.	2	4	5	1	12
CO3-52BT303.3- Gain an understanding of herbicide resistance crops and different types of biofertilizers and its importance and characteristics.	3	5	5	1	14
CO4-52BT303.4- Elucidate the detailed role of various microbes in the field of agriculture.	2	3	5	1	11
CO5-52BT303.5- Elaborate the mechanism of metabolic engineering in plants	2	4	1	1	10
Total Marks	**11**	**17**	**17**	**05**	**50**

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	Biotechnology fundamental and application (4th edition) - S.S.Purohit.
2	Plant Biotechnology – B.D.Singh
3	Plants, Genes and agriculture by Maartein, J.Christpeels, David E.Sdava.
4	Crop Biotechnology by P.R.Yadav, Rajiv Tyagi.
5	Plant Biotechnology by Chawla. Gendel,

(b) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Group Discussion
4. Role play
5. Demonstration
6. ICT Based teaching Learning
7. Brainstorming

CO, PO and PSO Mapping

Program Name: M.Sc. Biotechnology
Semester: III Semester
Course Title: Agriculture Biotechnology
Course Code: 52BT303

CO/PO/PSO Mapping								
Course Outcome (COs)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-52BT303.1- An overview of Biotechnology in agriculture	1	2	-	1	2	2	2	1
CO2-52BT303.2- Acquired the knowledge regarding transgenesis and genetic engineering	-	1	1	-	-	1	1	2
CO3-52BT303.3- Gain an understanding of herbicide resistance crops and different types of biofertilizers and its importance and characteristics	1	1	2	1	-	3	1	1
CO4-52BT303.4- Elucidate the detailed role of various microbes in the field of agriculture.	1	1	1	-	2	1	1	3
CO5-52BT303.5- Elaborate the mechanism of metabolic engineering in plants.	2	1	1	-	-	1	3	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	Cos	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,4,5 PSO 1,2, 3	**CO1-52BT303.1-** An overview of Biotechnology in agriculture	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	LI1.1	1.1,1.2,1.3,1.4,1.5, 1.6, 1.7, 1.8,1.9	1SL-1,2
PO 2,3, PSO 1,2, 3	**CO2-52BT303.2-** Acquired the knowledge regarding transgenesis and genetic engineering.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	LI2.1, LI2.2	2.1, 2.2, 2.3,2.4,2.5,2.6,2.7,2.8,2.9	2SL-1
PO 1,2,3,4 PSO 1,2, 3	**CO3-52BT303.3-** Gain an understanding of herbicide resistance crops and different types of biofertilizers and its importance and characteristics	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	LI3.1, LI3.2	3.1,3.2,3.3,3.4, 3.5, 3.6, 3.7, 3.8, 3.9	3SL-1,2
PO 1,2,3,5 PSO 1,2, 3	**CO4-52BT303.4-** Elucidate the detailed role of various microbes in the field of agriculture.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9	LI4.1, LI4.2	4.1,4.2,4.3,4.4, 4.5, 4.6,4.7,4.8, 4.9	4SL-1,2,3
PO 1,2,3, PSO 1,2, 3	**CO5-52BT303.5-** Elaborate the mechanism of metabolic engineering in plants.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9	LI5.1	5.1,5.2,5.3,5.4,5.5,5.6,5.7, 5.8, 5.9	5SL-1,2

Curriculum Developer Team:
Prof. Kamlesh Choure
Prof. Ashwini A. Waoo
Prof. Deepak Mishra
Dr. Monika Soni
Er. Arpit Srivastava

Program Name	**Masters of Science (M.Sc.)- Biotechnology**	
Semester	III	
Course Code:	52BT304	
Course title:	Scientific Writing and Patenting Process	**Curriculum Developer**: Dr. Deepak Mishra, Professor
Pre-requisite:	Student should have basic knowledge of Biotechnology, Genetic Engineering and practical as well as research skills.	
Rationale:	The paper on Scientific Writing and Patenting Process in an MSc Biotechnology program explores the critical role of specialized research and scientific tools in analyzing biotechnology and RDT research. It delves into the use of precise instruments for monitoring and analyzing data and literature, development of scientific writing skills and research aptitudes. This study enables students to understand how systematic research process helps us for doing any research in a systematic manner along with data publication. It also explore the knowledge of law and legislation, patenting and ethics in biotechnology.	
Course Outcomes (COs):	**CO1-52BT304.1:** Students are being knowledgeable with essentials of scientific writing and research methods through various tools available for scientific research. **CO2-52BT304.2:** Development of critical thinking skills for evaluating scientific literature and identifying research problems **CO3-52BT304.3:** Proficiency in communicating research findings through various written forms. **CO4-52BT304.4:** Recognize various issues related to RDT research and analyze the regulatory frameworks, law and legislations related to biotechnological research. **CO5-52BT304.5:** Understanding of patenting process, laws, and drafting patent applications.	

Scheme of Studies:

Board of Study	CourseCode	Course Title	Scheme of studies (Hours/Week)					Total Credits(C) (L:T:P=3:1:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Discipline Specific Course (DSC)	52BT304	Scientific Writing and Patenting Process	4	2	1	2	9	3+1+1=5

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);
SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits.
Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
DSC	52BT304	Scientific Writing and Patenting Process	15	20	10	5	50	50	100

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
DSC	52BT354	Scientific Writing & Patenting Process	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	12	04	01	05	22

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
52BT304.1: Students are being knowledge-able with essentials of scientific writing and research methods through various tools available for scientific research.	**SO1.1** Define and Describe concept of scientific writing and research, its types		**Unit-1** **CI1.1** Scientific Writing & Research- meaning, types,	**SL1.1** Search various reference books and study material to start the learning of research and scientific writing
	SO1.2 Describe about objectives and		**CI1.2** objectives, and approaches	**SL1.2** Differentiation of research problems based on objective

	approaches of research			
	SO1.3 Explain about methods and sources of literature		**CI1.3** Literature collection: Different sources	**SL1.3** Searching and literature on different online resources.
	SO1.4 Describe about biological online database	**LI1.1** To learn how to collect scientific literature from various sources and use biological online databases for research.	**CI1.4** Biological online databases,	
	SO1.5 & SO1.6 Study of sampling techniques	**LI1.2** To understand the process of determining sample design, collecting data, analyzing results, and testing hypotheses in scientific research.	**CI1.5 & CI1.6** Determining sample design	**SL1.4** Use of sampling methods for collection of scientific data related to different research problems
	SO1.7 & SO1.8 Study of data collection methods		**CI1.7 & CI1.8** collecting data	
	SO1.9 & SO1.10 Describe concept of hypothesis testing		**CI1.9 & CI1.10** analysis and hypothesis testing	**SL1.5** Setting up the Hypothesis and their application in research
	SO1.11 & SO1.12 Study about generalization and interpretation of research findings		**CI1.11 & CI1.12** Generalization and interpretation.	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail research and its types
	SW1.2 Mini Project	Collection of data and literature related to any biotechnological research problem
	SW1.3 Other Activities (Specify)	Searching of online databased available on internet and their application in research

Item	Cl	LI	SW	SL	Total
Approx. Hrs	12	04	01	05	22

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
52BT304.2: Development of critical thinking skills for evaluating scientific literature and identifying research problems	**SO2.1** Explore the concept and techniques of writing reviews	**LI2.1** To understand the process of writing scientific reviews, journal articles, books, and monographs, and to learn how to create a bibliography.	**Unit-II** **CI2.1** Writing review articles,	**SL2.1** Search various contents for writing a review article
	SO2.2 Describe the contents of research article		**CI2.2** Writing Journal articles, bibliography	**SL2.2** designing of a research article
	SO2.3 Reflecting about the concept and contents of books and monograph		**CI2.3** books, and monographs-	**SL2.3** Learn about contents of an ideal book
	SO2.4 Explain about contents of an ideal thesis	**LI2.2** To understand the structure of a thesis and the process of manuscript and proof correction. To learn about the research process, including the selection of research problems, stages of research execution, and research designs.	**CI2.4** Structure of thesis	**SL2.3** Searching and literature on different online resources.
	SO2.5 & SO2.6 Assessing the role of manuscript and proof correction in research		**CI2.5 & CI2.6** Manuscript and proof correction	
	SO2.7 & SO2.8 Explaining the steps of research process		**CI2.7 & CI2.8** Research Process: selection of problems:	**SL2.5** Use of research process to solve different research problems
	SO2.9 & SO2.10 Explaining the stages of execution of research		**CI2.9 & CI2.10** stages in the execution of research	
	SO2.11 & SO2.12 explain		**CI2.11 & CI2.12** Research	

	about different types of research designs.		Designs.	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe in detail about different stages of execution of research by using research process.
	SW2.2 Mini Project	Designing of a research thesis.
	SW2.3 Other Activities (Specify)	Take a research problem a select a specific research design for solving it.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	12	04	01	05	22

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
52BT304.3: Proficiency in communicating research findings through various written forms.	**SO3.1** Explain the role of different types of data in research.	**LI3.1** To understand the methods of collecting primary and secondary data, and to learn about different scaling techniques, including rating scales, ranking scales, and scale construction techniques.	**Unit-III** **CI3.1** Data Collection: Secondary Data, Primary Data	**SL3.1** Read about various types of data and their applications in research
	SO3.2 Assessing different methods used in data collection		**CI3.2** Methods of collection	**SL3.2** Collection of research data using different tools
	SO3.3 & SO3.4 Explaining concept and types of scales		**CI3.3 & CI3.4** Scaling Techniques Concepts and types,	**SL3.3** Illustration about different scaling techniques
	SO3.5 & SO3.6 Assessing different scaling methods used in research		**CI3.5 & CI3.6** Rating scales and Ranking scales, Scale Construction techniques	
	SO3.7 & SO3.8 Describe about multi-dimensional scaling		**CI3.7 & CI3.8** Multi-Dimensional Scaling.	
	SO3.9 & SO3.10 Assessing the role of research journals in research and their standards		**CI3.9 & CI3.10** Journals: Standard of research Journals	**SL3.4** Collection of different research journals
	SO3.11 & SO3.12 Describe about concept of impact factor	**LI3.2** To understand the	**CI3.11 & CI3.12** Impact factor, citation index	**SL3.5** Assess role of impact factor and citation index in research

	and citation index	standards of research journals, and to learn about impact factor, citation index, and their significance in evaluating the quality of research.		

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail different categories of data and its collection methods.
	SW3.2 Mini Project	Describe the role of scaling methods in research and their application for data validation
	SW3.3 Other Activities (Specify)	Prepare a list of research journal and checking their standard parameters.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	12	04	01	05	22

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
52BT304.4: Recognize various issues related to RDT research and analyze the regulatory frameworks, law and legislations related to biotechnological research.	**SO4.1** Exploring the legal and socioeconomic issues related to biotechnology	**LI4.1** To understand the legal, socioeconomic, and ethical aspects of biotechnology research and innovation, including intellectual property rights and regulatory frameworks.	**Unit-IV** **CI4.1** The legal and socioeconomic impacts of biotechnology	**SL4.1** Learn about legal and socioeconomic impact of biotechnology
	SO4.2 Assessing the ethical issues of RDT research and biotechnology		**CI4.2** Ethical concerns of biotechnology research and innovation	**SL4.2** Discuss ethical concern of biotechnology and its impact on society.
	SO4.3 Explaining the concept and types of IPRs	**LI4.2** To gain a deep understanding of intellectual property rights related to biotechnology and the regulatory frameworks governing GMOs in India.	**CI4.3** Intellectual property rights,	**SL4.3** Learn about various types of Intellectual Property
	SO4.4 Explaining the administrative framework of biotech and RDT research		**CI4.4** Regulatory framework in India governing GMOs	**SL4.4** Case studies related to RDT and biotech laws
	SO4.5 Evaluate impact of law on RDT research		**CI4.5** Recombinant DNA Guidelines (1990),	
	SO4.6 Describe the impact of law on research on transgenics.		**CI4.6** Revised Guidelines for Research in Transgenic Plants (1998),	
	SO4.7 & SO4.8 Assessing the role of law on preventing food adulteration		**CI4.7 & CI4.8** Prevention Food Adulteration Act (1955),	**SL4.5** Case studies related to Food laws
	SO4.9 & SO4.10 Describe law and standards of food regulation and safety		**CI4.9 & CI4.10** The Food Safety and Standards Bill (2005),	
	SO4.11 & SO4.12 Define the role of environmental policy on solving environmental issues		**CI4.11 & CI4.12** National Environment Policy (2006)	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Explain about regulation of RDT research through different law
	SW4.2 Mini Project	Describe the various issues related to biotechnology and RDT research.
	SW4.3 Other Activities (Specify)	Prepare one article on law and safety issues related to food and food ingradients

Item	Cl	LI	SW	SL	Total
Approx. Hrs	12	04	01	05	22

Course Outcome (CO)	**Session Outcomes (SOs)**	**LaboratoryInstruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
52BT304.5: Understanding of patenting process, laws, and drafting patent applications.	**SO5.1** Define the concept and objective of patenting.		**Unit-V** **CI5.1** Objectives of the patent system: Basic principles	**SL5.1** learn about basic concept & requirement of patents
	SO5.2 Able to execute to perform role of patent law		**CI5.2** general requirements of patent law,	**SL5.2** Review different Indian patent laws
	SO5.3 Apply the role of patenting system in biotech research	**LI5.1** To understand the basic principles and general requirements of patent law, the application of patent law to biotechnological inventions, and the legal developments related to patenting living organisms.	**CI5.3** Biotechnological inventions and patent law, Legal development,	**SL5.3** learn how get legal protection for invention by patenting
	SO5.4 Apply the patents for protection of innovation		**CI5.4** Patentable subjects and protection in biotechnology,	
	SO5.5 & SO5.6 Evaluate the patenting process for living organisms		**CI5.5 & CI5.6** The patenting living organisms,	
	SO5.7 & SO5.8 Describe international patent law and its impact on patenting	**LI5.2** To explore international conventions on patents, methods of patent application, and the legal implications of patenting in the context of biotechnology, including biodiversity and farmer rights.	**CI5.7 & CI5.8** International conventions patents	**SL5.4** Learn about international patenting law and legislations.
	SO5.9 & SO5.10 Describe process of patenting		**CI5.9 & CI5.10** methods of application of patents	

	SO5.11 & SO5.12 Elaborate the role of biodiversity and for plant protection		**CI5.11 & CI5.12** Biodiversity and farmer right.	**SL5.5** Learn about biodiversity and former right acts

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general characteristics of patent and impact of patent law on research
	SW5.2 Mini Project	Describe the role of patent law for protection of biotechnological innovations
	SW5.3 Other Activities (Specify)	Prepare a detail document on patent law of different countries

Course duration (in hours) to attain Course Outcomes:

Course Title: Scientific Writing and Patenting Process **Course Code:** 52BT304

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-52BT304.1: Students are being knowledgeable with essentials of scientific writing and research methods through various tools available for scientific research.	12	4	5	1	22
CO2-52BT304.2: Development of critical thinking skills for evaluating scientific literature and identifying research problems	12	4	5	1	22
CO3-52BT304.3: Proficiency in communicating research findings through various written forms.	12	4	5	1	22
CO4-52BT304.4: Recognize various issues related to RDT research and analyze the regulatory frameworks, law and legislations related to biotechnological research.	12	4	5	1	22
CO5-52BT304.5: Understanding of patenting process, laws, and drafting patent applications.	12	4	5	1	22
Total Hours	60	20	25	05	110

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Scientific Writing and Patenting Process **Course Code:** 52BT304

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-52BT304.1: Students are being knowledgeable with essentials of scientific writing and research methods through various tools available for scientific research.	2	1	1	1	5

CO2-52BT304.2: Development of critical thinking skills for evaluating scientific literature and identifying research problems	2	4	2	2	10
CO3-52BT304.3: Proficiency in communicating research findings through various written forms.	2	3	3	2	10
CO4-52BT304.4: Recognize various issues related to RDT research and analyze the regulatory frameworks, law and legislations related to biotechnological research.	3	5	5	2	15
CO5-52BT304.5: Understanding of patenting process, laws, and drafting patent applications.	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	Beier, F.K., Crespi, R.S. and Straus, T. Biotechnology and Patent protection-Oxford and IBH Publishing Co. New Delhi.
2	Singh K, Intellectual Property rights on Biotechnology, BCIL, New Delhi
3	Writing the doctoral dissertation. Barrons Educational series, 2nd edition, Davis, G.B. and C.A. Parker, 1997. pp 160.
4	Authoring a PhD, thesis: how to plan, draft, write and finish a doctoral dissertation, Duncary, P. 2003.
5	Beier, F.K., Crespi, R.S. and Straus, T. Biotechnology and Patent protection-Oxford and IBH Publishing Co. New Delhi.

(b) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to virology lab (BSL-3)
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: M. Sc. Biotechnology
Semester: III Semester
Course Title: Scientific Writing and Patenting Process
Course Code: 52BT304

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-52BT304.1: Students are being knowledgeable with essentials of scientific writing and research methods through various tools available for scientific research.	2	1	3	3	2	2	2	3
CO2-52BT304.2: Development of critical thinking skills for evaluating scientific literature and identifying research problems	2	1	3	2	3	1	3	3
CO3-52BT304.3: Proficiency in communicating research findings through various written forms.	1	2	3	2	3	1	2	2
CO4-52BT304.4: Recognize various issues related to RDT research and analyze the regulatory frameworks, law and legislations related to biotechnological research.	1	1	3	3	2	1	3	3
CO5-52BT304.5: Understanding of patenting process, laws, and drafting patent applications.	1	1	3	3	2	1	3	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2,3	**CO1-52BT304.1:** Students are being knowledgeable with essentials of scientific writing and research methods through various tools available for scientific research.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9 SO1.10 SO1.11 SO1.12	LI1 LI2	1.1,1.2,1.3,1.4,1.5, 1.6, 1.7, 1.8,1.9,1.10,1.11,1.12	1SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO2-52BT304.2:** Development of critical thinking skills for evaluating scientific literature and identifying research problems	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9 SO2.10 SO2.11 SO2.12	LI1 LI2	2.1,2.2,2.3,2.4,2.5,2.6,2.7,2.8,2.9,2.10,2.11,2.12	2SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO3-52BT304.3:** Proficiency in communicating research findings through various written forms.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9 SO3.10 SO3.11 SO3.12	LI1 LI2	3.1,3.2,3.3,3.4,3.5,3.6,3.7,3.8,3.9,3.10,3.11,3.12	3SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO4-52BT304.4:** Recognize various issues related to RDT research and analyze the regulatory frameworks, law and legislations related to biotechnological research.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9 SO4.10 SO4.11 SO4.12	LI1 LI2	4.1,4.2,4.3,4.4,4.5,4.6,4.7, 4.8,4.9,4.10,4.11,4.12	4SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO5-52BT304.5:** Understanding of patenting process, laws, and drafting patent applications.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9 SO5.10 SO5.11 SO5.12	LI1 LI2	5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8,5.9,5.10,5.11,5.12	5SL-1,2,3,4,5

Curriculum Developer Team:
Prof. Kamlesh Choure
Prof. Ashwini A. Waoo
Prof. Deepak Mishra
Dr. Monika Soni
Er. Arpit Srivastava

Program Name	**Masters of Science in Biotechnology (M. Sc. BT)**	
Semester	III	
Course Code:	52BT305-A	
Course title:	Design and Operation of Bioreactor	**Curriculum Developer**: Er. Arpit Srivastava, Assistant Professor
Pre-requisite:	Students should have basic knowledge of design & operation of bioreactor.	
Rationale:	Design and Operation of Bioreactor is a conglomerate of mathematics, biology and industrial design, and consists of various spectrums like the design and study of bioreactors (operational mode, instrumentation, and physical layout) to the creation of kinetic models. Biochemical engineers find employment opportunities in various industries. They provide their services in the food sector, nuclear sector, healthcare industry, pharmaceuticals, chemical manufacturing companies, research laboratories and other areas. This course provides us about the knowledge about the living organisms such as plants, animals, bacteria and fungi but the bioprocess engineering helps in development of the essential skills required to utilize the living organisms for the betterment of the human beings and the nature itself.	
Course Outcomes (COs):	**CO1-52BT305-A.1.** Recall the basic fundamentals of Design and Operation of Bioreactor **CO1-52BT305-A.2.** Describe the fluid flow dynamics and calculate and apply heat & mass transfer coefficient. **CO1-52BT305-A.3.** Comprehensive understanding the advanced bioreactor designs and their applications. **CO4-52BT305-A.4.** Comprehensive understanding the bioreactor designs and operation principles. **CO5-52BT305-A.5.** Comprehensive understanding the animal and plant cells cultivation techniques and applications.	

Scheme of Studies:

Board of Study	CourseCode	Course Title	Scheme of studies (Hours/Week)					Total Credits(C) (L:T:P=2:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Professional Elective Course (PE)	52BT305-A	Design and Operation of Bioreactor	3	2	1	3	9	2+1=3

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);
SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits.
Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+CAT+SA+AT)		
PE	52BT305-A	Design and Operation of Bioreactor	**15**	**20**	**10**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
PE	52BT355-A	Design and Operation of Bioreactor	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	03	14

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-52BT305-A.1. Recall the basic fundamentals of Design and Operation of Bioreactor	**SO1.1** Explain Fundamental studies & mathematical Model	**LI1.1** To Demonstrate the working of a Bench Top bioreactor with all its parts	**CI1.1** Fundamental studies & mathematical Model	**SL1.1** Find out some examples of bioprocess technique used in ancient India
	SO1.2 Determine the basic Applications of Batch, Fed Batch and Continuous Fermentation	**LI1.2** To perform the isolation of microorganisms from different kinds of samples	**CI1.2** Applications of Batch, Fed Batch and Continuous Fermentation	**SL1.2** Search various reference books and study material to start the learning of microorganisms
	SO1.3 Elaborate the Wall growth and Wash out Conditions		**CI1.3** Wall growth and Wash out Conditions	**SL1.3** Draw a flow chart showing upstream and fermentation processing
	SO1.4		**CI1.4**	

	Define the Aerobic and Anaerobic Fermentations		Aerobic and Anaerobic Fermentations	
	SO1.5 Explain Bioreactor, Introduction and type Plug flow reactor		**CI1.5** Bioreactor, Introduction and type Plug flow reactor	
	SO1.6 Define Maintenance of Reactors		**CI1.6** Maintenance, Engineering, & applications of Reactors	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail "Applications of Microorganisms in various Sectors"
	SW1.2 Mini Project	Draw various types of Fermenters with specifications and parts
	SW1.3 Other Activities (Specify)	Make a power point presentation on "Role of Fermentations in Ancient India"

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	02	13

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-52BT305-A.2. Describe the fluid flow dynamics and calculate and apply heat & mass transfer coefficient.	**SO2.1** Types of Fluid flow		**CI2.1** Types of Fluid flow	
	SO2.2 Differentiate Newtonian and Non-Newtonian Fluid flow		**CI2.2** Newtonian and Non-Newtonian Fluid flow	**SL2.1** To understand and differentiate between various types of fluid flow, including Newtonian and Non-Newtonian fluids, and to analyze different fluid flow regimes.
	SO2.3 Explain the Fluid flow Regimes	**LI2.1** Analysis of Types of Fluid Flow and Fluid Flow Regimes	**CI2.3** Fluid flow Regimes	
	SO2.4		**CI2.4**	**SL2.2**

	Explain Fundamentals of Heat transfer		Fundamentals of Heat transfer	To understand the fundamentals of heat and mass transfer, and to learn how to determine heat and mass transfer coefficients.
	SO2.5 Determine Fundamentals of Mass transfer		**CI2.5** Fundamentals of Mass transfer	
	SO2.6 Elaborate Heat & mass transfer coefficient	**LI2.2** Investigation of Heat and Mass Transfer Coefficients	**CI2.6** Application of Heat & mass transfer coefficient	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Explain the Fluid flow Regimes
	SW2.2 Mini Project	Explain Fundamentals of Heat & mass transfer
	SW2.3 Other Activities (Specify)	Application of Heat & mass transfer coefficient

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	07	04	01	02	14

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-52BT305-A.3. Comprehensive understanding the advanced bioreactor designs and their applications.	**SO3.1** Explain Stirred Tank reactors		**CI3.1** Stirred Tank reactors	
	SO3.2 Explain Reactors with recycle		**CI3.2** Reactors with recycle	
	SO3.3 Explain Series of connected Reactors	**LI3.1** Investigation of Reactors with Recycle and Series of Connected Reactors	**CI3.3** Series of connected Reactors	**SL3.1** To explore the effects of different reactor configurations, including reactors with recycle and series of connected reactors, on reaction performance and

				efficiency.
	SO3.4 Explain Bubble-column	**LI3.2** Comparative Analysis of Different Types of Reactors	**CI3.4** Bubble-column	**SL3.2** To understand the operation principles, advantages, and applications of various reactor types including stirred tank reactors, bubble-column reactors, fluidized bed reactors, trickle bed reactors, photobioreactors, and bioreactors for solid-state fermentation.
	SO3.5 Explain Fluidized bed		**CI3.5** Fluidized bed	
	SO3.6 Explain Trickle bed Photobioreactor		**CI3.6** Trickle bed Photobioreactor	
	SO3.7 Explain Bioreactor for Solid State Fermentation		**CI3.7** Bioreactor for Solid State Fermentation	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Explain Series of connected Reactors
	SW3.2 Mini Project	Explain Bubble-column, & Trickle bed Photobioreactor
	SW3.3 Other Activities (Specify)	Explain Bioreactor for Solid State Fermentation

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	03	14

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO4-52BT305-A.4.	**SO4.1**		**Unit-4**	**SL4.1**

Comprehensive understanding the bioreactor designs and operation principles.	Elucidate Residence Time in Bioreactor		**CI4.1** Residence Time in Bioreactor	To understand and calculate the residence time and Damkohler number (Da) in a bioreactor through self-directed study and experimentation.
	SO4.2 Derive the mathematical expression for Damkohler Number and its numerical	**LI4.1** To understand and calculate the residence time and Damkohler number (Da) in a bioreactor.	**CI4.2** Damkohler Number and its numerical	
	SO4.3 Explain & Analyze the Aeration system ,Agitation System & Agitator blade patterns	**LI4.2** To study the effects of aeration, agitation systems, and agitator blade patterns on the performance of a bioreactor.	**CI4.3** Aeration system, Agitation system & agitator blade patterns in reactors	**SL4.2** To explore the principles and practices of aeration systems in bioreactors & To understand the role of agitation systems and the impact of different agitator blade patterns in bioreactors.
	SO4.5 Interpretate Power No., Design Requirements of different parts of bioreactors		**CI4.5** Power No., Design Requirements of different parts of bioreactors	
	SO4.6 Explain Materials of construction of Bioreactors & Numerical Problem on empirical formula		**CI4.6** Materials of construction of Bioreactors & Numerical problem on empirical formula	**SL4.3** To explore the design requirements and materials of construction for bioreactors.

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Derive the mathematical expression for Damkohler Number and its numerical
	SW4.2 Mini Project	Explain Materials of construction of Bioreactors & Numerical Problem on empirical formula
	SW4.3 Other Activities (Specify)	Explain & Analyze the Aeration system, Agitation System & Agitator blade patterns

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	04	15

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO5-52BT305-A.5. Comprehensive understanding the animal and plant cells cultivation techniques and applications	**SO5.1** Elucidate the Animal, plant cell cultivation techniques	**LI5.1** To learn and practice the techniques of animal cell culture, including sourcing cells, using cell banks, preparing cell culture media, and setting up bioreactors for animal cell cultivation.	**CI5.1** Animal, plant cell cultivation techniques	
	SO5.2 Describe the Sources of cells, cell bank, Techniques of cell culture	**LI5.2** To learn and practice the techniques of plant cell culture, including sourcing plant cells, preparing culture media, and using bioreactors for plant cell cultivation.	**CI5.2** Sources of cells, cell bank, Techniques of cell culture	**SL5.1** To understand the sources of cells for animal and plant cell culture and the role of cell banks in maintaining cell lines.
	SO5.3 Explain in detail the Substrate on which cells grow in Laboratory		**CI5.3** Substrate on which cells grow in Laboratory	**SL5.2** To learn the fundamental techniques of cell culture and understand the substrates used for growing cells in the laboratory.
	SO5.4 Describe Media handling Equipment, Cell culture media		**CI5.4** Media handling Equipment, Cell culture media	**SL5.3** To explore the equipment used for media handling and preparation and to understand the composition and preparation of cell culture media.
	SO5.5 Explain the process of Preparation of material		**CI5.5** Preparation of material	
	SO5.6 Define Types of animal cell		**CI5.6** Types of animal cell culture	**SL5.4**

	culture bioreactors & products from plant cell culture		bioreactors & products from plant cell culture	To learn about the different types of bioreactors used for animal cell culture and the products derived from plant cell culture.

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Define Types of animal cell culture bioreactors
	SW5.2 Mini Project	Describe the Sources of cells, cell bank, Techniques of animal & plant cell culture
	SW5.3 Other Activities (Specify)	Explain the process of Preparation of material in animal & plant cell culture.

Course duration (in hours) to attain Course Outcomes:

Course Title: Design and Operation of Bioreactor **Course Code:** 52BT305-A

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-52BT305-A.1. Recall the basic fundamentals of Design and Operation of Bioreactor	6	4	3	1	14
CO1-52BT305-A.2. Describe the fluid flow dynamics and calculate and apply heat & mass transfer coefficient.	6	4	2	1	13
CO1-52BT305-A.3. Comprehensive understanding the advanced bioreactor designs and their applications.	7	4	2	1	14
CO4-52BT305-A.4. Comprehensive understanding the bioreactor designs and operation principles.	6	4	3	1	14
CO5-52BT305-A.5. Comprehensive understanding the animal and plant cells cultivation techniques and applications	6	4	4	1	15
Total Hours	31	20	14	05	70

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Design and Operation of Bioreactor **Course Code:** 52BT305-A

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-52BT305-A.1. Recall the basic fundamentals of Design and Operation of Bioreactor	2	1	1	1	5
CO1-52BT305-A.2. Describe the fluid flow dynamics and calculate and apply heat & mass	2	4	5	1	12

transfer coefficient.					
CO1-52BT305-A.3. Comprehensive understanding the advanced bioreactor designs and their applications.	3	5	5	1	14
CO4-52BT305-A.4. Comprehensive understanding the bioreactor designs and operation principles.	2	3	5	1	11
CO5-52BT305-A.5. Comprehensive understanding the animal and plant cells cultivation techniques and applications	2	4	1	1	10
Total Marks	**11**	**17**	**17**	**05**	**50**

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	Crueger and Crueger, 'Biotechnology' Panima Publishing Corporation, New Delhi.
2	Patel A.H., 'Industrial Microbiology', MacMillian India Ltd.
3	Geankoplis C.J., Transport Processes and Unit Operations. Prentice Hall India.2002.
4	McCabe W.L. & Smith J.C., Unit Operations In Chemical Engineering.5th Edition.Mcgrawhill.1993.
5	Incropera F.P., Fundamentals of Heat And Mass Transfer. John Wiley.1998.

(b) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Beverage producing plants & Distillery/Fermenter units
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: M.Sc. Biotechnology
Semester: III Semester
Course Title: Design and Operation of Bioreactor
Course Code: 52BT305-A

CO/PO/PSO Mapping								
Course Outcome (COs)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-52BT305-A.1. Recall the basic fundamentals of Design and Operation of Bioreactor	1	-	-	1	2	2	2	1
CO1-52BT305-A.2. Describe the fluid flow dynamics and calculate and apply heat & mass transfer coefficient.	-	1	1	-	-	1	1	2
CO1-52BT305-A.3. Comprehensive understanding the advanced bioreactor designs and their applications.	1	1	1	1	-	1	1	1
CO4-52BT305-A.4. Comprehensive understanding the bioreactor designs and operation principles.	1	1	1	-	2	1	1	3
CO5-52BT305-A.5. Comprehensive understanding the animal and plant cells cultivation techniques and applications	1	1	1	-	-	1	3	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2, 3	**CO1-52BT305-A.1.** Recall the basic fundamentals of Design and Operation of Bioreactor	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6	**LI 1** **LI 2**	1.1,1.2,1.3,1.4,1.5,1.6	**1SL-1,2,3**
PO 1,2,3,4,5 PSO 1,2, 3	**CO1-52BT305-A.2.** Describe the fluid flow dynamics and calculate and apply heat & mass transfer coefficient.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6	**LI 1** **LI 2**	2.1, 2.2, 2.3, 2.4, 2.4,2.5, 2.6	**2SL-1,2**
PO 1,2,3,4,5 PSO 1,2, 3	**CO1-52BT305-A.3.** Comprehensive understanding the advanced bioreactor designs and their applications.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6	**LI 1** **LI 2**	3.1,3.2,3.3,3.4, 3.5, 3.6	**3SL-1,2**
PO 1,2,3,4,5 PSO 1,2, 3	**CO4-52BT305-A.4.** Comprehensive understanding the bioreactor designs and operation principles.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6	**LI 1** **LI 2**	4.1,4.2,4.3,4.4, 4.5, 4.6	**4SL-1,2,3**
PO 1,2,3,4,5 PSO 1,2, 3	**CO5-52BT305-A.5.** Comprehensive understanding the animal and plant cells cultivation techniques and applications	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6	**LI 1** **LI 2**	5.1,5.2,5.3,5.4,5.5, 5.6	**5SL-1,2,3,4**

Curriculum Developer Team:

Prof. Kamlesh Choure
Prof. Ashwini A. Waoo
Prof. Deepak Mishra
Dr. Monika Soni
Er. Arpit Srivastava

Program Name	**Masters of Science (M.Sc.)- Biotechnology**	
Semester	III	
Course Code:	52BT305-B	
Course title:	Pharmaceutical Biotechnology	**Curriculum Developer**: Mrs. Keerti Samdariya, Assistant Professor
Pre-requisite:	Students should have basic knowledge of pharmaceutical biotechnology	
Rationale:	The paper on Pharmaceutical Biotechnology in an MSc Biotechnology program explores the role of biotechnology in drug discovery, development, and production, including the use of recombinant DNA technology and biopharmaceutical manufacturing. Students need to develop practical skills in laboratory techniques and methods used in producing, purifying, and analyzing pharmaceutical biotechnology products.	
Course Outcomes (COs):	**CO1-52BT305-B.1**- Understand the role of biotechnology in drug discovery, development, and production, including recombinant DNA technology and biopharmaceutical manufacturing.	
	CO2-52BT305-B.2- Extend practical skills in laboratory techniques and methods used in producing, purifying, and analyzing pharmaceutical biotechnology products.	
	CO3-52BT305-B.3- Evaluate knowledge of regulatory frameworks and quality control practices specific to pharmaceutical biotechnology.	
	CO4-52BT305-B.4- Understand the application of biotechnology in the pharmaceutical industry. Apply regulatory aspects, ethical considerations, and safety requirements associated with pharmaceutical biotechnology.	
	CO5-52BT305-B.5- Apply the knowledge of GLP and GMP in the Pharmaceutical laboratory.	

Scheme of Studies:

Board of Study	CourseCode	Course Title	Scheme of studies (Hours/Week)					Total Credits(C) (L: T: P=2:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Professional Elective Course (PE)	52BT305-B	Pharmaceutical Biotechnology	3	2	1	3	9	2+1=3

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);
SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits.
Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
PE	52BT305-B	Pharmaceutical Biotechnology	**15**	**20**	**10**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
PE	52BT355-B	Pharmaceutical Biotechnology	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	01	12

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO1 - 52BT305-B.1- Understand the role of biotechnology in drug discovery, development, and production, including recombinant DNA technology and biopharmaceutical manufacturing.	**SO1.1** A brief outline of the discovery of antibiotics.	**LI1.1** Demonstration of antibiotic action with bacterial strain.	**Unit 1** **CI1.1** A brief outline of the discovery of antibiotics.	**SL1.1** Explore the various antibiotics
	SO1.2 Define and describe synthetic antimicrobial agents.	**LI1.2** Diagrammatic presentation of types of antibiotics.	**CI1.2** Antibiotics and synthetic antimicrobial agents.	

	SO1.3 Differentiate antifungal antibiotics, antitumor substances	.	**CI1.3** Comparative study of antifungal antibiotics, antitumor substances	
	SO1.4 Classification and Explanation of Peptide antibiotics.		**CI1.4** Classification and Explanation Peptide antibiotics.	
	SO1.5 Classification, Explanation & mechanisms of antibiotics, antifungal, antitumor substances		**CI1.5** Classification, Explanation & mechanisms of antibiotics, antifungal, antitumor substances	
	SO1.6 Classification and mechanism of action of Chloramphenicol, Sulphonamides, and Quinolinone antimicrobial agents		**CI1.6** Classification and mechanism of action of Chloramphenicol, Sulphonamides, and Quinolinone antimicrobial agents	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail about Antibiotics and their classification.
	SW3.2 Mini Project	Describe the role of antibiotics in medical system
	SW3.3 Other Activities (Specify)	Prepare a diagrammatic poster for different antiviral, antibacterial and antifungal drug and their role in health.

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Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	02	13

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO1 - 52BT305-B.2- Extend practical skills in laboratory techniques and methods for producing, purifying, and analyzing pharmaceutical biotechnology products	**SO2.1** To explain the Mechanism of action of antibiotics inhibitors of cell wall, nucleic acid, & protein synthesis.	**LI2.1** To perform the Mode of action of antibiotic & non-antibiotic antimicrobial agents.	**Unit 2** **CI1.1** Mechanism of action of antibiotics inhibitors of cell wall, nucleic acid, protein synthesis.	**SL2.1** Read the Mode of action of antibiotics.
	SO2.2 To describe Molecular principles of drug targeting.		**CI2.2** Molecular principles of drug targeting.	**SL2.2** Learn Molecular principles of drug targeting.
	SO2.3 To describe the Mode of action of bacterial killing by quinolinones.		**CI2.3** Mode of action of bacterial killing by quinolinones and Bacterial resistance to quionolinones.	
	SO2.4 To explain the cellular permeability barrier.		**CI2.4** How the antimicrobial agents reach the targets cellular permeability barrier.	
	SO2.5 To elaborate on drug diffusion		**CI2.5** How the antimicrobial agents reach the targets by drug diffusion	
	SO2.6 To explain the Drug delivery system in gene therapy.		**CI2.6** How the antimicrobial agents used in Drug delivery system in gene therapy.	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe in detail Mechanism of action of antibiotics .
	SW2.2 Mini Project	Various Mode of action of Bacterial resistance to quionolinones..
	SW2.3 Other Activities (Specify)	How the antimicrobial agents reach the targets (cellular permeability barrier, cellular transport)

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours** **Item** | Cl | LI | SW | SL | Total **Approx. Hrs** | 06 | 04 | 01 | 03 | 14

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO3-52BT305-B.3- Evaluate knowledge of regulatory frameworks and quality control practices specific to pharmaceutical biotechnology.	**SO3.1** Explain the Microbial contamination.	**LI3.1** Demonstrate the sterilization process.	**Unit 3** **CI3.1** Microbial contamination and spoilage of pharmaceutical products and their sterilization.	**SL3.1** Read the sterilization process in industrial production of drugs.
	SO3.2 Define and differentiate sterile injectibles, and non-injectibles.	**LI3.2** Perform the production of microbial culture.	**CI3.2** Define and differentiate sterile injectibles, and non-injectibles.	
	SO3.3 Describe Manufacturing procedures and in process control of pharmaceuticals		**CI3.3** Manufacturing procedures and sterilization process used in the pharmaceutical industry.	
	SO3.4 pharmaceuticals produced by microbial fermentations (streptokinase, streptodornase).		**CI3.4** pharmaceuticals produced by microbial fermentations (streptokinase, & streptodornase)	**SL3.2** pharmaceuticals produced by microbial fermentations (streptokinase, streptodornase).
	SO3.5 Explain New vaccine technology: DNA vaccines.		**CI3.5** New vaccine technology: DNA vaccines,	**SL3.3** Discuss various types of vaccines involved in health system
	SO3.6 Illustrates new vaccine technology: synthetic peptide vaccines, multivalent subunit.		**CI3.6** New vaccine technology: synthetic peptide vaccines, multivalent.	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail on New vaccine technology, DNA vaccines, synthetic peptide vaccines.
	SW3.2 Mini Project	Describe the role of different vaccines.
	SW3.3 other activity	Prepare one article on different types of diseases and their vaccines.

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	02	13

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO4-52BT305-B.4- Understand the application of biotechnology in the pharmaceutical industry. Apply regulatory aspects, ethical considerations, and safety requirements associated with pharmaceutical biotechnology	**SO4.1** Describe the classification of pharmacopeia.	**LI4.1** To analyze the Immobilization process.	**Unit-4** **CI4.1** Explain classification of pharmacopeia.	**SL4.1** Learn about the Government regulatory practices and policies.
	SO4.2 Explain the IP, Government regulatory practices and policies, and FDA perspective.		**CI4.2** IP, Government regulatory practices and policies, FDA perspective	
	SO4.3 Describe BP, USP, Government regulatory practices and policies, FDA perspective		**CI4.3** BP, USP, Government regulatory practices and policies, FDA perspective	
	SO4.4 Evaluate reimbursement of drugs and biologicals.		**CI4.4** Reimbursement of drugs and biologicals, legislative perspective. Rational drug design.	
	SO4.5 Define and describe Immobilization procedures for pharmaceutical applications.	**LI4.2** To develop a model of the application of microbial enzymes in pharmaceuticals.	**CI4.5** Immobilization procedures for pharmaceutical applications (liposomes), Macromolecular, cellular and synthetic drug carriers.	**SL4.2** Learn about various types of Immobilization procedures for

				pharmaceutical applications.
	SO4.6 Biosensors in pharmaceuticals. Application of microbial enzymes in pharmaceuticals		**CI4.6** Biosensors in pharmaceuticals. Application of microbial enzymes in pharmaceuticals	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Explain Biosensors and their application in the pharmaceutical industry.
	SW4.2 Mini Project	Describe the various types of Pharmacopeias.
	SW4.3 Other Activities (Specify)	Prepare one article on the IP, BP, USP, Government regulatory practices and policies, FDA perspective.

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	02	01	03	12

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO5-52BT305-B.5: Apply the knowledge of Quality Assurance and Validation, GLP, and GMP in the Pharmaceutical laboratory.	**SO5.1** Explain Good Manufacturing Practices (GMP and GLP) in the pharmaceutical industry.	**LI5.1** Use of Good Laboratory Practices (GLP)	**Unit-5** **CI5.1** Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP) in the pharmaceutical industry.	**SL5.1** Find out the role of Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP) in the pharmaceutical industry.
	SO5.2 Define quality control, quality assurance, and quality management in pharmaceuticals.		. **CI5.2** Define quality control, quality assurance, and quality management in pharmaceuticals.	
	SO5.3 Elaborate ISO, WHO, and US certification		**CI5.3** ISO, WHO and US certification	**SL5.2** ISO, WHO and US certification

	SO5.4 Evaluate the Sterilization control and sterility testing.		**CI5.4** Sterilization control and sterility testing (heat sterilization, D value, z value, survival curve, Radiation, gaseous and filter sterilization)	
	SO5.5 Elaborate Chemical and biological indicators		**CI5.5** Chemical and biological indicators.	**SL5.3** Elaborate Chemical and biological indicators
	SO5.6 Design and layout of sterile product manufacturing unit. (Designing of Microbiology laboratory), Safety in the microbiology laboratory.		**CI5.6** Design and layout of sterile product manufacturing unit. (Designing of Microbiology laboratory), Safety in the microbiology laboratory.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain Sterilization control and sterility testing.
	SW5.2 Mini Project	Describe the Design and layout of the sterile product manufacturing unit.
	SW5.3 Other Activities (Specify)	Prepare one article on ISO, WHO, and US certification.

Course duration (in hours) to attain Course Outcomes:

Course Title: Pharmaceutical Biotechnology **Course Code: 52BT305-B**

Course Outcomes (COs)	**Class lecture (CI)**	**Laboratory Instruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO1-52BT305-B.1- Understand the role of biotechnology in drug discovery, development, and production, including recombinant DNA technology and biopharmaceutical manufacturing.	6	4	1	1	12
CO2-52BT305-B.2- Extend practical skills in laboratory techniques and methods used in producing, purifying, and analyzing pharmaceutical biotechnology products.	6	4	2	1	13
CO3-52BT305-B.3- Evaluate knowledge of regulatory frameworks and quality control practices specific to pharmaceutical biotechnology.	6	4	3	1	14

CO4-52BT305-B.4- Understand the application of biotechnology in the pharmaceutical industry. Apply regulatory aspects, ethical considerations, and safety requirements associated with pharmaceutical biotechnology.	6	4	2	1	13
CO5-52BT305-B.5- Apply the knowledge of GLP and GMP in the Pharmaceutical laboratory.	6	2	3	1	12
Total Hours	30	18	11	05	64

End-semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Pharmaceutical Biotechnology **Course Code: 52BT305-B**

Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1-52BT305-B.1- Understand the role of biotechnology in drug discovery, development, and production, including recombinant DNA technology and biopharmaceutical manufacturing.	2	1	1	1	5
CO2-52BT305-B.2- Extend practical skills in laboratory techniques and methods used in producing, purifying, and analyzing pharmaceutical biotechnology products.	2	4	2	2	10
CO3-52BT305-B.3- Evaluate knowledge of regulatory frameworks and quality control practices specific to pharmaceutical biotechnology.	3	5	5	2	15
CO4-52BT305-B.4- Understand the application of biotechnology in the pharmaceutical industry. Apply regulatory aspects, ethical considerations, and safety requirements associated with pharmaceutical biotechnology.	2	3	3	2	10
CO5-52BT305-B.5- Apply the knowledge of GLP and GMP in the Pharmaceutical laboratory.	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

S.No.	**Title/Author/Publisher details**
1	Pharmaceutical Microbiology – Edt. By W.B.Hugo & A.D.Russell Sixth edition. Blackwell scientific Publications.
2	Analytical Microbiology –Edt by Frederick Kavanagh Volume I & II. Academic Press New York.

3	Quinolinone antimicrobial agents – Edt. by David C. Hooper, John S.Wolfson .ASM Washington DC.
4	Pharmaceutical Microbiology – Edt. By W.B.Hugo & A.D.Russell Sixth edition. Blackwell scientific Publications.
5	Analytical Microbiology –Edt by Frederick Kavanagh Volume I & II. Academic Press New York.

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to virology lab (BSL-3)
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: M. Sc. Biotechnology
Semester: III Semester
Course Title: Pharmaceutical Biotechnology
Course Code: 52BT305-B

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-52BT305-B.1- Understand the role of biotechnology in drug discovery, development, and production, including recombinant DNA technology and biopharmaceutical manufacturing.	1	2	2	3	1	2	2	1
CO2-52BT305-B.2- Extend practical skills in laboratory techniques and methods used in producing, purifying, and analyzing pharmaceutical biotechnology products.	1	2	3	2	1	1	1	2
CO3-52BT305-B.3- Evaluate knowledge of regulatory frameworks and quality control practices specific to pharmaceutical biotechnology.	1	2	3	2	1	1	1	1
CO4-52BT305-B.4- Understand the application of biotechnology in the pharmaceutical industry. Apply regulatory aspects, ethical considerations, and safety requirements associated with pharmaceutical biotechnology.	-	1	1	-	2	1	1	3
CO5-52BT305-B.5- Apply the knowledge of GLP and GMP in the Pharmaceutical laboratory.	1	1	1	-	-	1	3	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2,3	**CO1-52BT305-B.1**- Understand the role of biotechnology in drug discovery, development, and production, including recombinant DNA technology and biopharmaceutical manufacturing.	SO1.1 SO1.2 SO1.3, SO1.4, SO1.5, SO1.6	**LI 1** **LI 2**	1.1,1.2,1.3,1.4,1.5,1.6	**1SL-1**
PO 1,2,3,4,5 PSO 1,2,3	**CO2-52BT305-B.2**- Extend practical skills in laboratory techniques and methods used in producing, purifying, and analyzing pharmaceutical biotechnology products.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5, SO2.6	**LI 1** **LI 2**	2.1,2.2,2.3,2.4,2.5,2.6	**2SL-1,2**
PO 1,2,3,4,5 PSO 1,2,3	**CO3-52BT305-B.3**- Evaluate knowledge of regulatory frameworks and quality control practices specific to pharmaceutical biotechnology.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5, SO3.6	**LI 1** **LI 2**	3.1,3.2,3.3,3.4,3.5,3.6	**3SL-1,2,3**
PO 1,2,3,4,5 PSO 1,2,3	**CO4-52BT305-B.4**- Understand the application of biotechnology in the pharmaceutical industry. Apply regulatory aspects, ethical considerations, and safety requirements associated with pharmaceutical biotechnology.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5, SO4.6	**LI 1** **LI 2**	4.1,4.2,4.3,4.4,4.5,4.6	**4SL-1,2**
PO 1,2,3,4,5 PSO 1,2,3	**CO5-52BT305-B.5**- Apply the knowledge of GLP and GMP in the Pharmaceutical laboratory.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5, SO5.6	**LI 1**	5.1,5.2,5.3,5.4,5.5,5.6	**5SL-1,2,3**

Curriculum Developer Team:

Prof. Kamlesh Choure
Prof. Ashwini A. Waoo
Prof. Deepak Mishra
Dr. Monika Soni
Er. Arpit Srivastava

Program Name	**M.Sc. Biotech**	
Semester	**Semester III**	
Course Code:	52BT305-C	
Course title:	**Biomolecular Modelling and Drug Designing**	**Curriculum Developer**: Mr. Piyush Kant Rai, Assistant Professor
Pre-requisite:	Students must have knowledge of Molecular models and their structures which is important in drug designing.	
Rationale:	The paper on MMDD in M.Sc. Biotech program explores the critical role of specialized mechanisms of protein 2D and 3D structure modeling and in analyzing microbial evolution and diversity. It delves into the use of tools for understanding mutation, evolution, and databases to learn more about how these data are generated and what biological mystery can be solved by using these data and tools.	
Course Outcomes (COs):	**CO1-52BT305-C.1:** Comprehensive Understanding of Drug Targets and Drug Discovery Process **CO2-52BT305-C.2:** To introduce the fundamental concepts of molecular modeling, molecular structure, internal energy, and energy minimization techniques. **CO3-52BT305-C.3:** Comprehensive understanding of molecular dynamics (MD) and Monte Carlo (MC) simulation techniques for conformational analysis **CO4-52BT305-C.4:** Understand the principles of macromolecular modeling and its application in drug design, including the design of ligands for known macromolecular targets, drug-receptor interactions, classical QSAR studies, and pharmacophore identification **CO5-52BT305-C.5:** Comprehensive understanding of finding new drug targets for treating diseases, particularly anti-cancer drugs, and the application of structure-based drug design	

Scheme of Studies:

Board of Study	CourseCode	Course Title	Scheme of studies (Hours/Week)					Total Credits(C) (L:T:P=2:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Professional Elective Course (PE)	52BT305-C	**Biomolecular Modelling and Drug Designing**	3	2	1	2	8	2+1=3

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);
SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits.
Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
PE	52BT305-C	**Biomolecular Modelling and Drug Designing**	15	20	5	5	45	5	50

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
PE	52BT355-C	Biomolecular Modeling & Drug Designing	35	5	5	5	50	50	50

Course-Curriculum:

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Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	02	13

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-52BT305-C.1: Comprehensive Understanding of Drug Targets and Drug Discovery Process	**SO1.1** Understand the different types of drug targets and their roles in pharmacology	**LI1.1** To understand and identify various drug targets including DNA, RNA, post-translational processing enzymes, metabolic enzymes involved in nucleic acid synthesis, G-protein coupled receptors, small molecule receptors, and transporters.	**CI1.1** Drug Target Classification	**SL1.1** To self-learn and understand the classification and importance of various drug targets, including DNA, RNA, post-translational processing enzymes, metabolic enzymes involved in nucleic acid synthesis, G-protein coupled receptors, small molecule receptors, and transporters.
	SO1.2 Describe the major characteristics and modes of action of various drugs		**CI1.2** Characteristics and Mode of Action of Drugs	
	SO1.3 Explore the history of drug discovery and the various approaches used		**CI1.3** Drug Discovery and History	
	SO1.4 Understand the role of serendipity in drug discovery		**CI1.4** Serendipity in Drug Discovery	
	SO1.5 Describe the concept of hit and lead compounds in the drug discovery process		**CI1.5** Concept of Hit and Lead in Drug Discovery	**SL1.2** To self-learn and understand the drug discovery process, including major characteristics of drugs, their modes of action, the concepts of agonist and antagonist, the history of drug discovery, classical approaches,

				serendipity, and the drug discovery pipeline.
	SO1.6 Understand the steps involved in the drug discovery pipeline	**LI1.2** To understand the process of drug discovery and development, including classical approaches, serendipity, the concept of hit and lead, and the drug discovery pipeline.	**CI1.6** Drug Discovery Pipeline	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe the major characteristics and modes of action of various drugs
	SW1.2 Mini Project	Describe the concept of hit and lead compounds in the drug discovery process
	SW1.3 Other Activities (Specify)	Understand the steps involved in the drug discovery pipeline

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	02	13

Course Outcome (CO)	**Session Outcomes (SOs)**	**LaboratoryInstruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO2-52BT305-C.2: To introduce the fundamental concepts of molecular modeling, molecular structure, internal energy, and	**SO2.1** Introduce the fundamental concepts of molecular modeling and its importance in computational chemistry and drug discovery		**CI2.1** Introduction to Molecular Modeling	
	SO2.2 Understand the components of molecular structure and	**LI2.1** To introduce students to molecular modeling and	**CI2.2** Molecular Structure and Internal Energy	**SL2.1** To self-learn the fundamental concepts of molecular

energy minimization techniques.	internal energy, and their significance in molecular modeling	visualization techniques, focusing on understanding molecular structure and internal energy components.		modeling, molecular structure, and internal energy components.
	SO2.3 How to use molecular graphics tools for visualizing and manipulating molecular structures		**CI2.3** Application of Molecular Graphics	
	SO2.4 Understand the concept of energy minimization and its application in finding stable molecular conformations	**LI2.2** To perform energy minimization on small molecules using molecular mechanics methods and understand the empirical representation of molecular energies and force fields	**CI2.4** Energy Minimization of Small Molecules	**SL2.2** To self-learn the principles of energy minimization, the empirical representation of molecular energies, and the use of force fields and molecular mechanics methods
	SO2.5 Explain how molecular energies are empirically represented and the role of force fields in molecular mechanics		**CI2.5** Empirical Representation of Molecular Energies and Use of Force Fields	
	SO2.6 Understand the concepts of local and global energy minima and their significance in molecular modeling		**CI2.6** Local and Global Energy Minima	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	How to use molecular graphics tools for visualizing and manipulating molecular structures
	SW2.2 Mini Project	Explain how molecular energies are empirically represented and the role of force fields in molecular mechanics
	SW2.3 Other Activities (Specify)	Understand the components of molecular structure and internal energy, and their significance in molecular modeling

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	02	13

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO3-52BT305-C.3: comprehensive understanding of molecular dynamics (MD) and Monte Carlo (MC) simulation techniques for conformational analysis	**SO3.1** Introduce the principles and applications of molecular dynamics (MD) simulations in conformational analysis	**LI3.1** To perform a molecular dynamics (MD) simulation to analyze the conformational changes of a small molecule	**CI3.1** Introduction to Molecular Dynamics (MD) Simulation	**SL3.1** To independently explore and understand the use of molecular dynamics (MD) simulations for conformational analysis of molecules.
	SO3.2 Introduce the principles and applications of Monte Carlo (MC) simulations in conformational analysis	**LI3.2** To perform a Monte Carlo (MC) simulation to explore the conformational space of a small molecule	**CI3.2** Introduction to Monte Carlo (MC) Simulation	**SL3.2** To independently explore and understand the use of Monte Carlo (MC) simulations and quantum chemistry methods (ab initio, DFT, semi-empirical) for conformational analysis.
	SO3.3 Introduce the principles and applications of ab initio methods in computational chemistry		**CI3.3** Principles of Ab Initio Methods	
	SO3.4 Introduce the principles and applications of density functional theory (DFT) in computational chemistry		**CI3.4** Principles of Density Functional Theory (DFT)	
	SO3.5 & SO3.6 Introduce the principles and applications of semi-empirical methods in computational chemistry		**CI3.5 & CI3.6** Principles of Semi-Empirical Methods	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Introduce the principles and applications of Monte Carlo (MC) simulations in conformational analysis
	SW3.2 Mini Project	Introduce the principles and applications of density functional theory (DFT) in computational chemistry
	SW3.3 Other Activities (Specify)	Introduce the principles and applications of semi-empirical methods in computational chemistry

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	02	13

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO4-52BT305-C.4: Understand the principles of macromolecular modeling and its application in drug design, including the design of ligands for known macromolecular targets, drug-receptor interactions, classical QSAR studies, and pharmacophore identification	**SO4.1** Understand the basics of macromolecular modeling and its importance in drug design		**CI4.1** Introduction to Macromolecular Modeling	
	SO4.2 Learn to design ligands that specifically interact with known macromolecular targets	**LI4.1** To design ligands for known macromolecular target sites and analyze drug-receptor interactions using computational tools	**CI4.2** Design of Ligands for Known Macromolecular Target Sites	**SL4.1** To independently explore the design of ligands for known macromolecular target sites and analyze drug-receptor interactions using computational tools
	SO4.3 Understand the mechanisms of drug-receptor interactions and their implications for drug efficacy		**CI4.3** Drug-Receptor Interactions	
	SO4.4 Explore classical QSAR studies and understand their impact on 3D modeling and drug design	**LI4.2** To perform QSAR studies and identify pharmacophores for novel drug design	**CI4.4** Classical QSAR Studies and Their Implications	**SL4.2** To independently explore classical QSAR studies and pharmacophore identification techniques for novel drug design
	SO4.5 Learn to use 2D and 3D databases for drug		**CI4.5** 2D and 3D Database Searching	

	design and discovery			
	SO4.6 Identify pharmacophores and use them for designing novel drugs		**CI4.6** Pharmacophore Identification and Novel Drug Design	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Explore classical QSAR studies and understand their impact on 3D modeling and drug design
	SW4.2 Mini Project	Learn to use 2D and 3D databases for drug design and discovery
	SW4.3 Other Activities (Specify)	Understand the mechanisms of drug-receptor interactions and their implications for drug efficacy

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	02	13

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO5-52BT305-C.5: Comprehensive understanding of finding new drug targets for treating diseases, particularly anti-cancer drugs, and the application of structure-based drug design	**SO5.1** Understand the basics of discovering new drug targets and focus on novel targets for anti-cancer drugs	**LI5.1** To explore the process of discovering new drug targets, particularly for anti-cancer drugs, and to apply structure-based drug design principles to these targets	**CI5.1** Introduction to Drug Target Discovery and Anti-Cancer Targets	**SL5.1** To independently explore the process of discovering new drug targets, especially for anti-cancer drugs, and apply structure-based drug design techniques
	SO5.2 Explore the structure-based drug design and its application to different types of drug targets		**CI5.2** Structure-Based Drug Design for All Classes of Targets	
	SO5.3 Understand the concepts of pharmacogenomics and pharmacogenetics and	**LI5.2** To investigate the concepts of pharmacogenomics and pharmacokinetics and	**CI5.3** Introduction to Pharmacogenomics vs. Pharmacogenetics	**SL5.2** To independently learn about pharmacogenomics, pharmacogenetics,

	their implications for drug development	their applications in personalized medicine.		pharmacokinetics, pharmacodynamics, and the role of personalized medicine, including its ethical considerations
	SO5.4 Explore the principles of pharmacokinetics and pharmacodynamics and their role in drug development		**CI5.4** Pharmacokinetics and Pharmacodynamics	
	SO5.5 Understand the concept of personalized medicine and its impact on drug development and patient care		**CI5.5** Personalized Medicine	
	SO5.6 Explore the ethical issues related to pharmacogenomics and personalized medicine		**CI5.6** Ethical Issues in Pharmacogenomics	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explore the structure-based drug design and its application to different types of drug targets
	SW5.2 Mini Project	Understand the concept of personalized medicine and its impact on drug development and patient care
	SW5.3 Other Activities (Specify)	Explore the ethical issues related to pharmacogenomics and personalized medicine

Course duration (in hours) to attain Course Outcomes:

Course Title: Biomolecular modeling and Drug designing **Course Code: 52BT305-C**

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-52BT305-C.1: Comprehensive Understanding of Drug Targets and Drug Discovery Process	06	04	02	1	13
CO2-52BT305-C.2: To introduce the fundamental concepts of molecular modeling, molecular structure, internal energy, and energy minimization techniques.	06	04	02	1	13
CO3-52BT305-C.3: comprehensive understanding of molecular dynamics (MD) and Monte Carlo (MC) simulation techniques for conformational analysis	06	04	02	1	13
CO4-52BT305-C.4: Understand the principles of macromolecular modeling and its application in drug design, including the design of ligands for known macromolecular targets, drug-receptor interactions, classical QSAR studies, and pharmacophore identification	06	04	02	1	13
CO5-52BT305-C.5: Comprehensive understanding of finding new drug targets for treating diseases, particularly anti-cancer drugs, and the application of structure-based drug design	06	04	02	1	13
Total Hours	30	20	10	05	65

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Biomolecular modeling and Drug designing **Course Code: 52BT305-C**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-52BT305-C.1: Comprehensive Understanding of Drug Targets and Drug Discovery Process	02	03	04	1	10
CO2-52BT305-C.2: To introduce the fundamental concepts of molecular modeling, molecular structure, internal energy, and energy minimization techniques.	02	05	02	1	10
CO3-52BT305-C.3: comprehensive understanding of molecular dynamics (MD) and Monte Carlo (MC) simulation techniques for conformational analysis	04	04	01	1	10
CO4-52BT305-C.4: Understand the principles of macromolecular modeling and its application in drug design, including the design of ligands for known macromolecular targets, drug-receptor interactions, classical QSAR studies, and pharmacophore identification	03	04	02	1	10
CO5-52BT305-C.5: Comprehensive understanding of finding new drug targets for treating diseases, particularly anti-cancer drugs, and the application of structure-based drug design	04	03	02	1	10
Total Marks	15	19	11	05	50

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	N. Clauden Cohen-Guide book on Molecular Modelling in Drug Design 2011
2	Paul.S Charifson –Practical application of computer Aided Drug Design
3	Molecular Modeling in Drug Design Rebecca Wade and Outi Salo-Ahen MDPI 2019

(b) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to bioinformatics lab
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: M. Sc. Biotechnology
Semester: III **Sem**
Course Title: Biomolecular modeling and Drug designing
Course Code: 52BT305-C

Course Outcome (Cos)	**Program Specific Outcomes (PSOs)**							
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-52BT305-C.1: Comprehensive Understanding of Drug Targets and Drug Discovery Process	1	2	2	3	1	-	-	-
CO2-52BT305-C.2: To introduce the fundamental concepts of molecular modeling, molecular structure, internal energy, and energy minimization techniques.	1	2	3	2	1	-	-	-
CO3-52BT305-C.3: comprehensive understanding of molecular dynamics (MD) and Monte Carlo (MC) simulation techniques for conformational analysis	1	2	3	2	1	-	**1**	**1**
CO4-52BT305-C.4: Understand the principles of macromolecular modeling and its application in drug design, including the design of ligands for known macromolecular targets, drug-receptor interactions, classical QSAR studies, and pharmacophore identification	1	2	3	2	1	**1**	**1**	**1**
CO5-52BT305-C.5: Comprehensive understanding of finding new drug targets for treating diseases, particularly anti-cancer drugs, and the application of structure-based drug design	1	2	2	3	1	-	-	-
Total	**5**	**10**	**13**	**12**	**5**			

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1, 2, 3, 4, 5 PSO 1, 2, 3	**CO1-52BT305-C.1:** Comprehensive Understanding of Drug Targets and Drug Discovery Process	SO1.1, SO1.2, SO1.3, SO1.4, SO1.5, SO1.6	**LI 1 LI 2**	CI1.1, CI1.2, CI1.3, CI1.4, CI1.5, CI1.6	**1SL- 1, 2**
PO 1, 2, 3, 4, 5 PSO 1, 2, 3	**CO2-52BT305-C.2:** To introduce the fundamental concepts of molecular modeling, molecular structure, internal energy, and energy minimization techniques	SO2.1, SO2.2, SO2.3, SO2.4, SO2.5, SO2.6	**LI 1 LI 2**	CI2.1, CI2.2, CI2.3, CI2.4, CI2.5, CI2.6	**2SL- 1, 2**
PO 1, 2, 3, 4, 5 PSO 1, 2, 3	**CO3-52BT305-C.3:** comprehensive understanding of molecular dynamics (MD) and Monte Carlo (MC) simulation techniques for conformational analysis	SO3.1, SO3.2, SO3.3, SO3.4, SO3.5, SO3.6	**LI 1 LI 2**	CI3.1, CI3.2, CI3.3, CI3.4, CI3.5, CI3.6	**3SL- 1, 2**
PO 1, 2, 3, 4, 5 PSO 1, 2, 3	**CO4-52BT305-C.4:** Understand the principles of macromolecular modeling and its application in drug design, including the design of ligands for known macromolecular targets, drug-receptor interactions, classical QSAR studies, and pharmacophore identification	SO4.1, SO4.2, SO4.3, SO4.4, SO4.5, SO4.6	**LI 1 LI 2**	CI4.1, CI4.2, CI4.3, CI4.4, CI4.5, CI4.6	**4SL- 1, 2**
PO 1, 2, 3, 4, 5 PSO 1, 2, 3	**CO5-52BT305-C.5:** Comprehensive understanding of finding new drug targets for treating diseases, particularly anti-cancer drugs, and the	SO5.1, SO5.2, SO5.3, SO5.4, SO5.5, SO5.6	**LI 1 LI 2**	CI5.1, CI5.2, CI5.3, CI5.4, CI5.5, CI5.6	**5SL- 1, 2**

	application of structure-based drug design				

Curriculum Developer Team:
Prof. Kamlesh Choure
Prof. Ashwini A. Waoo
Prof. Deepak Mishra
Dr. Monika Soni
Er. Arpit Srivastava

Program Name	**Masters of Science in Biotechnology (M.Sc. Biotech)**	
Semester	III	
Course Code:	**52BT306-A**	
Course title:	Downstream Processing	**Curriculum Developer**: Er. Arpit Srivastava, Assistant Professor
Pre-requisite:	Students should have basic knowledge of fermentation and downstream processing	
Rationale:	Downstream is refers to the recovery and the purification of biosynthetic products. Downstream processing constitutes a critical step in manufacturing of pharmaceuticals such as antibiotics, hormones, antibodies and vaccines and enzymes with regards to product purity, cost, and environmental impact. This course offers the importance of downstream processing in biotechnology and its problems associated with product purification. The objective of this course is to impart knowledge and skills on different separation, purification, recovery and processing techniques.	
Course Outcomes (COs):	**CO1-52BT306-A.1.** To understand the key concepts, methods, and stages involved in bioseparation processes and downstream processing. **CO2-52BT306-A.2.** To comprehend the principles and applications of various separation techniques. **CO3-52BT306-A.3.** To understand the principles and applications of aqueous two-phase extraction, membrane separation techniques and various methods for protein precipitation. **CO4-52BT306-A.4.** A comprehensive understanding of chromatography principles, techniques, and applications. **CO5-52BT306-A.5.** To understand the principles of crystallization and various drying techniques.	

Scheme of Studies:

Board of Study	CourseCode	Course Title	Scheme of studies (Hours/Week)					Total Credits(C) (L:T:P=2:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
ProgramElective (PE)	52BT306-A	Downstream Processing	3	2	1	3	9	2+0+1=3

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);
SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits.
Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+CAT+SA+AT)		
PE	52BT306-A	Downstream Processing	**15**	**20**	**10**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
PE	52BT356-A	Downstream Processing	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	03	14

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-52BT306-A.1. To understand the key concepts, methods, and stages involved in bioseparation processes and downstream processing.	**SO1.1** Explain concept of bioseparation processes		**Unit-1** **CI1.1** Introduction to bioseparation processes	**SL1.1** Develop a comprehensive understanding of bioseparation processes, including various techniques used for separating biological products.
	SO1.2 Analyze and evaluate the efficiency of bioseparation processes		**CI1.2** Analysis of Bioseparations	
	SO1.3		**CI1.3**	**SL1.2**

	Understand the key stages involved in downstream processing and their importance		Stages in Downstream Processing	Gain a thorough understanding of the stages in downstream processing, and how to ensure process and product quality.
	SO1.4 Importance of process and product quality in biomanufacturing		**CI1.4** Process and Product Quality in Bioseparation	
	SO1.5 Understand different methods of cell disruption and their applications	**LI1.1** To perform cell disruption using mechanical, enzymatic, and chemical methods, and to analyze the effectiveness of bioseparation techniques in isolating and purifying the target biomolecule.	**CI1.5** Cell Disruption for Product Release	**SL1.3** Understand various methods for cell disruption and the stabilization of bioproducts to enhance their quality and shelf-life.
	SO1.6 Methods for pretreatment and stabilization of bioproducts to ensure their quality and shelf-life	**LI1.2** To explore the stages of downstream processing, analyze product quality, and perform stabilization techniques to ensure the quality and shelf-life of the bioproduct.	**CI1.6** Pretreatment and Stabilization of Bioproducts	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Understand the key stages involved in downstream processing and their importance
	SW1.2 Mini Project	Elaborate the methods for pretreatment and stabilization of bioproducts to ensure their quality and shelf-life
	SW1.3 Other Activities (Specify)	Importance of process and product quality in biomanufacturing

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	03	14

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-52BT306-A.2. To comprehend the principles and applications of various separation techniques	**SO2.1** Understand the basic principles of filtration, including conventional and cross-flow filtration methods		**Unit-2** **CI2.1** Introduction to Filtration Principles	**SL2.1** Gain a comprehensive understanding of filtration principles, including conventional and cross-flow filtration, filter media, and membrane fouling
	SO2.2 Explore different types of filter media and understand the concept of membrane fouling		**CI2.2** Filter Media and Membrane Fouling	
	SO2.3 Describe the rotary vacuum filtration equipment and its operation	**LI2.1** To understand and apply principles of filtration and sedimentation, including conventional and cross-flow filtration, and to measure the sedimentation coefficient of particles	**CI2.3** Rotary Vacuum Filtration	
	SO2.4 Understand the principles of sedimentation and the concept of the sedimentation coefficient		**CI2.4** Sedimentation Principles and Sedimentation Coefficient	**SL2.2** Understand the principles of sedimentation, the sedimentation coefficient, and the operational principles of tubular and disk centrifuges
	SO2.5 Explore tubular and disk centrifuges and their applications	**LI2.2** To perform and analyze centrifugation using tubular and disk centrifuges, and to understand and demonstrate the principles of flocculation	**CI2.5** Centrifugation – Tubular and Disk Centrifuges	
	SO2.6 Understand ultracentrifugation for sedimentation at low accelerations and the principles of flocculation		**CI2.6** Ultracentrifugation and Flocculation Principles	**SL2.3** Develop an understanding of the principles of flocculation and its practical applications

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe the rotary vacuum filtration equipment and its operation
	SW2.2 Mini Project	Understand ultracentrifugation for sedimentation at low accelerations and the principles of flocculation
	SW2.3 Other Activities (Specify)	Explore different types of filter media and understand the concept of membrane fouling

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	03	14

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO3-52BT306-A.3. To understand the principles and applications of aqueous two-phase extraction, membrane separation techniques and various methods for protein precipitation.	**SO3.1** Understand the principles of aqueous two-phase extraction, including phase separation mechanisms and their applications		**Unit-3** **CI3.1** Principles of Aqueous Two-Phase Extraction	**SL3.1** Understand the principles of aqueous two-phase extraction, including phase separation mechanisms and applications
	SO3.2 Describe the plate extraction columns, their design, and their use in aqueous two-phase extraction	**LI3.1** To perform aqueous two-phase extraction using a plate extraction column and a centrifugal extractor, and to understand the principles of phase separation	**CI3.2** Plate Extraction Columns	
	SO3.3 Understand the principles and operation of centrifugal extractors used in aqueous two-phase extraction		**CI3.3** Centrifugal Extractors	
	SO3.4 Explore the principles and applications of ultrafiltration in membrane separation	**LI3.2** To perform membrane separation using ultrafiltration and dialysis, and to precipitate proteins using different methods	**CI3.4** Membrane Separation – Ultrafiltration	**SL3.2** Learn about membrane separation techniques, specifically ultrafiltration and dialysis, and their applications

	SO3.5 Understand the principles and applications of dialysis in membrane separation		**CI3.5** Membrane Separation – Dialysis	
	SO3.6 Describe the various methods of protein precipitation and their applications		**CI3.6** Protein Precipitation Methods	**SL3.3** Explore various methods of protein precipitation and understand their applications in protein purification.

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Understand the principles of aqueous two-phase extraction, including phase separation mechanisms and their applications
	SW2.2 Mini Project	Explore the principles and applications of ultrafiltration in membrane separation
	SW2.3 Other Activities (Specify)	Describe the various methods of protein precipitation and their applications

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	03	14

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO4-52BT306-A.4. A comprehensive understanding of chromatography principles, techniques, and applications.	**SO4.1** Understand the fundamental principles of chromatography and its various applications		**Unit-4** **CI4.1** Introduction to Chromatography Principles	**SL4.1** Gain a comprehensive understanding of the basic principles of chromatography and familiarize yourself with the equipment used in chromatographic techniques
	SO4.2 Describe the various types of chromatography equipment and detectors used in analysis		**CI4.2** Chromatography Equipment and Detectors	
	SO4.3 Understand the principles and applications of reverse	**LI4.1** To perform and analyze chromatographic separations	**CI4.3** Principles of Reverse Phase Chromatography	**SL4.2** Understand the principles and applications of reverse phase

	phase chromatography	using reverse phase and ion-exchange chromatography techniques		and ion-exchange chromatography techniques
	SO4.4 Describe the ion-exchange chromatography, including its principles and applications		**CI4.4** Principles of Ion-Exchange Chromatography	
	SO4.5 Understand the principles and applications of size exclusion and hydrophobic interaction chromatography	**LI4.2** To perform and analyze chromatographic separations using size exclusion and bioaffinity chromatography techniques	**CI4.5** Principles of Size Exclusion Chromatography (SEC) and Hydrophobic Interaction Chromatography (HIC)	**SL4.3** Explore and understand the principles and applications of size exclusion, hydrophobic interaction, bioaffinity, and pseudo-affinity chromatography techniques.
	SO4.6 Explore the principles of bioaffinity and pseudo-affinity chromatography and their applications		**CI4.6** Principles of Bioaffinity and Pseudo-Affinity Chromatography	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Describe the various types of chromatography equipment and detectors used in analysis
	SW4.2 Mini Project	Describe the ion-exchange chromatography, including its principles and applications
	SW4.3 Other Activities (Specify)	Explore the principles of bioaffinity and pseudo-affinity chromatography and their applications

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	03	14

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO5-52BT306-A.5. To understand the principles of crystallization and various drying techniques.	**SO5.1** Understand the fundamental principles of crystallization and how they apply to the	**LI5.1** To observe the process of crystallization and understand the factors	**Unit-5** **CI5.1** Introduction to Crystallization Principles	**SL5.1** To understand the fundamental principles of crystallization, including the

	formation of solid crystals from a solution	affecting crystal formation.		factors influencing crystal formation and purity.
	SO5.2 Describe the operation and application of vacuum shelf dryers in the drying process	**LI5.2** To understand and compare the drying processes using different types of dryers: vacuum shelf dryer, batch vacuum rotary dryer, freeze dryer, and spray dryer.	**CI5.2** Vacuum Shelf Dryers – Operation and Application	**SL5.2** To understand the operational principles and applications of vacuum shelf dryers and batch vacuum rotary dryers.
	SO5.3 Understand the principles and operation of batch vacuum rotary dryers		**CI5.3** Batch Vacuum Rotary Dryers – Principles and Operation	
	SO5.4 Describe the principles and operation of freeze dryers and their applications		**CI5.4** Freeze Dryers – Operation and Applications	**SL5.3** To gain an understanding of the principles and operations of freeze dryers and spray dryers, including their applications and limitations.
	SO5.5 Understand the principles and operation of spray dryers and their applications in drying processes.		**CI5.5** Spray Dryers – Principles and Operation	
	SO5.6 Compare and contrast different drying techniques: vacuum shelf dryers, batch vacuum rotary dryers, freeze dryers, and spray dryers		**CI5.6** Comparative Analysis of Drying Techniques	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Understand the fundamental principles of crystallization and how they apply to the formation of solid crystals from a solution
	SW5.2 Mini Project	Understand the principles and operation of batch vacuum rotary dryers
	SW5.3 Other Activities (Specify)	Compare and contrast different drying techniques: vacuum shelf dryers, batch vacuum rotary dryers, freeze dryers, and spray dryers

Course duration (in hours) to attain Course Outcomes:

Course Title: Downstream Processing **Course Code:** 52BT306-A

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-52BT306-A.1. To understand the key concepts, methods, and stages involved in bioseparation processes and downstream processing.	6	4	3	1	14
CO2-52BT306-A.2. To comprehend the principles and applications of various separation techniques	6	4	3	1	14
CO3-52BT306-A.3. To understand the principles and applications of aqueous two-phase extraction, membrane separation techniques and various methods for protein precipitation.	6	4	3	1	14
CO4-52BT306.A.4. A comprehensive understanding of chromatography principles, techniques, and applications.	6	4	3	1	14
CO5-52BT306-A.5. To understand the principles of crystallization and various drying techniques.	6	4	3	1	14
Total Hours	30	20	15	05	70

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Downstream Processing **Course Code:** 52BT306-A

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-52BT306-A.1. To understand the key concepts, methods, and stages involved in bioseparation processes and downstream processing.	2	1	1	1	5
CO2-52BT306-A.2. To comprehend the principles and applications of various separation techniques	2	4	4	1	11
CO3-52BT306-A.3. To understand the principles and applications of aqueous two-phase extraction, membrane separation techniques and various methods for protein precipitation.	3	5	5	1	14
CO4-52BT306-A.4. A comprehensive understanding of chromatography principles, techniques, and applications.	2	3	4	1	10
CO5-52BT306-A.5. To understand the principles of crystallization and various drying techniques.	5	4	1	0	10
Total Marks	**14**	**17**	**15**	**04**	**50**

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	Roger G. Harrison, Paul Todd, Scott R.Rudge and Demetri P. Pterides – Biosepartions Science and Engineering – Oxford University Press - 2003
2	R.O. Jenkins, (Ed.) – Product Recovery In Bioprocess Technology – Biotechnology By Open Learning Series, Butterworth-Heinemann (1992).
3	J.C. Janson And L. Ryden, (Ed.) – Protein Purification – Principles, High Resolution Methods And Applications, VCH Pub. 1989.
4	R.K. Scopes – Protein Purification – Principles and Practice, Narosa Pub. (1994).

(b) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Waste water/Effluent Treatment plant and downstream pharmaceutical plants
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: M. Sc. Biotechnology
Semester: III Semester
Course Title: Downstream Processing
Course Code: 52BT306-A

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-52BT306-A.1. To understand the key concepts, methods, and stages involved in bioseparation processes and downstream processing.	1	-	-	1	2	2	2	1
CO2-52BT306.A.2. To comprehend the principles and applications of various separation techniques	-	1	1	-	-	1	1	2
CO3-52BT306-A.3. To understand the principles and applications of aqueous two-phase extraction, membrane separation techniques and various methods for protein precipitation.	1	1	1	1	-	1	1	1
CO4-52BT306-A.4. A comprehensive understanding of chromatography principles, techniques, and applications.	1	1	1	-	2	1	1	3
CO5-52BT306-A.5. To understand the principles of crystallization and various drying techniques.	1	1	1	1	-	1	3	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2, 3	**CO1-52BT306-A.1.** To understand the key concepts, methods, and stages involved in bioseparation processes and downstream processing.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6	**LI 1** **LI 2**	1.1,1.2,1.3,1.4,1.5,1.6	**1SL-1,2,3**
PO 1,2,3,4,5 PSO 1,2, 3	**CO2-52BT306-A.2.** To comprehend the principles and applications of various separation techniques	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6	**LI 1** **LI 2**	2.1, 2.2, 2.3, 2.4, 2.5, 2.6	**2SL-1,2,3**
PO 1,2,3,4,5 PSO 1,2, 3	**CO3-52BT306-A.3.** To understand the principles and applications of aqueous two-phase extraction, membrane separation techniques and various methods for protein precipitation.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6	**LI 1** **LI 2**	3.1,3.2,3.3,3.4,3.5, 3.6	**3SL-1,2,3**
PO 1,2,3,4,5 PSO 1,2, 3	**CO4-52BT306-A.4.** A comprehensive understanding of chromatography principles, techniques, and applications.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6	**LI 1** **LI 2**	4.1,4.2,4.3,4.4,4.5,4.6	**4SL-1,2,3**
PO 1,2,3,4,5 PSO 1,2, 3	**CO5-52BT306-A.5.** To understand the principles of crystallization and various drying techniques.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6	**LI 1** **LI 2**	5.1,5.2,5.3,5.4,5.5,5.6	**5SL-1,2,3**

Curriculum Developer Team:
Prof. Kamlesh Choure
Prof. Ashwini A. Waoo
Prof. Deepak Mishra
Dr. Monika Soni
Er. Arpit Srivastava

Program Name	**Master of Science in Biotechnology (M. Sc. BT)**	
Semester	III	
Course Code:	52BT306-B	
Course title:	Vaccine Biotechnology and Drug Action	**Curriculum Developer**: Er. Arpit Srivastava, Assistant Professor
Pre-requisite:	Students should have basic knowledge of immunology and vaccines	
Rationale:	Vaccines are one of the most important discoveries in the history of Medicine. These biological preparations have been highly successful in preventing infectious diseases, significantly reducing the incidence of childhood diseases and mortality. Importance of Designing New Vaccine - Vaccine "teach" your body to defend itself from pathogens like viruses and bacteria. There are numerous viruses and bacteria discovered which can be potential disease-causing agents to Humans. To tackle these potential threats effective vaccines are required. This course will help students to explore new horizons of innovations in Vaccine designing domain.	
Course Outcomes (COs):	**CO1-52BT306-B.1** Explain fundamental principles of vaccine science and its role in biotechnology **CO2-52BT306-B.2** Outline the effects of Vaccine over immunity **CO3-52BT306-B.3** Identify novel strategies for vaccine design and preservation **CO4-52BT306-B.4** Examine methods to test the concentration of vaccine **CO5-52BT306-B.5** Predict, Design and Compare different vaccines the basis of its production	

Scheme of Studies:

Board of Study	CourseCode	Course Title	Scheme of studies (Hours/Week)					Total Credits(C) (L:T:P=2:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Professional Elective Course (PE)	52BT306-B	Vaccine Biotechnology and Drug Action	3	2	1	3	9	2+1=3

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);
SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits.
Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity (CAT)	Class Attendance (AT)	Total Marks (CA+CT+CAT+SA+AT)		
PE	52BT306-B	Vaccine Biotechnology and Drug Action	15	20	5	5	5	50	50	100

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
PE	52BT356-B	Vaccine Biotechnology & Drug Action	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	04	15

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-52BT306-B.1 Explain fundamental principles of vaccine science and its role in biotechnology	**SO1.1** Explain the Introduction & History of Vaccine		**Unit-1** **CI1.1** Introduction & History of Vaccine	**SL1.1** Understand the history and development of vaccines and their impact on public health.
	SO1.2 Describe & define the Vaccine immunization: active & passive immunization		**CI1.2** Vaccine immunization: active & passive immunization	**SL1.2** Differentiate between active and passive immunization and understand their mechanisms.
	SO1.3 Elaborate the Immune response & its detection	**LI1.1** To understand and perform an Enzyme-Linked	**CI1.3** Immune response & its detection	**SL1.3** Understand the body's immune response to vaccines

		Immunosorbent Assay (ELISA) to detect the presence of antibodies in a sample, which indicates an immune response to a vaccine.		and learn about methods for detecting immune responses.
	SO1.4 Explain in detail the designing of vaccines		**CI1.4** Designing of vaccines	
	SO1.5 Describe the Preservation of vaccines, method of vaccination, and dosage		**CI1.5** Preservation of vaccines, method of vaccination, and dosage	**SL1.4** Learn the principles of vaccine design, preservation, methods of administration, and appropriate dosage.
	SO1.6 Explain in detail the Concept of antigen & antibody, and antigen-antibody reactions.	**LI1.2** To understand and perform an agglutination test to detect the presence of antigens or antibodies in a sample through visible clumping.	**CI1.6** Concept of antigen & antibody, and antigen-antibody reactions.	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail about Vaccine immunization: active & passive immunization
	SW1.2 Mini Project	Elaborate the Immune response & its detection
	SW1.3 Other Activities (Specify)	Draw a flowchart compiling all procedures used in performing Immunoinformatics

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	04	15

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO2-52BT306-B.2 Outline the effects of Vaccine over immunity	**SO2.1** Explain in detail the live & attenuated vaccines	**LI2.1** To compare the immune responses generated by live, attenuated, and killed vaccines using an animal	**Unit-2** **CI2.1** Live & attenuated vaccines	**SL2.1** Understand the concepts, mechanisms, and examples of live, attenuated, and killed vaccines.

		model or cell culture.		
	SO2.2 Explain in detail the killed & recombinant vaccines.		**CI2.2** Killed Vaccines & Recombinant vaccines	
	SO2.3 Explain in detail the Subunit & conjugate vaccines	**LI2.2** To characterize and evaluate the efficacy of subunit, conjugate, and peptide vaccines using antigen-antibody reactions and protective immunity assays.	**CI2.3** Subunit & conjugate vaccines	**SL2.2** Learn about the principles, development, and examples of recombinant DNA, subunit, conjugate, and peptide vaccines.
	SO2.4 Explain in detail the Peptide vaccines & specific viral vaccines		**CI2.4** Peptide vaccines & specific viral vaccines	
	SO2.5 Elaborate the Viral Vaccine-Vaccinia, Polio, Hepatitis B, Influenza and HIV		**CI2.5** Viral Vaccine-Vaccinia, Polio, Hepatitis B, Influenza and HIV	**SL2.3** Gain knowledge about specific viral vaccines, their development, and their impact on disease prevention.
	SO2.6 Elaborate the Bacterial Vaccine -Pertusis, Cholera vaccine, Tetanus, BCG Vaccine		**CI2.6** Bacterial Vaccine -Pertusis, Cholera vaccine, Tetanus, BCG Vaccine	**SL2.4** Understand the development, mechanisms, and public health impact of specific bacterial vaccines.

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe the Killed Vaccines & Recombinant vaccines
	SW2.2 Mini Project	Elaborate the Viral Vaccine-Vaccinia, Polio, Hepatitis B, Influenza and HIV
	SW2.3 Other Activities (Specify)	Elaborate the Bacterial Vaccine -Pertusis, Cholera vaccine, Tetanus, BCG Vaccine

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	04	15

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**

CO3-52BT306-B.3 Identify novel strategies for vaccine design and preservation	**SO3.1** Introduction to Antibiotics and Mechanisms of Action		**Unit-3** **CI3.1** Introduction to Antibiotics and Mechanisms of Action	**SL3.1** Understand the basics of antibiotics, their history, significance, and general mechanisms of action.
	SO3.2 Explain in detail the Beta-lactam, Pencillins, Cephalosporins, Antibiotics: Structure, Chemistry, and SAR	**LI3.1** To analyze the structure, chemistry, and structure-activity relationship (SAR) of various classes of antibiotics and understand their mechanisms of action.	**CI3.2** Beta-lactam, Pencillins, Cephalosporins, Antibiotics: Structure, Chemistry, and SAR	**SL3.2** Understand the structure, chemistry, and structure-activity relationship (SAR) of beta-lactam antibiotics, including penicillins and cephalosporins.
	SO3.3 Explain in detail the Tetracyclines, Macrolides, and Aminoglycosides: Structure, Chemistry, and SAR		**CI3.3** Tetracyclines, Macrolides, and Aminoglycosides: Structure, Chemistry, and SAR	
	SO3.4 Miscellaneous Antibiotics and Antitubercular Agents	**LI3.2** To understand the mechanisms of action of antitubercular agents and anti-HIV drugs and evaluate their effectiveness through biochemical assays.	**CI3.4** Miscellaneous Antibiotics and Antitubercular Agents	**SL3.3** Learn about antitubercular agents, their mechanisms of action, and their role in treating tuberculosis.
	SO3.5 Elaborate the AIDS and Life Cycle of HIV		**CI3.5** AIDS and Life Cycle of HIV	**SL3.4** Understand the biology of HIV, the progression of AIDS, and the mechanisms of action of nucleoside and non-nucleoside reverse transcriptase inhibitors.
	SO3.6 Explain in detail Anti-HIV Agents: Nucleoside and Non-Nucleoside Analogues		**CI3.6** Anti-HIV Agents: Nucleoside and Non-Nucleoside Analogues	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe the Beta-lactam, Pencillins, Cephalosporins, Antibiotics: Structure, Chemistry, and SAR
	SW3.2 Mini Project	Elaborate the AIDS and Life Cycle of HIV
	SW3.3 Other Activities (Specify)	Explain in detail Anti-HIV Agents: Nucleoside and Non-Nucleoside Analogues

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours** **Item** | Cl | LI | SW | SL | Total **Approx. Hrs** | 06 | 04 | 01 | 04 | 15

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO4-52BT306-B.4 Examine methods to test the concentration of vaccine	**SO4.1** Explain in details the Introduction to Cancer and Classification of Anti-Cancer Agents	**LI4.1** Evaluation of Anti-Cancer Agents: Structure, Chemistry, SAR, and Mechanism of Action	**Unit-4** **CI4.1** Introduction to Cancer and Classification of Anti-Cancer Agents	**SL4.1** To understand the basics of cancer and the classification of anti-cancer agents.
	SO4.2 Explain in details the Alkylating Agents and Antimetabolites: Structure, Chemistry, and SAR		**CI4.2** Alkylating Agents and Antimetabolites: Structure, Chemistry, and SAR	
	SO4.3 Elaborate the Anti-Cancer Antibiotics and Plant Products: Structure, Chemistry, and SAR		**CI4.3** Anti-Cancer Antibiotics and Plant Products: Structure, Chemistry, and SAR	**SL4.2** To explore the structure, chemistry, and structure-activity relationship (SAR) of various anti-cancer agents.
	SO4.4 Explain in detail the Miscellaneous Anti-Cancer Agents and Mechanisms of Action		**CI4.4** Miscellaneous Anti-Cancer Agents and Mechanisms of Action	**SL4.3** To study the mechanism of action of different classes of anti-cancer agents.
	SO4.5 Elaborate the Anti-Parkinson's Agents and Introduction to Dementia and Alzheimer's Disease	**LI4.2** Investigation of Anti-Parkinson's Agents and Introduction to Dementia and Alzheimer's Disease	**CI4.5** Anti-Parkinson's Agents and Introduction to Dementia and Alzheimer's Disease	**SL4.4** Anti-Parkinson's Agents, Dementia, Alzheimer's Disease, and Narcotic Analgesics
	SO4.6 Explain in detail the Narcotic Analgesics		**CI4.6** Narcotic Analgesics	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Elaborate the Anti-Cancer Antibiotics and Plant Products: Structure, Chemistry, and SAR
	SW4.2 Mini Project	Elaborate the Anti-Parkinson's Agents and Introduction to Dementia and Alzheimer's Disease
	SW4.3 Other Activities (Specify)	Explain in detail the Narcotic Analgesics

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	04	15

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO2-52BT305.5 Predict, Design and Compare different vaccines the basis of its production	**SO5.1** Describe Introduction to Antipyretics and NSAIDs	**LI5.1** Analysis of the Properties and Mechanism of Action of Antipyretics and NSAIDs	**Unit-5** **CI5.1** Introduction to Antipyretics and NSAIDs	**SL5.1** To gain a foundational understanding of antipyretics and non-steroidal anti-inflammatory drugs (NSAIDs), their classifications, and clinical uses.
	SO5.2 Explain in detail the Biosynthesis of Eicosanoids		**CI5.2** Biosynthesis of Eicosanoids	**SL5.2** To understand the biosynthesis of eicosanoids and their role in inflammation.
	SO5.3 Elaborate the Mechanism of Anti-Inflammatory Action of NSAIDs and Side Effects		**CI5.3** Mechanism of Anti-Inflammatory Action of NSAIDs and Side Effects	**SL5.3** Mechanism of Anti-Inflammatory Action and Side Effects of NSAIDs
	SO5.4 Describe & define the Chemistry, Structure, and SAR of Salicylates - Aspirin as an Example		**CI5.4** Chemistry, Structure, and SAR of Salicylates - Aspirin as an Example	

	SO5.5 Describe & define the Chemistry, Structure, and SAR of p-Aminophenol Derivatives - Paracetamol as an Example		**CI5.5** Chemistry, Structure, and SAR of p-Aminophenol Derivatives - Paracetamol as an Example	**SL5.4** To analyze the chemistry, structure, and structure-activity relationship (SAR) of salicylates and p-aminophenol derivatives, using aspirin and paracetamol as examples.
	SO5.6 Comparative Analysis of Aspirin and Paracetamol	**LI5.2** Comparative Study of the Chemistry, Structure, and Structure-Activity Relationship (SAR) of Aspirin and Paracetamol	**CI5.6** Comparative Analysis of Aspirin and Paracetamol	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Elaborate the Mechanism of Anti-Inflammatory Action of NSAIDs and Side Effects
	SW5.2 Mini Project	Describe & define the Chemistry, Structure, and SAR of p-Aminophenol Derivatives - Paracetamol as an Example
	SW5.3 Other Activities (Specify)	Comparative Analysis of Aspirin and Paracetamol

Course duration (in hours) to attain Course Outcomes:

Course Title: Vaccine Biotechnology and Drug Action **Course Code:** 52BT306-B

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-52BT306-B.1. Explain fundamental principles of vaccine science and its role in biotechnology	6	4	4	1	15
CO2-52BT306-B.2. Outline the effects of Vaccine over immunity	6	4	4	1	15
CO3-52BT306-B.3. Identify novel strategies for vaccine design and preservation	6	4	4	1	15
CO4-52BT306-B.4. Examine methods to test the concentration of vaccine	6	4	4	1	15
CO5-52BT306-B.5. Predict, Design and Compare different vaccines the basis of its production	6	4	4	1	15
Total Hours	30	20	20	05	75

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Vaccine Biotechnology and Drug Action **Course Code:** 52BT306-B

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-52BT306-B.1. Explain fundamental principles of vaccine science and its role in biotechnology	2	1	1	1	5
CO2-52BT306-B.2. Outline the effects of Vaccine over immunity	2	4	5	1	12
CO3-52BT306-B.3. Identify novel strategies for vaccine design and preservation	3	5	4	1	13
CO4-52BT306-B.4. Examine methods to test the concentration of vaccine	2	3	4	1	10
CO5-52BT306-B.5. Predict, Design and Compare different vaccines the basis of its production	5	4	1	0	10
Total Marks	**14**	**17**	**15**	**04**	**50**

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	Advanced vaccination technologies for infectious and chronic diseases. (2024). In Elsevier eBooks.
2	An Introduction to Medicinal Chemistry ; Graham.L.Patrick , John Spencer, 2009
3	Pharmaceutical Chemistry 2; Dr.A.V.Kasture, Dr.S.G.Wadodkar
4	Kuby, 'Immunology', W. H. Freeman & Compan
5	Medicinal Chemistry; Ashuthosh Khar Revised Third Edition, New Age Publishers

(b) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Waste water/Effluent Treatment plant and downstream pharmaceutical plants
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: M.Sc. Biotechnology
Semester: III Semester
Course Title: Vaccine Biotechnology and Drug Action
Course Code: 52BT306-B

Course Outcome	Program Specific Outcomes (PSOs)							
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-52BT306-B.1. Explain fundamental principles of vaccine science and its role in biotechnology	-	1	-	1	2	1	2	1
CO2-52BT306-B.2. Outline the effects of Vaccine over immunity	-	1	-	-	1	2	-	2
CO3-52BT306-B.3. Identify novel strategies for vaccine design and preservation	-	1	1	1	-	3	2	-
CO4-52BT306-B.4. Examine methods to test the concentration of vaccine	-	-	1	-	2	2	1	3
CO5-52BT306-B.5. Predict, Design and Compare different vaccines the basis of its production	1	-	1	2	-	1	1	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2, 3	**CO1-52BT306-B .1.** Explain fundamental principles of vaccine science and its role in biotechnology	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6	**LI 1** **LI 2**	1.1,1.2,1.3,1.4,1.5,1.6	**1SL-1,2,3,4**
PO 1,2,3,4,5 PSO 1,2, 3	**CO2-52BT306-B .2.** Outline the effects of Vaccine over immunity	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6	**LI 1** **LI 2**	2.1, 2.2, 2.3, 2.4, 2.5,2.6	**2SL-1,2,3,4**
PO 1,2,3,4,5 PSO 1,2, 3	**CO3-52BT306-B .3.** Identify novel strategies for vaccine design and preservation	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6	**LI 1** **LI 2**	3.1,3.2,3.3,3.4,3.5,3.6	**3SL-1,2,3,4**
PO 1,2,3,4,5 PSO 1,2, 3	**CO4-52BT306-B .4.** Examine methods to test the concentration of vaccine	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6	**LI 1** **LI 2**	4.1,4.2,4.3,4.4,4.5,4.6	**4SL-1,2,3,4**
PO 1,2,3,4,5 PSO 1,2, 3	**CO5-52BT306-B .5.** Predict, Design and Compare different vaccines the basis of its production	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6	**LI 1** **LI 2**	5.1,5.2,5.3,5.4,5.5,5.6	**5SL-1,2,3,4**

Curriculum Developer Team:
Prof. Kamlesh Choure
Prof. Ashwini A. Waoo
Prof. Deepak Mishra
Dr. Monika Soni
Er. Arpit Srivastava

Program name	Masters of Science (M.Sc.)- Biotechnology	
Semester	III	
Course Code:	52BT306-C	
Course title:	Bioprogramming and Soft Computing Techniques	**Developer**: Mr. Piyush Kant Rai, Assistant Professor
Pre-requisite:	Fundamental understanding of bio-programming and soft computing techniques to enable effective engagement with advanced concepts in the subject	
Rationale:	Incorporating bio-programming and soft computing techniques is essential. It equips students with foundational knowledge, empowering them to comprehend and apply advanced concepts in the subject, ensuring a seamless integration of computational methodologies into biological frameworks.	
Course Outcomes (COs):	**CO1-52BT306-C.1.** Students will gain a thorough understanding of the underlying principles and theories of bioprogramming and soft computing techniques **CO2-52BT306-C.2.** To develop students' skills in applying bioprogramming and soft computing techniques to solve computational problems**.** **CO3-52BT306-C.3.** To explore the potential applications of bioprogramming and soft computing techniques in various domains. **CO4-52BT306-C.4** To learn and practice soft computing technique and algorithm with its uses in bioinformatics. **CO5-52BT306-C.5** To recite the visual basic and data array labelling in biological sciences**.**	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits(C) (L:T:P=2:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Professional Elective Course (PE)	52BT306-C	Bio programming and Soft Computing Techniques	3	2	1	1	7	2+1=3

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+SA+CAT+ AT)		
PE	52BT306-C	Bio programming and Soft Computing Techniques	15	20	5	5	5	50	50	100

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
PE	52BT356-C	Bioprogramming & Soft Computing Techniques	35	5	5	5	50	50	50

Unit-1 Introduction to R Programming

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	02	01	02	11

Course outcome (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO1-52BT306-C.1. Students will gain a thorough understanding of the underlying principles and theories of bioprogramming and soft computing techniques	**SO1.1** Overview of the R Language; Defining	**LI1.1** Demonstration of basic of linux- UI	**CI1.1** Overview of the R Language	**SL1.1** Draw a flow chart diagram of R-programming installation and working.
	SO1.2 Introduction to R Project; Obtaining R, where to get help Generating		**CI1.2** R Project; Obtaining R, where to get help Generating	**SL1.2** Read the R-project documentation.
	SO1.3 Elaborate workflow of R Code – Basic Programming Concepts		**CI1.3** R Code –Basic Programming Concepts	
	SO1.4 how many types of Datasets included in R Packages; Manipulating objects		**CI1.4** Datasets included in R Packages; Manipulating objects	
	SO1.5 What is Graphics (Basics) Mathematical Operations		**CI1.5** Graphics (Basics) Mathematical Operations	
	SO1.6 Explain Hypothesis testing and data handling; t-tests.		**CI1.6** Hypothesis testing and data handling; t-tests.	

SW-1 Suggested Sessional Work (SW): anyone

Assignments:	1.describe about the timeline of R-code 2. Prepare list of programs available in the R project for biologist.
Mini Project:	2. Find out some research paper reflecting “Datasets included in R Packages”
Other Activities (Specify):	3. Describe the Graphics (Basics) Mathematical Operations

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	02	13

Unit-2 Introduction to MATLAB

Course outcome (COs)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-52BT306-C.2. Students will gain a thorough understanding of the underlying principles and theories of bioprogramming and soft computing techniques	**SO2.1 & SO2.2** how to use MATlab as calculator or standard Matlab windows	**LI2.1** Demonstration of MATLAB	**CI2.1 & CI2.2** MATlab as calculator, standard Matlab windows	**SL2.1** Find out the uses of MATLAB
	SO2.3 & SO2.4 Able to write script files, writing functions, simple graphics, Data types.	**LI2.2** Perform primary analysis of statistical data using MATLAB	**CI2.3 & CI2.4** writing script files, writing functions, simple graphics, Data types.	**SL2.2** Apply MATLAB for the given data
	SO2.5 & SO2.6 File Input-output, Communication with external devices.		**CI2.5 & CI2.6** File Input-output, Communication with external devices.	

SW-2 Suggested Sessional Work (SW): anyone

Assignments:	1. Explain the difference graphics and data.
Mini Project:	2. list the array and string for the MATLAB data
Other Activities (Specify):	3. Describe the File Input-output, Communication with external devices.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	07	04	01	02	14

Unit-3 Introduction to Python

Course outcome (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO3-52BT306-C.3. To explore the potential applications of bioprogramming and soft computing techniques in various domains.	**SO3.1** basic of Features of Python its data types and variables	**LI3.1** Demonstrate the python environments and variable setup	**CI3.1** Features of Python, Data types, Variables operators, Features of Python, Data types, Variables, operators and expressions, control flow tools, functions, Data structures, Input and Output	**SL3.1** Explore Python libraries and list their uses
	SO3.2 Introduction to object-oriented programming CSS and Zope	**LI3.2** Determine the growth kinetics using wet Lab data	**CI3.2** Introduction to object-oriented programming CSS and Zope	**SL3.2** Find out list tools in python library for the raw data handling
	SO3.3 Introduction to PERL, Variable Types, Data types, operators, control structures, lists and Arrays, Subroutines, Hash functions, other useful functions, Regular expressions		**CI3.3** Introduction to PERL, Variable Types, Data types, operators, control structures, lists and Arrays, Subroutines, Hash functions, other useful functions, Regular expressions	
	SO3.4 Introduction to BIO-PERL, BIO-PERL object**s,** implementation of Bioinformatics algorithms for searching and matching in PERL		**CI3.4** Introduction to BIO-PERL, BIO-PERL object**s,** implementation of Bioinformatics algorithms for searching and matching in PERL	
	SO3.5 BLAST parsing		**CI3.5** BLAST parsing	
	SO3.6 Database concept, working with forms, Data Definition & Manipulation Languages, Data Control Languages		**CI3.6** Database concept, working with forms, Data Definition & Manipulation Languages, Data Control Languages	
	SO3.7 Introduction to PL/SQL, SQL plus and SQLJ.		**CI3.7** Introduction to PL/SQL, SQL plus and SQLJ.	

SW-3 Suggested Sessional Work (SW): anyone

Assignments:	1. Elaborate the Perl database concept and its working
Mini Project:	2. Introduction to PL/SQL, SQL plus and SQLJ.
Other Activities (Specify):	3. Describe the BLAST parsing

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	02	01	02	11

Unit-4 Introduction to Soft computing

Course outcome (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO4-52BT306-C.4 To learn and practice soft Computing technique and algorithm with its uses in bioinformatics.	**SO4.1** General concept of soft computing		**CI4.1** General concept of soft computing	**SL4.1** Practice the soft computing technique and algorithm with its uses in bioinformatics
	SO4.2 Able to elaborate Hidden Markov Models and its Application in Bioinformatics ANN (Artificial Neural Networks)	**LI4.1** Demonstrate the ANN with respect biologically active proteins function	**CI4.2** Hidden Markov Models: Application in Bioinformatics ANN (Artificial Neural Networks)	**SL4.2** Elaborate the different kinds of ANN
	SO4.3 & SO4.4 basics of SVM (Support Vector Machines)		**CI4.3 & CI4.4** Concepts and Applications of SVM (Support Vector Machines)	
	SO4.5 & CI4.6 understand Basic concepts and Applications of Genetic Algorithms		**CI4.5 & CI4.6** Basic concepts and Applications of Genetic Algorithms	

SW-4 Suggested Sessional Work (SW): anyone

Assignments:	1. Explain the Support vector machines
	2. prepare a list of command for the genetic algorithm
Mini Project:	2. Generalize the difference between HMM and ANN
Other Activities (Specify):	3. Find out literature sources on genetic algorithm.

Unit-5 Introduction to VB

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	02	01	02	11

Course outcome (COs)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO4-52BT306-C.5 To recite the visual basic and data array labelling in biological sciences.	**SO5.1** Introduction to Visual Basic-Client/Server Technology		**CI5.1** Visual Basic-Introduction to Client/Server Technology	**SL5.1** Collect the information regarding major functional genes and protein associated with cancer
	SO5.2 Able to understand different sterilization equipment and instruments		**CI5.2** Recognize the different sterilization equipment and instruments	**SL5.2** Elaborate the different sterilization equipment and instruments
	SO5.3 Interpret the Thermal Death Time and Decimal Reduction time	**LI5.1** Differentiate the Thermal death time and decimal reduction time	**CI5.3** Interpret the Thermal Death Time and Decimal Reduction time	
	SO5.4 Classify different antimicrobial agents		**CI5.4** Classify different antimicrobial agents	
	SO5.5 To understand the role of bactericidal and bacteriostatic chemicals		**CI5.5** understand the role of bactericidal and bacteriostatic chemicals	
	SO5.6 Introduction to Data Connectivity, Different Database Connectivity.		**CI5.6** Introduction to Data Connectivity, Different Database Connectivity.	

SW-5 Suggested Sessional Work (SW): anyone

Assignments:	1. Elaborate various antimicrobial agents playing important role.
Mini Project:	2. Find the difference bactericidal and bacteriostatic chemicals.
Other Activities (Specify):	3. Find out literature sources on data connectivity.

Brief of hours suggested for the Course Outcome

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-52BT306-C.1. Students will gain a thorough understanding of the underlying principles and theories of bioprogramming and soft computing techniques	6	2	2	1	11
CO1-52BT306-C.2. Students will gain a thorough understanding of the underlying principles and theories of bioprogramming and soft computing techniques	6	4	2	1	13
CO3-52BT306-C.3. To explore the potential applications of bioprogramming and soft computing techniques in various domains.	7	4	2	1	14
CO4-52BT306-C.4 To learn and practice soft Computing technique and algorithm with its uses in bioinformatics.	6	2	2	1	11
CO4-52BT306-C.5 To recite the visual basic and data array labelling in biological sciences.	6	2	2	1	11
Total Hours	**31**	**14**	**10**	**05**	**60**

Suggestion for End semester Assessment

Course Outcome	Marks Distribution				Total Marks
	A	**A**	**E**	**C**	
CO1-52BT306-C.1. Students will gain a thorough understanding of the underlying principles and theories of bioprogramming and soft computing techniques	2	1	1	1	5
CO1-52BT306-C.2. Students will gain a thorough understanding of the underlying principles and theories of bioprogramming and soft computing techniques	2	4	2	2	10
CO3-52BT306-C.3. To explore the potential applications of bioprogramming and soft computing techniques in various domains	3	5	5	2	15
CO4-52BT306-C.4 To learn and practice soft Computing technique and algorithm with its uses in bioinformatics.	2	3	3	2	10
CO4-52BT306-C.5 To recite the visual basic and data array labelling in biological sciences.	5	4	1	0	10
Total	**14**	**17**	**12**	**07**	**50**

Legend: A: Apply, **A:** Analyze, **E:** Evaluate, **C:** Create

Suggested learning Resources:

(a) Books:

S.no.	Title	Author	Publisher	Edition & Year
1	Introduction to MATLAB-6	D.M.Etter	Pearson College Div	2004
2	Programming Python	Mark Lutz	O'Reilly Media	2011
3	BioinformaticsGenes, Proteins and Computers	Christine Orengo, David Jones, Janet Thornton	Taylor & Francis	2003

(b) Online sources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Demonstration
7. ICT Based teaching Learning (Video Demonstration/Tutorials CBT, Blog, Facebook, Twitter, WhatsApp, Mobile, Online sources)
8. Brainstorming

CO, PO and PSO Mapping

Program Title: M. Sc. Biotechnology, 3rd Sem
Course Code: 52BT306-C
Course Title: Bio-programming and Soft Computing Techniques

CO/PO Mapping								
Course Outcome	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-52BT306-C.1. Students will gain a thorough understanding of the underlying principles and theories of bioprogramming and soft computing techniques	1	2	2	3	1	**1**	**2**	**1**
CO1-52BT306-C.2. Students will gain a thorough understanding of the underlying principles and theories of bioprogramming and soft computing techniques	1	2	3	2	1	**1**	**1**	**2**
CO3-52BT306-C.3. To explore the potential applications of bioprogramming and soft computing techniques in various domains	1	2	3	2	1	**2**	**1**	**3**
CO4-52BT306-C.4 To learn and practice soft Computing technique and algorithm with its uses in bioinformatics.	1	1	2	3	2	**2**	**1**	**1**
CO4-52BT306-C.5 To recite the visual basic and data array labelling in biological sciences.	1	2	3	3	1	**1**	**1**	**2**

Legend: CO, PO Mapping Comparison Range **(1) Low (2) Medium (3) High**

Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2,3	**CO1-52BT306-C.1.** Students will gain a thorough understanding of the underlying principles and theories of bioprogramming and soft computing techniques	1.1,1.2,1.3,1.4,1.5,1.6	LI 1	1.1,1.2,1.3	1.1,1.2
PO 1,2,3,4,5 PSO 1,2,3	**CO1-52BT306-C.2.** Students will gain a thorough understanding of the underlying principles and theories of bioprogramming and soft computing techniques	2.1,2.2,2.3,2.4,2.5,2.6	LI 1 LI2	2.1, 2.2, 2.3	2.1,2.2
PO 1,2,3,4,5 PSO 1,2,3	**CO3-52BT306-C.3.** To explore the potential applications of bioprogramming and soft computing techniques in various domains	3.1,3.2,3.3,3.4,3.5,3.6,3.7	LI 1 LI 2	3.1,3.2,3.3,3.4,3.5	3.1,3.2
PO 1,2,3,4,5 PSO 1,2,3	**CO4-52BT306-C.4** To learn and practice soft Computing technique and algorithm with its uses in bioinformatics.	4.1,4.2,4.3,4.4,4.5,4.6	LI 1	4.1,4.2,4.3	4.1,4.2
PO 1,2,3,4,5 PSO 1,2,3	**CO4-52BT306-C.5** To recite the visual basic and data array labelling in biological sciences.	5.1,5.2,5.3,5.4,5.5,5.6	LI 1	5.1,5.2,5.3,5.4	5.1,5.2

Curriculum Developer Team:
Prof. Kamlesh Choure
Prof. Ashwini A. Waoo
Prof. Deepak Mishra
Dr. Monika Soni
Er. Arpit Srivastava

Semester 4

Course Code:	52BT451
Course Title:	6 Months Project work/ Dissertation
Course Outcomes:	
52BT451.1	Analyze complex biotechnological data to draw informed conclusions and drive research initiatives.
52BT451.2	Evaluate contemporary biotechnological research to identify knowledge gaps and propose innovative methodologies.
52BT451.3	Design and execute experimental protocols to investigate specific biotechnological questions.
52BT451.4	Synthesize research findings to generate new insights and advancements in biotechnology.
52BT451.5	Communicate research outcomes effectively through comprehensive written dissertations and professional presentations.

AKS UNIVERSITY

DEPARTMENT OF BIOTECHNOLOGY

Guideline for Project/Dissertation/Industrial Internship

Guidelines and Format
for
M. Sc. Biotechnology
M. Sc. Microbiology
Thesis Preparation

AKS UNIVERSITY
SATNA (M.P.)

For internal use only

April 2022

TABLE OF CONTENT

PART 1: MUST-KNOW ISSUES

1. Enrolment and Pre-requisites

Your research project begins in your last semester. The project/dissertation is considered as a credit course which must be completed within the same semester to qualify for M. Sc. Biotechnology/Microbiology degree. Other important courses such as Biostatistics, Scientific Writing Workshop and Research Methodology should be taken prior to the start of your thesis project.

2. Goals and Objectives

The aim of the research project is to provide students with practice on how to undertake original research in the major fields of biotechnology. The results will be presented to examiners set up by the University. By the end of the research project students will have gained experience in conducting independent research and should be capable in it.

3. Duration and workload

The research project comprises a credit module equivalent to 6 working months. Students are expected to devote regular time in preparing the research proposal, commencing the research project, writing the thesis and presenting it before an Evaluation Committee.

S. No.	Nomenclature for M. Sc. degree program	Duration
1	Dissertation (4^{th} Sem)	6 Months

Industrial training/Internship/Apprentice Program

Students who are getting opportunity to initiate their project/internship/apprentice/dissertation for 6-month program, can apply by getting a recommendation letter against the acceptance from any biotechnology/food/pharma/dairy or relevant industry. The department will accept the work on the basis of its relevance and their evaluation can be done on the basis of the work given or presented by the student. Department of Biotechnology of AKS University has a Life Membership of **LSSSDC** program of Skill India and students will also get an opportunity in this sector would be consider as their project/internship/apprentice/dissertation for 6-month program.

4. Scope

Projects should be original laboratory, field-based or survey research on a topic proposed an internal adviser at university or any outside relevant organization/research lab or industry. You could also conduct their thesis project outside the University given that your proposal is approved with adequate supervision by external supervisor.

5. Choice of projects

Department of Biotechnology and its faculty members will offer a list of possible projects for students' consideration. The proposed projects are closely related to the supervisor's expertise and considered feasible given the current conditions of the University laboratory system or alternatives elsewhere. Students can select the project they are most interested in and discuss with the faculty member proposing the project. Competition may exist when more than one student is interested in the same project. The supervisor has the right to select the most suitable student but criteria for selection should be publicized.

It is possible for students to propose and arrange these projects themselves, but the topic and scientific content must be endorsed by an Advisor of the Department of the University. For project that will be conducted outside the University and supervised by non-University employer, students are requested to provide evidence for such an arrangement by completing Form BT01 along with a CV of your supervisor.

6. Assessment

The thesis will be evaluated by an anonymous examiner assigned by the University. Students are allowed to present his/her thesis only if the examiner approved the same. Viva-Voce can be conducted in which student have to present his/her work in form of PowerPoint presentation 15-20 slides, on the basis of presentation, quality of work and viva, the assessment can be done through external and internal members of evaluation committee.

7. Importance

The student will gain extensive exposure to scientific instruments, their handling, and the ability to easily set up a research pipeline that will assist them in completing project work on the topics assigned to them. The in-house training program is known as CEBRT, and students can contact the Head of the Department directly for more information. The format and guidelines presented here are for the 6-month dissertation program; students are advised to follow the entire structure of guidelines so that they can easily proceed. Students from other colleges and universities must present an official recommendation letter signed by the concerned authority or Head of the Department of their university or college; they are welcomed under the domain of CEBRT; they must also follow the same procedure outlined in this guideline once they contact the training coordinator and Head of the Department.

8. Progress report

About four weeks after the start of your research you are required to submit a progress report to the Department using Form BT02. This progress report must becertified by the supervisor. Change of the initial research title and/or objectives, if well justified, are possible and should be officially approved by the Department.

9. Thesis submission and revision

- The date for submission of completed theses is set by the Department (i.e., six months depending on the course scheme and commencement of the research) and will be confirmed before the beginning of the semester.
- Two copies of thesis (soft-bounded) should be submitted to the Department two weeks before the date set for thesis defense.
- After a successful defense, the student revises his/her thesis according to the comments and amendments required by the Examiner. The adviser should make sure that all corrections are followed by the student by approving the revised thesis using Form BT03.
- The revised thesis is finally checked and approved by the Department.
- Students are required to submit two copies of thesis (hard binding is required) and a and the electronic versions of the thesis (in both .doc and /pdf formats) and the presentation in PowerPoint.

PART 2: THESIS CONTENT

From 2022 onwards students are required to write theses in the form of an extended paper. This new requirement is not only to train students with manuscript preparation, but also to facilitate later publication of good research by the Department. For your thesis the following sections are required in the order shown below. Start each section on a new page.

- Cover page: use the format issued by the Department
- Acknowledgment
- Certificate
- Index including (List of Figures, Tables)
- Main body: paper-styled, including
    - *Title, student name and affiliation* (internal cover page same as main cover page)
    - *Abstract*
    - *Introduction*
    - *Review of Literature*
    - *Materials and Methods*
    - *Results*
    - *Discussion*
    - *Conclusion*
    - *References*
- Appendix (if needed only)

ACKNOWLEDGMENT

This section is to recognize the people, and institutions who have helped you in completing your research project. The page is very informal and you can write in any style that you want. It is best to keep this section short. List here those individuals who provided help during the research (e.g., providing funding, language help, writing assistance or proof reading the article, etc.).

ABSTRACT

The abstract is a very brief overview of your entire study. It must come immediately after the title page. The abstract should briefly state the purpose of the research (introduction), how the problem was studied (methods), the important findings (results), and what the findings mean (conclusion). It is important to be descriptive but concise and to say only what are essential, using no more than 200 words. The author should also suggest some keywords that well represent the content of the research.

INTRODUCTION

This section is short (about 2 - 3 pages) and should be comprehensible to an informed lay person and give enough background to enable the reader to place the particular research problem in a context of common knowledge. It is important to state (i) the research problems (ii) a snap-shot literature review on what have been known or not known yet in

relation to relevant hypotheses or assumptions suggested by you, (iii) the purposes of your research, (iv) scope and limitation and (v) expected outcomes.

More specifically, all problem elements, including the variables to be studied, should be expressed in an orderly system of relationships. Research questions must be clear, consistent, and measurable. They guide the research design process. Indicate "why" the study is being proposed.

Provide an adequate background (literature review) and clearly state the objectives of the work, avoiding a detailed literature survey or a summary of the results. Try to answer the question: "what potential impact will the results of the study have on the current body of knowledge?

MATERIALS & METHODS

This section should provide an accurate description of all methods and materials used inyour study. It should be written in the past tense in the passive voice. Provide sufficient detail to allow the work to be reproduced, with details of supplier and catalogue number when appropriate. Methods already published should be indicated by a reference: only relevant modifications should be described. See Appendix 2 for an example of this section.

Recommended structure of the section:

2.1 Research object and location (information about the object of your research and where it was conducted)

2.2 Experimental design: describe the experimental design, methods adopted ordeveloped to collect data. Relevant instruments and materials should be mentioned along with their description. Do not just simply list all the chemicals, instruments or devices used in the research. If you use standard methods(published and used by many similar studies, for example Kjeldall method to determine crude protein concentration), just mention the name of the methods and cite the reference that describe the method. In case the method should be described but too long, detailed information can be presented in the Appendix.

2.3 Data analysis: describe statistical methods used for data analysis with enough details so that the reliability of your research can be assessed. Data should be analyzed using statistics, either descriptive or inferential or both. Raw data are never included in your thesis unless they are needed to give evidence for specific conclusions which cannot be obtained by looking at an analysis, or summation, ofthe data. If your study includes more than one experiment, describe one by one.

RESULTS

Summarize the findings without interpretation. Results should be clear and concise. Only analyzed data should be presented in forms of figures, graphs, tables and/or text descriptions of observations. When presenting statistically summarized data, you should state whether the number is a mean or median and clearly state how the data spread is expressed (± standard deviation, ± standard error of the mean, or inter-quartile range). When claiming a statistically significant result, you must support such a statement with

declaration of the probability (p) value and the test that was used to generate that value. Consult a statistician if you feel you need help in doing your statistical test and seek his advice in presenting your results. All Figures and Tables should be numbered chronologically as they appear in your thesis. All Figures and Tables must be referred to in the text to facilitate reading. See further guidelines for constructing tables and figures in Part 3.

DISCUSSION

This should explore the significance of the results of the work, not repeat them. Discuss all the significant outcomes of your research; see how they fit with our current understandingof the research areas or what implications it implies for future studies or industrial application. Any limitation or weakness of the research should also be discussed and ended up with recommendations for possible improvement.

CONCLUSION

This section should state the conclusions and recommendations that you have drawn from your work (in relation to the research question or tested hypothesis) and relate the findings of your study to previously published work. Students should avoid to state the key results here instead of conclusions. Recommendations should be relevant to your research findings in order to provide the readers with tips, suggestions or modes of action so that they can follow if interested.

REFERENCES

This must contain complete list of all references cited in the text (see Section 5.2 on referencing).

APPENDIX

Any other relevant information that cannot be appropriately accommodated elsewhere can be placed in an Appendix (or Appendices) at the end of the dissertation. Try not to use them unless you absolutely have to. They are considered useful for listing raw data or details of experimental protocols if you feel it is necessary to do so.

PART 3: THESIS FORMAT

From 2022 onwards students at the Department of Biotechnology are required to write their theses in the form of an extended paper. The format of your thesis is, therefore, a blended design of a traditional thesis, i.e. with the cover page, followed by Acknowledgment and ended up with an Appendix. The main body of the thesis is, however, a paper which is allowed to be a bit longer than the standard. In order to facilitate professional writing, the format of Journal of Innovation in Applied Research (jiar.in). You are advised to strictly follow the instructions below.

THESIS LAYOUT

- The thesis must be word-processed in English (American or British usage is accepted, but not a mixture of these) using Time New Roman font 12-point size with 1.5 line spacing. The text should be fully justified and leave 1 space between sentences; Heading and Sub Headings can be typed as in Time New Roman, Bold and 14 font size in numbers like 1, 1.1, 1.1.2 etc.
- Page set-up: use A4 paper with the left margin of 4.0 cm to allow binding. All the other margins are 2.5 cm.
- Each page of the main body must be numbered, starting with the page that has the title of your research and the abstract. Place the number in the center of the bottom of the page. No header/footer is allowed.
- Hard Binding is accepted for 6 months dissertation once you submit the final version of your thesis.

NUMBER OF PAGES

- Keep your writing short, informative and as concise as possible.
- No page number is required for the Cover page, Acknowledgment, References and Appendix.
- The length of the main body of your thesis should be ideally between 40-50 pages approx. for 6-month dissertation. When needed the addition of few more pages are allowed, but the total number of pages of the main body should not exceed 80.
- Your supervisor will advise you on the length of each section and the level of details required.

COVER PAGE

- The cover page is designed to highlight your research title while providing important information such as the name of the educational provider, name of student and adviser(s) and year of publication.
- Use the standard format provided by the Department (see Appendix 1).

HEADINGS

The appropriate use of headings is a great assistance to the reader, breaking the text into logical blocks. Divide your thesis into clearly defined and numbered sections. Subsections should be numbered 1.1 (then 1.1.1, 1.1.2, ...), 1.2, etc. Any subsection may be given a brief heading. Each heading should appear on its own separate line. The recommended structure and headings of the main body is as follows:

Title

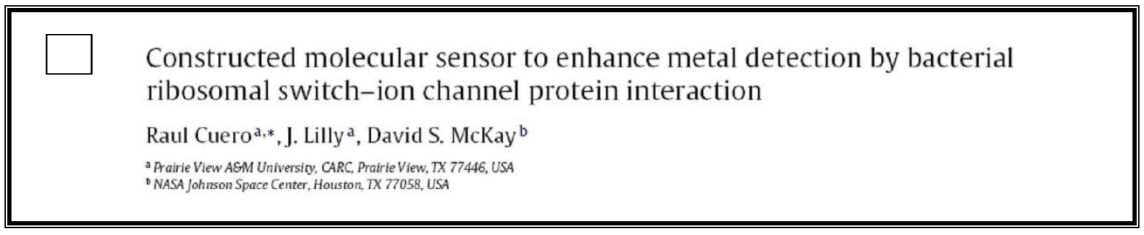
Author name(s) and affiliation

Abstract

Keywords

1. Introduction
2. Materials & Methods
   - 2.1 Research object and location
   - 2.2 Experimental design
   - 2.3 Data analysis
3. Results
   - 3.1 sub-headline 1
   - 3.2 sub-headline 2
   - 3.n sub-headline n
4. Discussion
5. Conclusion

References



Constructed molecular sensor to enhance metal detection by bacterial ribosomal switch–ion channel protein interaction

Raul Cuero[a,*], J. Lilly[a], David S. McKay[b]

[a] Prairie View A&M University, CARC, Prairie View, TX 77446, USA
[b] NASA Johnson Space Center, Houston, TX 77058, USA

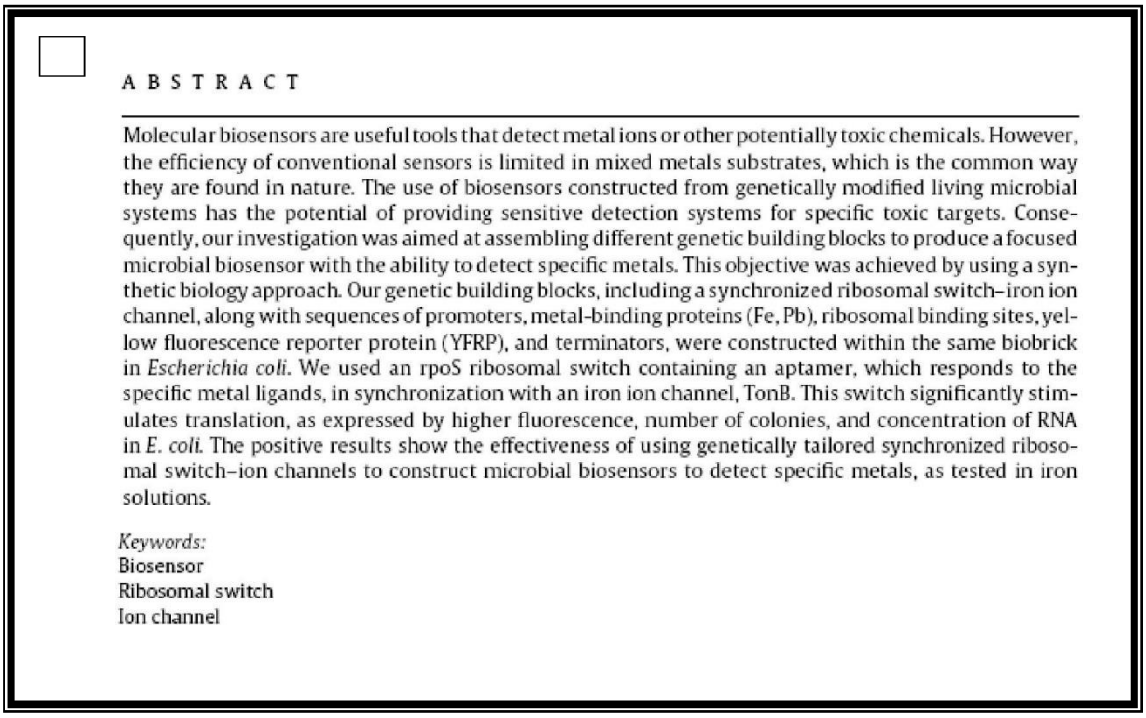
TITLE PAGE INFORMATION (see the example above)

- The title should be concise and informative as it will be used in information- retrieval systems. Avoid abbreviations and formulae where possible.
- Author names and affiliations: where the family name may be ambiguous (e.g., adouble name), please indicate this clearly. Your official affiliation address is "Department of Biotechnology, AKS University, Satna". Indicate all affiliations with a lower-case superscript letter immediately

after the author's name and in front of the appropriate address if your adviser/co-worker is from another institution. Provide the e-mail address of the corresponding author, i.e. yours in most cases.

ABSTRACT

- Not more than 200 words and should be as a single paragraph.
- Keywords: immediately after the abstract. Provide a maximum of 6 keywords, using American spelling and avoiding general and plural terms and multiple concepts (avoid, for example, 'and', 'of'). Be sparing with abbreviations: only abbreviations firmly established in the field may be eligible. These keywords will be used for indexing purposes.



ABSTRACT

Molecular biosensors are useful tools that detect metal ions or other potentially toxic chemicals. However, the efficiency of conventional sensors is limited in mixed metals substrates, which is the common way they are found in nature. The use of biosensors constructed from genetically modified living microbial systems has the potential of providing sensitive detection systems for specific toxic targets. Consequently, our investigation was aimed at assembling different genetic building blocks to produce a focused microbial biosensor with the ability to detect specific metals. This objective was achieved by using a synthetic biology approach. Our genetic building blocks, including a synchronized ribosomal switch–iron ion channel, along with sequences of promoters, metal-binding proteins (Fe, Pb), ribosomal binding sites, yellow fluorescence reporter protein (YFRP), and terminators, were constructed within the same biobrick in *Escherichia coli*. We used an rpoS ribosomal switch containing an aptamer, which responds to the specific metal ligands, in synchronization with an iron ion channel, TonB. This switch significantly stimulates translation, as expressed by higher fluorescence, number of colonies, and concentration of RNA in *E. coli*. The positive results show the effectiveness of using genetically tailored synchronized ribosomal switch–ion channels to construct microbial biosensors to detect specific metals, as tested in iron solutions.

Keywords:
Biosensor
Ribosomal switch
Ion channel

TABLES

- Number tables consecutively in accordance with their appearance in the text.
- Place footnotes to tables below the table body and indicate them with superscriptlowercase letters. Avoid vertical rules.
- Be sparing in the use of tables and ensure that the data presented in tables donot duplicate results described elsewhere in the article.

Examples:

Table 1
First central composite design 2^2 coded for the study of the effect of pH, enzyme concentration and glutaraldehyde concentration on the immobilization process of glucosyltransferase onto Celite, for conversion of sucrose into isomaltulose; the statistical analyses were carried out only in the first batch of 2.5 h, at 33 °C and 130 rpm.

Assay	Variables			Conversion of sucrose into isomaltulose (%)		
	pH	Enzyme (U/g of Celite)	Glutaraldehyde (%)	1° batch	2° batch	3° batch
1	−1 (5.6)	−1 (32.6)	−1 (0.10)	7.38	7.38	9.03
2	+1 (7.4)	−1 (32.6)	−1 (0.10)	0.00	0.00	0.00
3	−1 (5.6)	+1 (87.0)	−1 (0.10)	21.92	21.92	23.63
4	+1 (7.4)	+1 (87.0)	−1 (0.10)	1.34	1.34	1.59
5	−1 (5.6)	−1 (32.6)	+1 (0.40)	1.51	0.00	1.59
6	+1 (7.4)	−1 (32.6)	+1 (0.40)	0.00	0.00	0.00
7	−1 (5.6)	+1 (87.0)	+1 (0.40)	12.75	8.73	10.64
8	+1 (7.4)	+1 (87.0)	+1 (0.40)	0.00	1.52	1.15
9	−1.68 (5.0)	0 (59.8)	0 (0.25)	19.81	18.09	20.32
10	+1.68 (8.0)	0 (59.8)	0 (0.25)	0.00	0.00	0.09
11	0 (6.5)	−1.68 (14.1)	0 (0.25)	0.00	0.00	0.00
12	0 (6.5)	+1.68 (105.5)	0 (0.25)	7.23	8.00	7.19
13	0 (6.5)	0 (59.8)	−1.68 (0.00)	16.94	14.12	11.54
14	0 (6.5)	0 (59.8)	+1.68 (0.50)	3.25	2.87	3.77
15	0 (6.5)	0 (59.8)	0 (0.25)	4.31	6.33	4.62
16	0 (6.5)	0 (59.8)	0 (0.25)	6.18	5.96	4.29

FIGURE CAPTION

Ensure that each illustration has a caption. A caption should comprise a brief title and a description of the illustration. Keep text in the illustrations themselves to a minimum but explain all symbols and abbreviations used.

Example:

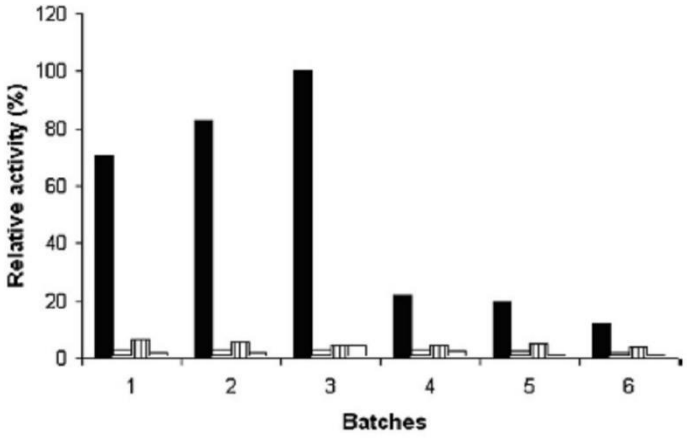


Fig. 5. Relative glucosyltransferase activity of the different low methoxyl pectin microcapsules containing glucosyltransferase after six batches of 30 min each of conversion of sucrose into isomaltulose. (■) Microcapsules with fat; (▤) microcapsules without fat; (◧) lyophilized microcapsules with fat; and (□) lyophilized microcapsules without fat.

CITATION IN TEXT

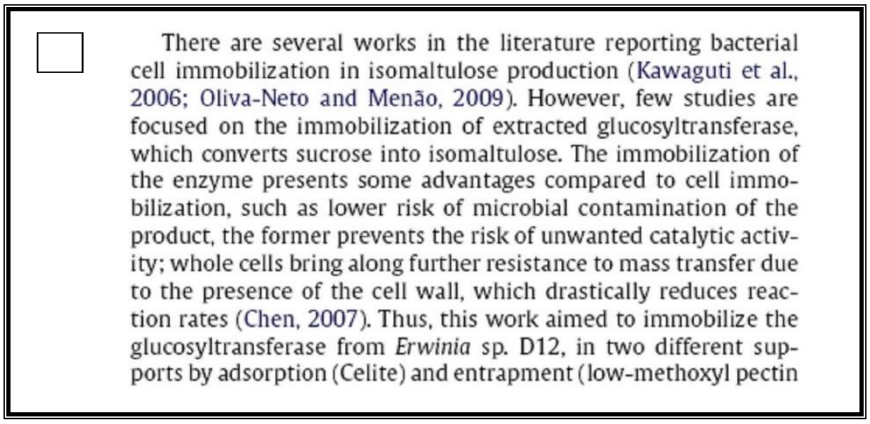
Please ensure that every reference cited in the text is also present in the reference list and vice versa. Any references cited in the abstract must be given in full. Unpublished results and personal communications are not recommended in the reference list, but may bementioned in the text. If these references are included in the reference list they should follow the standard reference style as follows and should include a substitution of the

publication date with either 'Unpublished results' or 'Personal communication'. Citation of areference as 'in press' implies that the item has been accepted for publication.

All citations in the text should refer to:

- *Single author:* the author's name (without initials, unless there is ambiguity) and theyear of publication;
- *Two authors:* both authors' names and the year of publication;
- *Three or more authors:* first author's name followed by 'et al.' and the year ofpublication.

Citations may be made directly (or parenthetically). Groups of references should belisted first alphabetically, then chronologically.



There are several works in the literature reporting bacterial cell immobilization in isomaltulose production (Kawaguti et al., 2006; Oliva-Neto and Menão, 2009). However, few studies are focused on the immobilization of extracted glucosyltransferase, which converts sucrose into isomaltulose. The immobilization of the enzyme presents some advantages compared to cell immobilization, such as lower risk of microbial contamination of the product, the former prevents the risk of unwanted catalytic activity; whole cells bring along further resistance to mass transfer due to the presence of the cell wall, which drastically reduces reaction rates (Chen, 2007). Thus, this work aimed to immobilize the glucosyltransferase from *Erwinia* sp. D12, in two different supports by adsorption (Celite) and entrapment (low-methoxyl pectin

WEB REFERENCE

As a minimum, the full URL should be given and the date when the reference was last accessed. Any further information, if known (DOI, author names, dates, reference to a source publication, etc.), should also be given. Web references can be listed separately (e.g., after the reference list) under a different heading if desired, or can be included in the reference list. Avoid using websites as reference unless absolutely necessary.

REFERENCE LIST (APA Format)

References should be arranged first alphabetically and then further sorted chronologically if necessary. More than one reference from the same author(s) in the same year must be identified by the letters 'a', 'b', 'c', etc., placed after the year of publication. Journal name must be written in full name.

Examples:

Reference to a journal publication:

Van der Geer, J., Hanraads, J.A.J., Lupton, R.A., 2010. The art of writing a scientificarticle. Journal of Science Communication 163, 51–59.

Reference to a book:

Strunk Jr., W., White, E.B., 2000. The Elements of Style, fourth ed. Longman, New York.

Reference to a chapter in an edited book:

Mettam, G.R., Adams, L.B., 2009. How to prepare an electronic version of your article,in: Jones, B.S., Smith , R.Z. (Eds.), Introduction to the Electronic Age. E-Publishin.

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Nudler, E., Mironov, A.S., 2004. The riboswitch control of bacterial metabolism. Trends in Biochemical Science 29 (1), 11–17.

APPENDIX

All materials placed in the appendix must be directly relevant to the paper. The material must be cross-referenced to the development of the research in the text of the paper using an explanatory note or a parenthetical reference. Avoid the temptation to use the appendix to bulk up the paper.

LANGUAGE AND GRAMMAR

- Use simple but clear language
- Take time to check your work for misspelled words, typographical error, mislabeled figures, tables or photos.
- If you need help in grammar, seek the help of an editor before submitting your work to your adviser. Your adviser is not expected to correct errors in spelling, punctuation, grammar, and formatting.

ABBREVIATION

Define abbreviations that are not standard in this field in a footnote to be placed on the first page of the article. Such abbreviations that are unavoidable in the abstract must be defined at their first mention there, as well as in the footnote. Ensure consistency of abbreviations throughout the article.

ACKNOWLEDGING THE WORK OF OTHERS

Plagiarism

Plagiarism is copying another person's idea or written work and claiming it as your own.This is an academic offence and you are strictly prohibited from doing this. Make sure thatall information, photos, figures and tables are properly acknowledged. Less Than 5% plagiarism is accepted only as per the authenticate software used. DO NOT COPY/PASTE ANY CONTENT FORM WEB OR RESEARCH PAPERS, the project can be disqualified once it found with unfair means. Therefore, no evaluation can be done for the dame.

Citations

You must always acknowledge your sources of factual information and diagrams you wish touse. This is known as a *citation.*

PART 4: THESIS DEFENCE

PRESENTATION

- Presentation should last up to 15 minutes with another 15 minutes for questions andanswers
- Slides should be prepared using Microsoft PowerPoint and presented from a disk.
- Rehearse your presentation and anticipate questions that may be asked by theEvaluation Committee.
- If you are not sure about the pronunciation of certain terminologies, be sure to ask aknowledgeable person before your defense.
- Try not to read from your slides and maintain eye contact with your audience
- Use pointers or laser devices properly
- Ask your supervisor for advice on the content and structure of your presentation.
- Even a successful defense is generally followed by certain minor adjustments in your document, and some final paperwork amendments. You should take notes during the Q&A session, and contact the Secretary of the Evaluation Committee for a detailed request for thesis improvement.

CONTENT OF PRESENTATION

- The presentation should be a brief introduction of your topic, purpose of your study; description of the methods used and the results.
- It is advisable that your presentation has enough important details in order to avoid misunderstanding or excessive questions. Also, keep it short as time is limited.
- Make sure your answers are relevant to the questions of the Evaluation Committee.

APPENDIX 1: FORMAT OF THESIS COVER PAGE

AKS University, Satna

(5 lines from logo)

TITLE OF THESIS

(3 lines)

A thesis submitted to
The Department of Biotechnology, AKS University
In partial fulfillment of the requirements for the degree of
M. Sc. in …….

(6 lines)

Student name: Full name of student – Student Code.
Supervisor: Title and full name of supervisor(s)

(7 lines)

Month/Year

APPENDIX 2: RELEVANT FORMS

(proposal development, proposal defense, midway progress report, evaluation, etc.)

Form **BT01**

THESIS REGISTRATION

1. (Student's name) ..... (ID) .....
2. (Department) .....
3. (Thesis title) .....

.....

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4. (Objectives) .....

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5. (Research content) .....

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6.(Research location) .....

.....

7. (Duration) (from): ..... (to): .....
8. (Supervisor):

   (Full name).....

   (Address).....

   .....

   Email: .....

(Supervisor)

(Department)

Form **BT02**

THESIS PROGRESS REPORT

1. Student name: ..... Student's ID.....
2. Supervisor .....
3. Thesis title .....

.....

SECTION A: to be completed by student

Thesis processing management

Content	Status		Tentative completion time
	Complete	On going	
1.	□	□	
2.	□	□	
3.	□	□	
n.	□	□	

Presence of obstacles to thesis completion, if any,

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Important note: Date to submit the completed thesis:

Date:.....

Signature of student

SECTION B: to be completed by the principal Supervisor

Has the student:	Yes	No
(i) Shown relevant knowledge and understanding toward specific project field?	☐	☐
(ii) Shown initiative consistent with the requirements of the research program?	☐	☐
(iii) Made satisfactory progress in the research program?	☐	☐
(iv) Shown the ability to complete the research program by the due date?	☐	☐

If no, please recommend extension for completion or cut some parts of the proposal

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Date:.....

Signature of supervisor

Form **BT03**

Evaluation Form

Academic Adviser

Name of Student ..... ID: .....

Criteria	Maximum marks	Your mark
Independence in work	10	
Creativity	10	
Level of commitment	20	
Writing skill	20	
Overall quality of thesis *	40	
Total	**100**	

* The maximum mark should not exceed 30 unless the student produced a manuscript for possible publication. A hard copy of the manuscript should be enclosed with this evaluation form.

_____

Name of Adviser

_____

Date Signed

Evaluation Form

Thesis Reviewer

Name of Student_____ID: _____

Criteria	Maximum mark	Your mark
Project goal and objectives (clear, achievable)	15	
Quality of Literature Review *(comprehensive, relevant)*	15	
Materials and Methods *(sound methods, appropriate materials and supporting equipment)*	25	
Results and Significant contribution *(please evaluated against the specific objectives of the project)*	30	
Writing skill and format (including compliance do thesis guidelines)	15	
Total	**100**	

Comments and recommendations for improvement/ correction (blank section is not acceptable)

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Name of Examiner (Signature and Date)

_____

Date Signed

Form **BT05**

Evaluation Form

For examiner of the Scientific Committee

Name of Student ..... ID: .....

Criteria	Maximum mark	Your mark
Introduction *(research problem well stated, clear objectives)*	10	
Good understanding of the research field	10	
Methodology *(sound, appropriate or creative)*	20	
Quality of results *(evaluated against the research objectives)*	20	
Presentation skills *(quality of slides, speaking skills, timing)*	20	
Quality of answers *(relevant to questions, satisfied by the committee members)*	20	
Total	**100**	

Additional comments/suggestions for improvement:

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Name of Examiner

_____

Date Signed