Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Structure and Curriculum of Two Year Post Graduate Programme with Exit option

Postgraduate Programme of Science and Technology

M.Sc.in Biotechnology

Board of Studies

in

Biotechnology

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

(PG-II)

w.e.f. June, 2024

(In Accordance with NEP-2020)

Review Statement

The NEP Cell reviewed the Curriculum of **M.Sc. in Biotechnology** Programme to be effective from the **Academic Year 2023-24.** It was found that, the structure is as per the NEP-2020 guidelines of Govt. of Maharashtra.

Date: 09/08/2023

Place: Latur

NEP Cell

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CERTIFICATE

I hereby certify that the documents attached are the Bonafide copies of the Curriculum of **M.Sc. in Biotechnology** Programme to be effective from the **Academic Year 2023-24.**

Date: 14/07/2023

Place: Latur

(Dr. Sachin Kulkarni)
Chairperson
Board of Studies in Biotechnology
Rajarshi Shahu Mahavidyalaya, Latur
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Members of Board of Studies in the Subject Biotechnology

Under the Faculty of Science and Technology

Sr. No.	Name	Designation	In position
1	**Dr. Sachin S. Kulkarni** Head, Department of Biotechnology, Rajarshi Shahu Mahavidyalaya, Latur (Autonomous)	Chairperson	HoD
2	**Prof. Tukaram. A. Kadam** Professor, School of Life Sciences SRTMU, Nanded.	Member	V.C. Nominee
3	**Dr. Rahul. P. Bhagat** Asst. Professor, Department ofBiotechnology, Govt. Institute of Science, Aurangabad (Autonomous)	Member	Academic Council Nominee
4	**Dr. Rajesh M. Jorgewad** Asst. Professor, Department of Biotechnology and Bioengineering, KIT college, Kolhapur (Autonomous)	Member	Academic Council Nominee
5	**Dr. Gunderao. H. Kathwate** Asst. Professor, Dept. of Biotech. S. P. P. U. Pune	Member	Expert from outside for Special Course
6	**Mr. Abhay. M. Desai** Wockhardt, Aurangabad	Member	Expert from Industry
7	**Dr. SantoshNarwade** Serum Institute Pvt.Ltd. Pune	Member	P.G. Alumni
8	**Dr. Manisha. A. Dhotre**	Member	Faculty Member
9	**Mr. Udaybhanu. P. Sirdeshmukh**	Member	Faculty Member
10	**Dr. Ravindra. B. Ade**	Member	Faculty Member
11	**Dr. Sanghapal. S. Kshirsagar**	Member	Faculty Member
12	**Mr. Suraj. D. Kadam**	Member	Faculty Member
13	**Mr. Akash. J. Waghmare**	Member	Faculty Member
14	**Miss. Swati G. Swami**	Member	Faculty Member
15	**Mr. Sanket M. Bansode**	Member	Faculty Member
16	**Miss. Karun. S. Komatwar**	Member	Faculty Member
17	**Dr. Kakasaheb. S. Raut**	Member	Member from same Faculty

From the Desk of the Chairperson…

Biotechnology as a subject is a highly interdisciplinary that combines biological sciences with engineering technologies to manipulate living organisms and biological systems to produce products that advances healthcare, medicine, agriculture, food, pharmaceuticals and environment. At its simplest, biotechnology is technology based on biology - which harnesses cellular and bimolecular processes to develop technologies and products that help to improve our lives and health of our planet.

Taking into consideration of the importance of Biotechnology, Rajarshi Shahu Mahavidyalaya, Latur (Autonomous), have taken an initiative to introduce a new emerging field as an undergraduate Programme in biotechnology under the faculty of science. B. Sc. Biotechnology is a Three-year graduate degree program which is started in the academic year 2004-05 followed by the postgraduate program started in academic year 2006-07.

National Education Policy (NEP) 2020 recognizes the relevance of biotechnology in the education system due to its interdisciplinary nature, potential for research and innovation, and its alignment with the development of 21st-century skills. By integrating

biotechnology into the curriculum, the policy aims to prepare students for the challenges

and opportunities of a rapidly advancing biotechnology driven world.

NEP-2020 has conceptualized the idea to develop well rounded competent individuals for making the nation a self-reliant and global leader. In the same spirit, we at Department of Biotechnology, have developed a curriculum framework to encompass the goals of NEP 2020. In the overall curriculum we have incorporated choice of courses of study, creating academic pathways having constructive combinations with exit point as well as focus on experiential learning for students by providing multidisciplinary and holistic approach to the courses taught as major courses along with electives of choice for equipping the students with adequate knowledge leading to the choice of better career paths.

With reference to global changes occurring in higher education in various national and foreign universities, the newly designed syllabi of M.Sc. Biotechnology as per NEP 2020 guidelines are effectively implemented from June, 2023. The committee members of Board of Studies in Biotechnology also took the local need and employability of graduate students into consideration while framing the given curriculum, keeping in view of the guidelines given in the University Grants Commission, New Delhi.

By aligning curriculum development, pedagogy, interdisciplinary connections, research opportunities, industry collaborations, teacher training, and available infrastructure with the institute, the department of biotechnology plans to integrate students with a comprehensive understanding of biotechnology, foster critical thinking and research skills, and prepare them for future careers in the field.

(Dr. Sachin Kulkarni)
Chairperson
Board of Studies in Biotechnology

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Structure for Two Year Postgraduate Degree Programme in Biotechnology in accordance with NEP-2020

Year Level	Sem	Major		RM	OJT/FP	RP	Cum. Cr	Marks	Degree
		Mandatory	**Elective**	RMC 4Cr	NA	NA	**20Cr**	Theory: 1Cr=25M	**PG Diploma (After 03 Year B.A. Degree)**
I 6.0	**I**	Major I 4Cr Major II 4Cr Major III 4Cr	MEC-I(A) OR MEC-I(B) 4Cr						
	II	Major IV 4Cr Major V 4Cr Major VI 4Cr	MEC-II(A) OR MEC-II(B) 4Cr	NA	OJT-I 4Cr /FP-I 4Cr	NA	**20Cr**	OJT/FP: 1Cr=25M	
	Total	**Major 24Cr**	**MEC 08Cr**	**RMC 04Cr**	**OJT/FP 04Cr**	**NA**	**40Cr**		
II 6.5	**III**	Major VII 4Cr Major VIII 4Cr Major IX 4Cr	MEC-III(A) OR MEC-III(B) 4Cr	NA	NA	RP-I 4 Cr	**20Cr**	RPI & RPII: 1Cr=25M	**PG Degree (After 03 Year UG Degree)**
	IV	Major X 4Cr Major XI 4Cr Major XII 4Cr	MEC-IV(A) OR MEC-IV(B) 4Cr	NA	NA	RP-II 6Cr	**22Cr**		
	Total	**Major 24 Cr**	**MEC 08 Cr**	**NA**	**NA**	**RP 10 Cr**	**42Cr**		
Cum. Total of I & II Year		**Major 48 Cr**	**MEC 16Cr**	**RMC 04Cr**	**OJT/FP 04Cr**	**RP 10Cr**	**40+42 =82 Cr**		**82 Credits**

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Department of Biotechnology

PG Skeleton in Accordance with NEP-2020

Illustrative Credit Distribution Structure for Two Year M.Sc. Degree

Year Level	Sem	Major		Lab Course	RM	OJT/FP	RP	Cum. Cr	Marks	Degree
		Mandatory	**Elective**		RMC 4Cr	NA	NA	**20Cr**	Theory: 1Cr=25M Lab Course: 1Cr=50M	**PG Diploma (After 03 Year B.Sc. Degree)**
I 6.0	**I**	Major I 3Cr Major II 3Cr Major III 3Cr	MEC I 3Cr	LC-I 1Cr LC-II 1Cr LC-III 1Cr LC-IV 1Cr						
	II	Major IV 3Cr Major V 3Cr Major VI 3Cr	MEC II 3Cr	LC-V 1Cr LC-VI 1Cr LC-VII 1Cr LC-VIII 1Cr	NA	OJT-I 4Cr /FPI 4Cr	NA	**20Cr**	OJT/FP: 1Cr=25M	
	Total	**Major 18Cr**	**MEC 06Cr**	**LC-8Cr**	**RMC 04Cr**	**OJT/FP 04Cr**	**NA**	**40Cr**		
Exit Option: PG Diploma with 40 Credits After 03 Year B.Sc. Degree										
II 6.5	**III**	Major VII 3Cr Major VIII 3Cr Major IX 3Cr	MEC III 3Cr	LC-IX 1Cr LC-X 1Cr LC-XI 1Cr LC-XII 1Cr	NA	NA	RP-I 4Cr	**20Cr**	RPI & RPII: 1Cr=25M	**PG Degree (After 03 Year UG Degree)**
	IV	Major X 3Cr Major XI 3Cr Major XII 3Cr	MEC IV 3Cr	LC-XIII 1Cr LC-XIV 1Cr LC-XV 1Cr LC-XVI 1Cr	NA	NA	RP-II 6Cr	**22Cr**		
	Total	**Major 18Cr**	**MEC 06Cr**	**LC-8Cr**	**NA**	**NA**	**RP 10 Cr**	**42Cr**		
Cum. Total of I & II Year		**Major 36Cr**	**MEC 12Cr**	**LC-16Cr**	**RMC 04Cr**	**OJT/FP 04Cr**	**RP 10Cr**	**40+42 =82 Cr**		**82 Credits**
	Exit Option: Two Years 04 Sem. PG Degree with 82 Credits After 03 Year UG Degree									

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Abbreviations:

1. MMC : Major Mandatory Course
2. MEC : Major Elective Course
3. RMC : Research Methodology Course
4. OJT : On Job Training (Internship/Apprenticeship)
5. FP : Field Project
6. RP : Research Project
7. Cum. Cr : Cumulative Credit

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Year & Level	Semester	Course Code	Course Title	Credits	No. of Hrs.
II 6.5	III	602BIO3101 (MMC VII)	Genetic Engineering	03	45
		602BIO3104	Lab Course-IX	01	30
		602BIO3102 (MMC VIII)	Microbial Biotechnology	03	45
		602BIO3105	Lab Course-X	01	30
		602BIO3103 (MMC IX)	Plant and Agricultural Biotechnology	03	45
		602BIO3106	Lab Course-XI	01	30
		602BIO3201 MEC-III (A) Or 602BIO3202 MEC-III (B)	Advance Pharmaceutical Biotechnology Or Enzyme and Protein Engineering	03	45
		602BIO3203	Lab Course-XII	01	30
		601BIO1301 (RP-I)	Research Project-I	04	120
	Total Credits			**20**	
	IV	602BIO4101 (MMC X)	Animal and Livestock Biotechnology	03	45
		602BIO4104	Lab Course-XIII	01	30
		602BIO4102 (MMC XI)	Clinical Research, IPR, Bio entrepreneurship and Start up	03	45
		602BIO4105	Lab Course-XIV	01	30
		602BIO4103 (MMC XII)	Food and Nano Biotechnology	03	45
		602BIO4106	Lab Course-XV	01	30
		602BIO4201 MEC-IV (A) Or 602BIO4202	Environmental Biotechnology Or Omics Technology	03	45

		MEC-IV(B)			
		602BIO4203	Lab Course-XIV	01	30
		(RP-II)	Research Project-II	06	180
	Total Credits			**22**	
Total Credits (Semester III & IV)				**42**	

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Programme Outcomes (POs) for M.Sc. Programme	
PO 1	
PO 2	
PO 3	
PO 4	
PO 5	
PO 6	
PO 7	

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Programme Specific Outcomes (PSOs) for M.Sc. Biotechnology	
PSO No.	Upon completion of this programme the students will be able to -
PSO 1	Integrate basic principles of common analytical techniques of protein molecular structures to engage in hands-on practices for implementation of such techniques to facilitate the development of biopharmaceutical manufacturing.
PSO 2	Induce the understandings of basic principles of process units' operations of industrial products with hands-on practices for implementation of such techniques to facilitate the development of biopharmaceutical manufacturing.
PSO 3	Gain fundamental knowledge of molecular biotechnology, protein expression, and structural biology for the development of new products having clinical application.
PSO 4	Plan, conduct, execute and write-up a proposal of original research Practical skills.
PSO 5	Promote the entrepreneurship for self-growth and sustainability with the aim of promoting lab to land practices in, clinical, agriculture, food, nano, plant and animal biotechnology.
PSO 6	Integrate fundamental concepts of leadership, entrepreneurship and innovation, financial decision making and marketing to business enterprises.
PSO 7	Equip the students with the skills required for carrying out research in cutting edge areas of life sciences.
PSO 8	Make the students competent for dealing with the future problems and challenges of regional and global interest in overall development of society.

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Semester - Third

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Course Type: MMC-VII

Course Title: Genetic Engineering

Course Code: 602BIO3101

Credits: 03 **Max. Marks: 75** **Lectures: 45Hrs.**

Learning Objectives

LO 1 To comprehend principles and techniques for DNA and RNA isolation, quantification

LO 2 To master various DNA sequencing methods (Maxam-Gilbert, Sanger-Nicolson, Pyrosequencing) including principles, applications, advantages, and limitations.

LO 3 To master the utilization of restriction endonucleases and DNA modifying enzymes for genetic engineering

LO 4 To develop expertise in employing prokaryotic hosts and vectors, including plasmid vectors and bacteriophages, for genetic manipulation

LO 5 To develop skills in the selection, screening, and analysis of recombinants using various techniques

LO 6 To master the application of molecular biology techniques Polymerase Chain Reaction (PCR), (RFLP), RAPD, AFLP used for genetic analysis and identification of recombinants.

LO 7 To develop proficiency in vector engineering and codon optimization techniques, along with host engineering strategies, to enhance gene expression in higher organisms.

LO 8 To master the diverse strategies of gene delivery and expression in various organisms

Course Outcomes

After completion of the course, the student will be able to-

CO 1 Proficiently isolate and quantify nucleic acids

CO 2 Apply understanding of DNA sequencing methods to analyze DNA sequences effectively

CO 3 Apply advanced knowledge of genetic engineering tools

CO 4 Demonstrate proficiency in constructing genomic and cDNA libraries

CO 5 Demonstrate proficiency in employing a variety of techniques like Northern blotting, Southern blotting, Western blotting, PCR, RFLP, RAPD, AFLP screening of recombinants.

CO 6 Apply advanced knowledge of molecular biology methods to analyze and interpret data obtained from screening processes

CO 7 Demonstrate proficiency in utilizing vector engineering, codon optimization, and host engineering.

CO 8 Apply advanced knowledge of gene expression mechanisms in bacteria, yeast, insects, insect cells, mammalian cells, and plants.

Unit No.	Title of Unit & Contents	Hrs.
I	**DNA isolation and Sequencing methods.**	**9**
	1. Isolation of DNA and RNA. 2. Quantification of nucleic acids. 3. Radiolabeling of nucleic acids: End labeling, nick translation, labeling by primer extension. 4. DNA sequencing: Maxam- Gilbert (Chemical) and Sanger-Nicolson (dideoxy/ enzymatic) sequencing method, Pyrosequencing, NGS.	
	Unit Outcomes: UO 1 Proficiently isolate and quantify nucleic acids UO 2 Apply understanding of DNA sequencing methods to analyze DNA sequences effectively	
II	**Tools of Genetic Engineering**	**11**
	1. Nucleases, Restriction endonucleases: Types of restriction endonucleases, classification, and uses. 2. Restriction mapping. DNA modifying enzymes: Polymerases, Phosphatases, and DNA ligases. 3. Prokaryotic host. 4. Plasmid vectors, Bacteriophage, T7 expression vectors, pET vector system. 5. Construction of genomic and cDNA libraries 6. Joining of DNA Fragments to vectors, Homopolymer tailing, cohesive and blunt end ligation, adaptors, and linkers.	
	Unit Outcomes: UO 1 Apply knowledge of restriction endonucleases in molecular biology techniques such as DNA cloning, PCR, and DNA fingerprinting. UO 2 Proficiency in the design and utilization of plasmid vectors, bacteriophages, and T7 expression vectors for gene cloning and expression.	

Unit No.	Title of Unit & Contents	Hrs.
III	**Screening and Selection of Recombinants.**	**12**
	1. Selection, screening, and analysis of recombinants. 2. Principle of hybridization. Northern blotting, Southern blotting, Western blotting. 3. Polymerase chain reaction 4. Restriction fragment length polymorphism, RAPD, AFLP, Map Construction.	
	Unit Outcomes: UO 1 Able to discrimination between recombinant and non-recombinant clones. UO 2 Explain the concept genetic analysis, gene expression studies, and disease diagnosis through precise molecular detection methods	
IV	**Expression of gene in higher organism**	**13**
	1. Vector Engineering and codon optimization, host engineering. 2. Strategies of gene delivery, *in vitro* translation, 3. Expression in bacteria, yeast, insects, and insect cells. Expression in mammalian cells and plant 4. Chromosome engineering, 5. Targeted gene replacement, gene editing, gene regulation & silencing.	
	Unit Outcomes: UO 1 Apply specificity of gene expression through optimized vector design and codon usage. UO 2 Apply advanced knowledge of targeted delivery of genetic material into host cells for various applications such as gene therapy and genetic engineering.	

Learning Resources:

1. Principles of Gene Manipulation, R.N. Old & S.B. Primrose, Blackwell Publishing, 1994
2. From Genes to Clones, E.L. Winnaeker, Wiley VCH, 1987
3. Recombinant DNA, J.D. Watson, J. Witkowski, M. Gilman, & M. Zoller, W.H. Freeman & Co. Ltd., 1992

4. An Introduction to Genetic Engineering, D.S.T. Nicholl, Cambridge University Press, 2008
5. Molecular Biotechnology, J.J. Pasternak, American Society for Microbiology, 1996
6. The Biochemistry of Nucleic Acid, Adam et al., Springer, 1992
7. Genetic Engineering, J.K. Setlow, Springer, 2005
8. Molecular Cloning: A Laboratory Manual, J. Sambrook & D.W. Russell, Cold Spring Harbor Laboratory Press, 2012
9. Principles of Gene Therapy, T. Wirth & N. Parker, Humana Press, 2014
10. Genetic Engineering: Principles and Methods, J.K. Setlow & V.P. Setlow, Springer, 2016

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Course Type: Lab Course
Course Title: Lab Course –IX (Based on MMC-VII)
Course Code: 602BIO3104
Credits: 01 **Max. Marks: 50** **Hours: 30**

Learning Objectives

LO 1 To demonstrate proficiency in isolating nucleic acid
LO 2 To master the technique of endonuclease digestion of nucleic acid
LO 3 To understand the principles and procedures involved in thermal melting of DNA.
LO 4 To acquire skills in isolating plasmid DNA through both mini preparation and large-scale isolation methods.
LO 5 To develop expertise in performing in vitro DNA ligation and transformation of E. coli bacteria.
LO 6 To gain proficiency in DNA blotting techniques and DNA hybridization.
LO 7 To demonstrate competence in isolating cytoplasmic RNA and performing electrophoresis on denaturing gels.
LO 8 To master techniques such as blotting, PCR/RFLP, along with their computational analysis.

Course Outcomes

After completion of the course, the student will be able to-

CO 1 Analyze chromatin structure through determination of mono-nucleosome size and chromatin gel electrophoresis.
CO 2 Gain competence in analyzing DNA fragments following endonuclease digestion through agarose gel electrophoresis.
CO 3 Understand the principles and procedures involved in thermal melting of dna.
CO 4 Gain mastery in isolating plasmid DNA via both mini preparation and large-scale isolation methods.
CO 5 Gain ability to perform in vitro DNA ligation and successfully transform e. Coli bacteria.
CO 6 Adopt skill in employing DNA blotting and hybridization techniques effectively.
CO 7 Become proficient in isolating cytoplasmic RNA and conducting electrophoresis on denaturing gels.
CO 8 Receive competence in various advanced techniques such as northern blotting, nucleic acid sequencing, and PCR/RFLP analysis, including computational analysis and use current biochemical techniques to plan and carry out experiments.

Practical No.	Unit
1.	Isolation of nuclei and analysis of chromatin- i) determination of mono-nucleosome size ii) chromatin gel electrophoresis
2.	Endonuclease digestion of nuclei and analysis of DNA fragments by Agarose gel electrophoresis
3.	Thermal melting of DNA
4.	Isolation of plasmid DNA-i) mini preparation ii) large-scale isolation
5.	*In vitro DNA ligation, transformation of E.coli.*
6.	Techniques: a) DNA blotting technique b) DNA hybridization.
7.	Isolation of cytoplasmic RNA.
8.	Electrophoresis of RNA on denaturing gels.
9.	Northern blotting technique.
10.	Separation of poly A+RNA on oligo-dT column
11.	cDNA synthesis and cloning.
12.	RNA hybridization-dot and northern blots.
13.	In *situ* detection of RNA in embryos/tissue.
14.	*In vitro* translation.
15.	Nucleic acid Sequencing and its computational analysis. 16. PCR/RFLP technique.
16.	Isolation of nuclei and analysis of chromatin- i) determination of mono-nucleosome size ii) chromatin gel electrophoresis
17.	Endonuclease digestion of nuclei and analysis of DNA fragments by Agarose gel electrophoresis
18.	Thermal melting of DNA
19.	Isolation of plasmid DNA-i) mini preparation ii) large-scale isolation
20	*In vitro DNA ligation, transformation of E.coli.*

N.B.: Any Ten Practicals from above.

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Course Type: MMC-VIII
Course Title: Microbial Biotechnology
Course Code: 602BIO3102
Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives

LO 1 To understand the principles of microbial production and its significance in generating biochemicals, pharmaceuticals, and industrial enzymes.
LO 2 To explore the various methods involved in the microbial production of organic acids, solvents, biofuels, and amino acids.
LO 3 To examine the processes and techniques used in the microbial synthesis of vitamins, antibiotics, and recombinant products.
LO 4 To analyze the environmental applications of microbes.
LO 5 To investigate the production, immobilization techniques, and commercial applications of industrial enzymes.
LO 6 To explore biotransformation reactions and their applications in transforming steroids, sterols, and nonsteroid compounds.
LO 7 To evaluate the role of microbial biotechnology in sustainable production processes and its impact on various industries.
LO 8 To critically assess the challenges and advancements in microbial production techniques, considering factors such as yield optimization, substrate utilization, and downstream processing.

Course outcomes

After completion of the course, the student will be able to-

CO 1 Demonstrate a comprehensive understanding of microbial production processes and their applications in generating biochemicals, pharmaceuticals, and industrial enzymes.
CO 2 Acquire practical skills in microbial cultivation, fermentation techniques, and downstream processing necessary for the production of target compounds.
CO 3 Be proficient in analyzing and optimizing microbial production systems to enhance yield, efficiency, and product purity.
CO 4 Gain insights into the environmental implications of microbial biotechnology and its role in waste management, pollution control, and sustainable resource utilization.
CO 5 Develop expertise in biocatalysis and its potential applications in various industries.
CO 6 Equipped with the knowledge and skills required to work in biotechnology, pharmaceuticals, environmental science, and related fields, contributing to research, development, and innovation.

CO 7 Capable of critically evaluating scientific literature, patents, and technological advancements in microbial production, fostering a culture of continuous learning and innovation.

CO 8 Prepared to address contemporary challenges in microbial biotechnology, such as bioprocess optimization, strain engineering, and bioreactor design, contributing to the advancement of the field.

Unit No.	Title of Unit & Contents	Hrs.
I	Microbial Production of Biochemicals	**11**
	1. Organic acids Production: Citric acid, Lactic acid, Acetic acid 2. Solvents and Biofuels: Butanol, Ethanol, Brewing Industry overview 3. Amino acids Production: • Methods of Production • Production of L-Glutamic acid, L Lysine, L-Tryptophan	
	Unit Outcomes: UO 1 Demonstrate a comprehensive understanding of organic acid and amino acid production UO 2 Gain insight into the brewing industry and Proficiency in Solvents and Biofuels	
II	**Microbial Production of Pharmaceuticals**	**10**
	1. Vitamins Production: Vitamin B12, Riboflavin 2. Antibiotics Production: Beta-Lactam Antibiotics (e.g. Penicillin), Carbohydrate Antibiotics (e.g. Streptomycin), Tetracycline, Nucleoside Antibiotics, Aromatic Antibiotics 3. Recombinant Products: • Production of Hepatitis B Vaccine • Insulin Production • Erythropoietin Production	
	Unit Outcomes: UO 1. Get acquainted with production process of vitamins and antibiotics UO 2. Develop expertise in the production of recombinant pharmaceuticals.	
III	**Environmental Applications of Microbes**	**10**
	1. Biomethanation 2. Bioleaching: Mechanism and Examples 3. Biosorption and Microbial Recovery of Petroleum (MEOR) 4. Microbial Polysaccharides: Xanthan and Dextran 5. Production of Biopolymers and Bio-pesticides	
	Unit Outcomes: UO 1. Understand the principles of Biomethanation, Bioleaching and Biosorpion process UO 2. Analyze the applications and environmental benefits of	

Unit No.	Title of Unit & Contents	Hrs.
	biopolymers and bio-pesticides	
IV	**Microbial Enzyme Production and Biotransformation**	**13**
	1. Enzyme Immobilization Techniques 2. Commercial Applications of Microbial Enzymes 3. Production of Key Microbial Enzymes: Amylases, Glucose Isomerase, L-Asparaginase, Proteases, Pectinases and Lipases 4. Biotransformation Reactions 5. Types of Bioconversion Reactions 6. Microbial Transformation of Steroids and Sterols 7. Microbial Transformation of Nonsteroid Compounds: • L-Ascorbic Acid • Prostaglandins • Antibiotics	
	Unit Outcomes: UO 1. Understand the principles and techniques involved in enzyme immobilization and its applications in various industries. UO 2. Analyze the commercial significance of microbial enzymes and their applications in different sectors, such as food, pharmaceuticals, and biotechnology.	

Learning Resources:

1. Industrial Microbiology: An Introduction, Michael J. Waites, Neil L. Morgan, and John S. Rockey, Wiley-Blackwell, 2001.
2. Microbial Production of Biopolymers and Polymer Precursors: Applications and Perspectives" edited by Alane Beatriz Vermelho and Luciana Porto de Souza Vandenberghe, CRC Press, 2020.
3. Biotechnology: A Textbook of Industrial Microbiology, W. Crueger and A. Crueger, Sinauer Associates, 1989.
4. Bioprocess Engineering: Basic Concepts, Shuler, M.L., Kargi, F., Prentice Hall, 2001.
5. Biochemical Engineering Fundamentals, James E. Bailey and David F. Ollis McGraw-Hill Education, 1986.
6. Industrial Biotechnology: Principles and Applications, Christoph Wittmann and James C. Liao, Wiley-VCH, 2016.
7. Industrial Microbiology, 1st Edition, Casida, J.R., L.E., Willey Eastern Ltd, New Delhi, 2006.
8. Industrial Microbiology, 4th Edition, Prescott and Dunn, CBS Publishers, New Delhi, 1987.
9. Principles of Fermentation Technology, Stanbury, P.F., and Whitaker, A., 2nd edition Pergamon Press, Oxford,2005

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10. Biotechnology. U Satyanarayana. Uppala Author Publisher Interlinks, Vijaywada, India,2005.
11. Microbial Technology, Peppler & Perlman. Vol- I, II Academic Press
12. Basic Biotechnology, Bu'Lock J. and Kristansen B. (Eds), Academic Press Inc Ltd, London,1987.
13. Manual of Industrial Microbiology and Biotechnology, Demain A.L., Davies J.E. (Ed in Chief) ASM, 2nd Edition Washington, USA.,1999.
14. Industrial Microbiology, G. Reed, 4th edition, CBS Publishers (AVI Publishing Co.), 2020.
15. Comprehensive Biotechnology, Cooney & Humphery. Vol-3. Pergamon Press, 1987.
16. Text Book of Biotechnology, , H.K Das, 3rd edition, Willey India,2008
17. Industrial Microbiology, A.H Patel, 2nd edition, Macmillan Publication,2011.

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Course Type: Lab Course
Course Title: Lab Course –X (Based on MMC-VIII)
Course Code: 602BIO3105
Credits: 01 **Max. Marks: 50** **Hours: 30**

Learning Objectives

LO 1. To develop practical skills in the production processes of industrial products using microbial biotechnology techniques, including fermentation and cultivation methods.
LO 2. To gain proficiency in quantitative analysis methods for assessing the yield, purity, and activity of microbial biotechnology products.
LO 3. To acquire knowledge and proficiency in isolation techniques for microbial strains and biotechnological products.
LO 4. To understand the principles and applications of purification techniques specific to microbial biotechnology, including chromatography and filtration methods.
LO 5. To learn to optimize upstream processes such as media formulation, inoculum preparation, and bioreactor operation for efficient product synthesis.
LO 6. To enhance understanding of downstream processing techniques for product recovery, purification, and characterization in microbial biotechnology.
LO 7. To develop problem-solving skills by troubleshooting issues encountered during practical exercises and experiments in microbial biotechnology.
LO 8. To foster teamwork and collaboration through group-based laboratory activities, promoting effective communication and cooperation among peers.

Course outcomes

After completion of the course, the student will be able to-

CO 1. Demonstrate competency in executing the production of industrial products using microbial biotechnology techniques, adhering to safety protocols and good laboratory practices.
CO 2. Apply optimization strategies to both upstream and downstream processes, maximizing the yield, quality, and efficiency of microbial biotechnology products.
CO 3. Perform quantitative analysis of microbial biotechnology products accurately, interpreting experimental data and drawing meaningful conclusions.
CO 4. Execute isolation techniques effectively, obtaining pure cultures and biotechnological products suitable for further analysis and application.
CO 5. Implement purification techniques to obtain highly purified microbial biotechnology products, meeting industry standards and regulatory requirements.

CO 6. Successfully troubleshoot challenges encountered during production, isolation, and purification processes, demonstrating problem-solving abilities.

CO 7. Collaborate effectively with peers in laboratory settings, contributing to a positive and productive learning environment.

CO 8. Demonstrate proficiency in documenting experimental procedures, results, and observations accurately and systematically, adhering to scientific principles and protocols in microbial biotechnology research and practice.

Practical No.	Unit
1	Production of sauerkraut by Microorganisms
2	Production and quantitation of Antibiotics
3	Production and estimation of lactic acid by Lactobacillus Sp.
4	Production of fermented milk by Lactobacillus acidophilus.
5	Comparison of ethanol production using various Organic wastes /raw Material
6	Laboratory scale production of biofertilizers
7	Production and estimation of Bacterial Lipase
8	Production and Estimation of Bacterial and Fungal Amylase
9	Production and estimation of alkaline protease from bacterial source
10	Produce bioplastics (e.g., polyhydroxyalkanoates) using microbial fermentation of renewable feedstocks and characterize the properties of the bioplastics.
11	Evaluate the ability of microorganisms to degrade environmental pollutants (e.g., hydrocarbons, heavy metals) using batch or continuous bioreactor systems
12	Production and isolation of bacterial exo-polysaccharides
13	Perform quality control tests on microbial products (e.g., antibiotics, enzymes) including microbial enumeration, purity testing, and potency assays
14	Visit to Fermentation Industry

N.B.: Any Ten Practicals from above.

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Course Type: MMC IX
Course Title: Plant and Agricultural Biotechnology
Course Code: 602BIO3103
Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives

LO 1. To understand the advancements in the field of biotechnology with respect to plants.
LO 2. To follow modern techniques and their applications in crop improvements, such as tissue culture, plant breeding, and transgenics.
LO 3. To understand the modern trends in plant & agricultural biotechnology.
LO 4. To understand pathological aspects of plant disease.
LO 5. Analyze the applications of plant biotechnology in crop improvement, such as disease resistance, herbicide tolerance, and improved nutritional content.
LO 6. Apply molecular biology tools and techniques for plant genetic analysis and manipulation.
LO 7. Analyze the applications of plant biotechnology in crop improvement, such as disease resistance, herbicide tolerance, and improved nutritional content.
LO 8. Evaluate the ethical, social, and environmental implications of genetically modified crops and biotechnological interventions in agriculture.

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Course outcomes

After completion of the course, the student will be able to-

CO 1 Analyze the origins of cultivated plants and the concept of vavilov's centres of origin in plant diversity.
CO 2 Explore the functions and importance of botanical gardens and herbaria in plant research, conservation, and education.
CO 3 Understand the molecular basis of infection and disease resistance/defense mechanisms in plants.
CO 4 Evaluate the physiological aspects of parasitism in plants and examine control measures, including the use of fungicides and other management strategies.
CO 5 Understand the processes involved in the development of male and female gametophytes in plants and their significance in sexual reproduction
CO 6 Explore the formation of somatic hybrids and cybrids and their potential applications in crop improvement and genetic manipulation.

CO 7 Understand the principles and techniques involved in plant breeding, including introduction, selection, and hybridization methods such as pedigree, backcross, mass selection, and bulk method

CO 8 Discuss the development of transgenic crops, their benefits, and the biosafety aspects associated with their cultivation and consumption.

Unit No.	Title of Unit & Contents	Hrs.
I	**Plant Resource Development**	**10**
	1. Domestication and introduction of plants. 2. Origin of cultivated plants, Vavilov's centres of origin. 3. Plants as sources for food, fodder, fibres, spices, beverages, edible oils, drugs, narcotics, insecticides, timber, gums, resins, and dyes; 4. latex, cellulose, starch, and its products; 5. Energy plantations; 6. Botanical Gardens and Herbaria	
	Unit Outcomes: UO 1. Analyze the origins of cultivated plants and the concept of Vavilov's centres of origin in plant diversity. UO 2. Explore the functions and importance of botanical gardens and herbaria in plant research, conservation, and education.	
II	**Plant Pathology**	**10**
	1. crop diseases caused by viruses, bacteria, mycoplasma, fungi, and nematodes; 2. Modes of infection and dissemination; Molecular basis of infection and disease resistance/ defense; 3. Physiology of parasitism and control measures. Fungal toxins. 4. Modelling and disease forecasting; 5. Plant quarantine.	

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Unit No.	Title of Unit & Contents	Hrs.
	Unit Outcomes: UO 1. Understand the molecular basis of infection and disease resistance/defense mechanisms in plants. UO 2. Evaluate the physiological aspects of parasitism in plants and examine control measures, including the use of fungicides and other management strategies.	
III	**Plant Biotechnology**	**12**
	1. Development of male and female gametophytes. 2. Endosperm—its development and function. 3. Patterns of embryo development; Polyembryony, apomixis; 4. Pollen haploids, 5. embryo rescue methods and their applications. 6. Protoplast culture. 7. Somatic hybrids and Cybrids; 8. Micropropagation; Somaclonal variation and its applications	
	Unit Outcomes: UO 1 Understand the processes involved in the development of male and female gametophytes in plants and their significance in sexual reproduction UO 2 Explore the formation of somatic hybrids and cybrids and their potential applications in crop improvement and genetic manipulation.	
IV	**Agricultural Biotechnology**	**13**
	1. Methods of plant breeding— introduction, selection and hybridization (pedigree, backcross, mass selection, bulk method); 2. Mutation, polyploidy, male sterility, and heterosis breeding. 3. Use of apomixis in plant breeding 4. Genetic engineering—methods of transfer of genes; 5. Transgenic crops and biosafety aspects;	

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Unit No.	Title of Unit & Contents	Hrs.
	6. Development and use of molecular markers in plant breeding;	
	Unit Outcomes: UO 1. Understand the principles and techniques involved in plant breeding, including introduction, selection, and hybridization methods such as pedigree, backcross, mass selection, and bulk method UO 2. Discuss the development of transgenic crops, their benefits, and the biosafety aspects associated with their cultivation and consumption.	

Learning Resources:

1. Biotechnology and Genomics, P.K. Gupta, Rastogi Publications, Meerut, India, 2004
2. Transgenic Plants: A Production System for Industrial and Pharmaceutical Proteins, M.R.L. Owen & J. Pen (Eds), John Wiley & Sons, England, 1996
3. Agricultural Biotechnology, S.S. Purohit, Agro Botanica, India, 1999
4. Plant Cell Biotechnology, R. Endress, Springer Verlag, Germany, 1994
5. Textbook of Modern Plant Pathology, K.S. Bilgrami & H.G. Dube, Vikas Publications, New Delhi, 1994
6. Genetics and Biotechnology in Crop Improvement, P.K. Gupta, Rastogi Publications, Meerut, 1998
7. Fundamentals of Plant Pathology, V.N. Pathak, N.K. Khatri, & M. Pathak, Agrobotanical Publications, Bikaner, 1996
8. General Microbiology, Vol. II, C.B. Powar & H.F. Daginawala, Himalaya Publishing House, Mumbai, 1990
9. Agricultural Biotechnology, S.S. Purohit, Agrobios India, Jodhpur, 2002
10. Biotechnology, U. Satyanarayana, Books and Allied Pvt. Ltd., Kolkata, 2007
11. Biofertilizer and Organic Farming, S.C. Vyas, S. Vyas, S. Vyas, & H.A. Modi, Akta Prakashan, Nadiad, G.S., Meerut, 1998
12. Experiments in Microbiology, Plant Pathology, Tissue Culture and Mushroom Cultivation, S.C. Vyas, S. Vyas, S. Vyas, & H.A. Modi, Vishwa Prakashan, New Age International (p) Ltd., New Delhi, 1998
13. Microbiology and Biotechnology: A Laboratory Manual, P.T. Kalaichelvan & P.C. Dandiya, MJP Publishers, Chennai, 2004
14. Laboratory Manual of Plant Biotechnology, S.S. Purohit & K.R. Aneja, Agrobotonical Pub. India, 1995

15. Methods in Biotechnology, Hans Peter Schmauder, Taylor and Francis, London, 1997
16. Methods in Plant Molecular Biology, 1st edition, M.A. Schuler & R.E. Zielinski, Academic Press, 1989
17. Methods in Biotechnology and Bioengineering, S.P. Vyas & D.V. Kohli, CBS Publishers and Distributors, New Delhi, 2002

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Course Type: Lab Course
Course Title: Lab Course –XI (Based on MMC IX)
Course Code: 602BIO3106
Credits: 01 **Max. Marks: 50** **Hours: 3**

Learning Objectives

LO 1 Acquire proficiency in aseptic techniques essential for maintaining sterile conditions in plant tissue culture laboratories, ensuring contamination-free cultures and reliable experimental outcomes.

LO 2 Develop competence in preparing culture media tailored to specific plant tissue culture requirements, understanding the importance of nutrient composition and pH in supporting plant growth and development.

LO 3 Gain insight into the principles and techniques of micropropagation, mastering the skills necessary for mass production of genetically uniform plants from a small explant, facilitating rapid multiplication of elite plant varieties.

LO 4 Acquire skills in isolating bacterial and fungal plant pathogens from diseased plant tissues, enhancing knowledge of plant pathology and disease management strategies.

LO 5 Understand the impact of different culture media formulations on plant growth and development, exploring the role of nutrients, hormones, and growth regulators in influencing plant physiology.

LO 6 Engage in plant breeding experiments to study genetic variability, heritability, and trait inheritance patterns, fostering an understanding of plant breeding principles and techniques for crop improvement.

LO 7 Develop proficiency in identifying bacterial, fungal, and viral plant diseases through morphological, physiological, and molecular techniques, enabling accurate disease diagnosis and management.

LO 8 Enhance observational and analytical skills through visits to botanical gardens, gaining firsthand exposure to diverse plant species, habitats, and conservation efforts.

Course outcomes

After completion of the course, the student will be able to-

CO 1 Demonstrate proficiency in managing plant tissue culture laboratories, adhering to strict aseptic protocols and safety measures to ensure successful culture establishment and maintenance.

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CO 2 Formulate culture media suitable for various stages of plant tissue culture, optimizing nutrient concentrations and hormonal balances to support desired growth and development patterns.

CO 3 Master micropropagation techniques, capable of efficiently propagating plants on a large scale for commercial and research purposes, contributing to crop production and genetic conservation efforts.

CO 4 Develop skills in isolating and identifying bacterial, fungal, and viral plant pathogens, enabling accurate disease diagnosis and the development of effective disease management strategies.

CO 5 Critically analyze experimental data from plant breeding experiments and disease identification assays, drawing conclusions and making recommendations based on scientific evidence.

CO 6 Integrate theoretical knowledge with practical skills acquired through hands-on experiments and field visits, enhancing their understanding of agricultural and plant biotechnology concepts.

CO 7 Recognize the importance of ethical considerations and sustainability in agricultural biotechnology, applying principles of responsible research conduct and environmental stewardship in their work.

CO 8 Develop communication skills to effectively communicate scientific findings and collaborate with peers and professionals in the field of agricultural and plant biotechnology, fostering interdisciplinary teamwork and knowledge exchange.

Practical No.	Unit
1	Plant tissue culture laboratory design
2	Aseptic techniques
3	Media preparation
4	Micro propagation
5	Anther culture
6	Isolation of bacterial plant pathogens
7	Isolation of fungal plant pathogens
8	Effect of media on plant growth
9	Plant breeding experiments.
10	Visit botanical gardens.
11	Plant DNA isolation
12	Protoplast isolation
13	Synthetic seed preparation
14	Identification of bacterial diseases.
15	Identification of fungal diseases.
16	Identification of viral diseases.
17	Seed culture

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18	Embryo Culture

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Course Type: MEC-III (A)
Course Title: Advanced Pharmaceutical Biotechnology
Course Code: 602BIO3201
Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives

LO 1. Understand the principles of chemotherapy and the mechanisms of action of antimicrobial agents.
LO 2. Identify and analyze the various mechanisms of microbial resistance to antibiotics and antimicrobial agents.
LO 3. Classify antibiotics based on their chemical structures and mechanisms of action, with examples illustrating their therapeutic applications.
LO 4. Describe the general characteristics of secondary metabolites, categorizing them based on their types and highlighting their medicinal applications.
LO 5. Explain the structure, mechanism of action, and therapeutic applications of antibacterial, antifungal, antiviral, and anticancer drugs.
LO 6. Evaluate drug discovery and development processes, including historical perspectives, molecular biology techniques, and combinatorial drug discovery approaches.
LO 7. Discuss the principles of rational drug design and drug targeting, exploring strategies to optimize drug efficacy and minimize adverse effects.
LO 8. Analyze the stability of drugs, pharmacokinetic and pharmacodynamic properties.

Course outcomes

After completion of the course, the student will be able to-

CO 1. Develop proficiency in identifying and selecting appropriate chemotherapeutic agents for the treatment of infectious diseases.
CO 2. Apply knowledge of antibiotic classification and mechanisms of action in clinical decision-making, ensuring optimal patient care and antimicrobial stewardship.
CO 3. Demonstrate an understanding of drug discovery and development processes.
CO 4. Acquire skills in evaluating the efficacy, safety, and stability of drugs through preclinical and clinical trials.
CO 5. Interpret the results of preclinical toxicity testing, including acute, sub-acute, and chronic toxicity studies.
CO 6. Demonstrate knowledge of biosimilar technology and its implications in pharmaceutical development and regulatory approval processes.

CO 7. Familiarize with Indian, international pharmacopoeias, and global regulatory guidelines, ensuring compliance with quality standards and regulatory requirements in drug manufacturing and marketing.

CO 8. Critically analyze clinical trial phases and their significance in drug development, recognizing the ethical and regulatory considerations involved in human experimentation and patient safety.

Unit No.	Title of Unit & Contents	Hrs.
I	**Chemotherapeutic Agents and Antibiotics**	**10**
	1. Chemotherapy Antimicrobial Drug. Mechanism of action of antimicrobial agents. 2. Microbial Resistance to antibiotics and antimicrobial agents (Types and Mechanism). 3. Types of Antibiotics: Classification of antibiotics with example. 4. General characteristics of an Secondary Metabolites: Types and Medicinal Applications	
	Unit Outcomes: UO 1. Demonstrate a comprehensive understanding of chemotherapeutic agents and antibiotics in the management of infectious diseases. UO 2. Identifying different types of resistance and understanding the implications of resistance in clinical practice and public health	
II	**Antibacterial, Antifungal and Antiviral Drugs**	**10**
	1. Chemotherapeutics Agents Structure, Mechanism of Action and Applications of Antibacterial drug: Sulfonamides, Quinolones. 2. Antiviral drug: Amantadine, Azidothymidine. 3. Antifungal drug: Nystatin, Griseofulvin.Mechanism of action of 4. Anticancer drugs, Drugs acting on CNS, Insulin, Blood factor VIII.	
	Unit Outcomes: UO 1 Understanding the structure, mechanism of action, and therapeutic applications of specific antibacterial, antifungal, and antiviral drugs. UO 2 Develop critical thinking skills to assess the potential benefits and limitations of different antibacterial, antifungal, and antiviral drugs.	
III	**Drug Discovery, Development and Targetting**	**13**

Unit No.	Title of Unit & Contents	Hrs.
	1. Discovery and Development of drug, History, drug targeting, Molecular Biology and Combinatorial drug discovery, Rational Drug designing. 2. Stability of Drug, 3. Pharmacokinetics, Pharmacodynamics. 4. Drug delivery systems, Liposomes.	
	Unit Outcomes: UO 1. Grasp the principles of drug discovery, development, and targeting to the design and optimization of novel therapeutic agents. UO 2. Adept at applying molecular biology techniques and rational drug design approaches to expedite the development of targeted drugs.	
IV	**Clinical Trials, Regulatory Guidelines and Pharmacopoeia**	**12**
	1. Clinical Trials Phases of Clinical trials of drugs, Preclinical drug evaluation of its biological activity, potency and toxicity- 2. Toxicity test in animals including acute, sub-acute and chronic toxicity, ED50 and LD50 determination, special toxicity test like teratogenecity and mutagenecity. 3. Biosimilar Technology, Introduction to Indian, 4. International Pharmacopoeia and global regulatory guidelines	
	Unit Outcomes: UO 1. Gain a comprehensive understanding of the various phases of clinical trials, enabling them to design and implement clinical research studies. UO 2. Develop proficiency in navigating regulatory frameworks and pharmacopoeia standards, ensuring adherence to quality control measures and ethical considerations in pharmaceutical development and marketing.	

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Learning Resources:

1. Pharmaceutical Microbiology, W. B. Hugo & A. D. Russell, Wiley India, 2021
2. Pharmacology and Pharmacobiotechnology, Ashutosh Kar, New Age, 2017
3. Essentials of Pharmaceuticals, FSK Barar, S.Chand, 2000
4. Molecular Biotechnology, B. Glick & J. Pasernak, ASM Press, 2020
5. Drug Designing, Doble, McGraw Hill, 2011
6. Pharmaceutical Biotechnology, S.P. Vyas & Dixit, CBS, 2007
7. Medicinal Chemistry, B. Razdan, CBS, 2018
8. Pharmacology and Pharmacotherapeutics, Satoskar & Bhandarkar, Popular, 2020
9. Pharmaceutical Biotechnology, Purohit & Saluja, Student Edition, 2003
10. Biotechnology: Secondary Metabolites, K.G. Ramawat & J.M. Merillon, Oxford, 2011
11. Chemistry of Natural Products, R.H. Thomson (Ed.), Springer, 1993
12. Biopharmaceuticals, S.N. Jogdand, Himalaya Publishing, 2006

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Course Type: Lab Course
Course Title: Lab Course XII (Based on MEC -III (A))
Course Code: 602BIO3203
Credits: 01 **Max. Marks: 50** **Hours: 30**

Learning Objectives

LO 1. Understand the principles and techniques involved in biological assay for estimating penicillin/streptomycin.
LO 2. Gain proficiency in chemical assay methods including titration and spectrophotometric techniques, and interpretation of analytical data.
LO 3. Learn the procedures for assessing the antimicrobial activity of antibiotics through agar diffusion or broth dilution methods.
LO 4. Develop skills in determining the Minimum Inhibitory Concentration (MIC) of antibiotics against specific microbial strains using broth dilution or agar dilution methods.
LO 5. Acquire knowledge and techniques for determining the shelf life of antibiotics.
LO 6. Gain practical experience in conducting sterility testing of commercial pharmaceutical products.

Course outcomes

After completion of the course, the student will be able to-

CO 1. Demonstrate proficiency in performing biological and chemical assays for the estimation antibiotics.
CO 2. Interpret MIC data accurately to guide clinical treatment decisions and optimize antibiotic dosing regimens for effective microbial control.
CO 3. Evaluate the shelf life of antibiotics based on stability studies, ensuring product integrity and compliance with regulatory standards for pharmaceutical products.
CO 4. Demonstrate competence in conducting sterility testing of pharmaceuticals, adhering to regulatory guidelines and ensuring product safety and efficacy.
CO 5. Gain insights into pharmacopeial standards and global regulatory guidelines in the pharmaceutical industry, understanding their importance in ensuring product quality, safety, and efficacy.

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Practical No.	Unit
1	Estimation of penicillin/streptomycin by biological assay.
2	Estimation of penicillin/streptomycin by chemical assay.
3	Determination of Minimum Inhibitory Concentration (MIC) of Antibiotic
4	Determination of shelf life of antibiotics (Expired drugs)
5	Sterility testing of commercial pharmaceuticals.
6	Study of microbial spoilage of pharmaceuticals.
7	Sterility testing of injectable as per IP.
8	Effect of chemical disinfectant on growth of bacteria
9	Study of Pharmacopeia and global regulatory guidelines in pharma industry
10	Study of dug action by using Zebra fish (Danio rerio) as model organism
11	Visit to Pharmaceutical industry

N.B.: Any Ten Practicals from above.

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Course Type: MEC I (B)
Course Title: Enzyme Technology and Protein Engineering
Course Code: 602BIO3202
Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives

LO 1 To study the concept of classification of enzymes.

LO 2 To understand the role of enzymes in various sectors.

LO 3 To acquaint the knowledge about role of entropy in catalysis.

LO 4 To study the concept of allosteric enzymes with their applications.

LO 5 To study Enzyme Kinetics.

LO 6 To know the stabilization of biphasic aqueous-organic systems.

LO 7 To understand the kinetics of Immobilization & Protein Engineering.

LO 8 To learn the concept of Recombinant proteins.

Course Outcomes

After completion of the course, the student will be able to-

CO 1. Describe structure, functions and the mechanisms of action of enzymes.

CO 2. Learn kinetics of enzyme catalyzed reactions and enzyme inhibitory.

CO 3. Perform immobilization of enzymes.

CO 4. Get exposure of wide applications of enzymes and their future potential.

CO 5. Acquire knowledge of significance of vmax and km.

CO 6. Acquaint the knowledge of turnover number and end point kinetic assay.

CO 7. Gain the knowledge about enzyme kinetics in biphasic liquid systems.

CO 8. Understand the concept of biosensors.

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Unit No.	Title of Unit & Contents	Hrs.
I	**Introduction To Enzymes & Enzyme Kinetics**	**12**
	1. The Enzyme-Introduction, 2. Nomenclature of enzymes, 3. Classification of enzymes, 4. Applications in Industrial, Medical, Analytical, Chemical, Pharmaceutical and Food Sectors.	
	Unit Outcomes: UO 1 Describe the nomenclature of enzymes. UO 2 Discuss the Applications of enzymes in Industrial and Medical field.	
II	**Enzyme Kinetics**	**10**
	1. Michaelis - Menten equation, Brigg's- Haldane equation, 2. Graphical procedures in enzymology 3. Advantages and disadvantages of alternate plotting, 4. Estimation of constants using graphical technique, Kinetics for reversible reactions, basics of enzymatic reaction, 5. Collision theory and transition state theory 6. Role of entropy in catalysis, presteady state kinetics, 7. Significance of Vmax and Km, 8. Kinetics of multi- substrate reactions, 9. Allosteric enzymes – The Monad – Changeux – Wyman model (MCW) and The Koshland – Nemethy – Filmer (KNF) model, 10. Enzyme inhibition - types of inhibitors- Mode of action and experimental determination. 11. Enzyme activity, international units, specific activity, turnover number, end point kinetic assay.	
	Unit Outcomes: UO 1 Explain the advantages and disadvantages of alternate plotting.	

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Unit No.	Title of Unit & Contents	Hrs.
	UO 2 Discuss the concept of enzyme inhibition and their classification.	
III	**Effect of Physical Factors & Enzyme Kinetics in Biphatic Reaction**	**10**
	1. Temperature dependence of rate constants of enzymatic reaction, 2. Thermal deactivation, pH 3. Effect on rate constants and protein structure. 4. pH dependence: ionization of Acids and Bases. 5. Enzyme kinetics in biphasic liquid systems, 6. Stabilization of biphasic aqueous-organic systems, 7. Equilibria in biphasic aqueous- organic systems.	
	Unit Outcomes: UO 1. Understand the concept of enzyme kinetics in biphasic liquid systems. UO 2. Explain the concept of temperature dependence of rate constants of enzymatic reaction.	
IV	**Enzyme Immobilization, Kinetics of Immobilization & Protein Engineering**	**13**
	1. Immobilization of Biocatalysts an Introduction, 2. Electrostatic Effect, effect of charged and uncharged support, Kinetics of immobilized enzymes 3. Effect of external and internal mass transfer, 4. Damkohler number, effectiveness factor, Intraparticle diffusion kinetics, Biot number. 5. Biosensors - glucose oxidase, cholesterol oxidase, urease and antibodies as biosensors, 6. Introduction to protein engineering, 7. Structure prediction sequence structure relationship. 8. Recombinant proteins using fusion protein strategies for enhanced recovery,	

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Unit No.	Title of Unit & Contents	Hrs.
	7. Engineering protein for the affinity purification, (engineering of streptavidin) 8. Stabilization of enzymes by protein engineering (e.g. pseudomonas isoamylase)	
	Unit Outcomes: UO 1 Explain the concept of protein engineering. UO 2 Understand the concept of stabilization of enzymes by protein engineering.	

Learning Resources:

1. Biochemical Engineering Fundamentals, Bailey JE, Ollis, DF, McGraw Hill Education, 2nd edition, 2017.
2. Biochemical Engineering, Marcel Decker Blanch HW and Clark DS, University of California, 1995.
3. Bioreaction Engineering, modeling and control, Schugerl K., Bellgart KH (Eds): Springer-Verlag, Berlin, 2000.
4. Enzymes, palmer, East west publication, 2008.
5. Handbook of Enzyme Biotechnology, 3rd Edition, Wiseman, A: Ellis Horwood Publication, 1995.
6. Bioprocess technology, kinetics and reactors, Moser, A: Springer Verlag, 2011.
7. Biochemical Engineering Principles and functions, Syed Trnveer Ahmed Inamdar, PHI Learning Private limited, 2012.
8. Protein and enzyme engineering, Saurabh Bhatia, IOP Publishing Ltd, 2018.
9. Protein Engineering: Tools and Applications, Huimin Zhao, WILEY-VCH GmbH, 2021.
10. Enzyme Technology, Ashok Pandey, Springer Science & Business Media, 2006.

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Course Type: Lab Course
Course Title: Lab Course –XII (Based on MEC-III (B)
Course Code: 602BIO3203
Credits: 01 **Max. Marks: 50** **Hours: 30**

Learning Objectives

LO 1 To provide hands on isolation of high yielding microbial strains for the commercially important enzyme production.

LO 2 To train students for standardizing medium composition for enzyme production.

LO 3 To introduce students for the development of enzyme assay methods.

LO 4 To provide hands on gel filtration method for determination of molecular weight.

LO 5 To determine enzyme activity and specific activity.

LO 6 To make understand to analyse the method of checking the purity of the enzymes by using SDS-PAGE.

Course Outcomes

After completion of the course, the student will be able to-

CO 1 Learn the kinetics of enzyme catalyzed reactions and enzyme inhibitory and regulatory process.

CO 2 Perform immobilization of enzymes.

CO 3 Get exposure of wide applications of enzymes and their future potential

CO 4 Carry out enzyme isolation and purification protocols.

Practical No.	Unit
1.	Isolation of high yielding microbial strains for the production of commercially important enzymes.
2.	Production of commercially important enzymes from microbial sources.
3.	Standardization of medium composition for the optimum production of enzymes.
4.	Determination of enzyme activity and specific activity.

5.	Partial purification of isolated enzymes.
6.	Characterization of enzymes-Effect of pH, temperature, and inhibitors on enzyme activity etc.
7.	Molecular weight determination of enzyme by Gel filtration method.
8.	Method of checking the purity of the enzyme -SDS-PAGE
9.	Immobilization of enzymes –Different Techniques such as adsorption, entrapment, encapsulation and cross- linking.
10.	Strain improvement techniques- physical, chemical and genetic manipulation methods.
11.	Development of enzyme assay methods
12.	Formulation of enzyme stability.

N.B.: Any Ten Practicals from above.

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Semester - Fourth

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Department of Biotechnology

Course Type: MMC- X

Course Title: Animal and Livestock Biotechnology

Course Code: 602BIO4101

Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives:

LO 1 To Understand the basic principles of cell culture, including cell types, growth requirements, and culture techniques.

LO 2 To Learn and practice sterile techniques necessary for cell culture to prevent contamination and maintain cell health.

LO 3 To Understand the composition of cell culture media and learn to prepare different types of media suitable for specific cell types.

LO 4 To Learn to operate and maintain cell culture equipment such as incubators, biosafety cabinets, and microscopes.

LO 5 To Development of affordable new generation vaccines and diagnostics against major diseases of livestock, dogs and poultry

LO 6 To Study assisted reproductive technologies (ARTs) like artificial insemination, in vitro fertilization (IVF), and cloning, and their applications in animal breeding and conservation.

LO 7 To Learn about techniques such as gene cloning, PCR, DNA sequencing, and gene editing (e.g., CRISPR/Cas9) and their applications in animals.

LO 8 To Genome analysis and genetic characterization of indigenous livestock breeds

Course Outcomes:

After completion of the course, the student will be able to-

CO 1 Acquire a solid understanding of the principles and techniques of animal cell culture, including cell biology, sterile technique, and culture maintenance.

CO 2 Develop proficiency in a variety of cell culture techniques, including cell line establishment, maintenance, and manipulation, as well as cell counting and viability assessment.

CO 3 Learn to design and execute cell culture experiments, including the selection of appropriate cell lines, culture conditions, and assays.

CO 4 Understand and practice safe laboratory techniques, including proper handling and disposal of hazardous materials.

CO 5 Gain knowledge about the genetics of livestock species, including breeding strategies, genetic diversity, and the role of genomics in livestock improvement.

CO 6 Learn and practice biotechnological techniques used in livestock research and production, such as gene editing, cloning, and transgenic animal production.

CO 7 Understand assisted reproductive technologies (arts) used in livestock breeding, including artificial insemination, embryo transfer, and in vitro fertilization.

CO 8 Learn how biotechnology can improve livestock production efficiency, including traits related to growth rate, feed efficiency, and environmental adaptation.

Unit No.		Hrs.
I	**Basics of Animal Cell Culture**	**12**
	1. Introduction to Animal Cell Culture, Planning and Layout of animal tissue culture laboratory. 2. Cell Culture Media and Reagents: Types, Growth supplements, serum free media, balanced salt solution, other cell culture reagents. 3. Tissue Culture Techniques: Primary and secondary culture, continuous cell lines, suspension culture, Tissue Specific Culture and organ culture. 4. Behaviour of cells in culture conditions, their growth pattern, cell metabolism, estimation of cell number. 5. Cell Line Development and Maintenance.: Establishment, Characterization, Maintenance and Contamination Control	
	Unit Outcomes: UO 1. To understand basics of animal cell culture including laboratory setup. UO 2. To understand the process of media preparation, cell handing, cell characterization and contaminants in animal cell culture.	
II	**Scale-Up and Commercial Applications of Animal Biotechnology**	**10**

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Unit No.		Hrs.
	1. Cell culture reactors; Scale-Cell Culture Reactors and Scale-Up Techniques. 2. Advanced Bioreactor Systems: Rotating chambers, Perfused suspension cultures, Fluidized bed reactors and their role in suspension culture, Scale-up in monolayers. 3. Multi Surface propagators Multiarray disks, spirals and tubes, Roller culture; Microcarriers, Perfused monolayer cultures; Membrane perfusion. 4. Hollow fiber perfusion; Matrix perfusion; Microencapsulation, Growth monitoring 5. Transfection and transformation of cells; Commercial scale production of animal cells, Application of animal cell culture for in vitro testing of drugs. 6. Testing of toxicity of environmental pollutants in cell culture; Application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins.	
	Unit Outcomes: UO 1. To understand industrial level applications of cell culture and related processes in culturing cells. UO 2. To understand applications of animal tissue culture in industry and human welfare.	
III	**Molecular Techniques and Applications in Livestock Biotechnology**	**10**
	1. Genome organization of any suitable Livestock with example 2. Physical and genetic map, current status of genome maps of livestock. 3. Marker Assisted Selection (MAS), Polymerase Chain Reaction (PCR), its types and applications. 4. Molecular markers and its applications - RFLP, RAPD, AFLP, Microsatellite/ Minisatellite markers, SNP markers. 5. DNA fingerprinting. DNA sequencing, Genome sequencing, Genomic Library, Genomics database of Livestock. gene editing (e.g., CRISPR/Cas9)	
	Unit Outcomes: UO 1 To understand the concept of marker assisted selection in Livestock biotechnology. UO 2 To understand molecular marker study and its applications in research.	

Unit No.		Hrs.
IV	**Breeding Techniques and Transgenic Technology in Livestock**	13
	1. History of development of important breeds of dairy cattle. 2. Methods of cross breeding and its types, assisted reproductive technologies (ARTs) like artificial insemination, in vitro fertilization (IVF), and cloning, and their applications in animal breeding and conservation 3. milk quality and production efficiency, Transgenesis and methods of gene transfer in animals. 4. Statistical techniques for analyzing molecular genetic data, Quantitative Trait Loci (QTL) mapping and its application in animal breeding 5. Genome scan, Candidate gene approach, Genomic selection in livestock, Applications of transgenic technology in livestock improvement and molecular biopharming.	
	Unit Outcomes: UO 1. To understand livestock breeding and its quality improvement by the application of biotechnology. UO 2. To understand QTL mapping and its applications in livestock biotechnology.	

Learning Resources:

1. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, Freshney, R. Ian, Wiley-Blackwell, Seventh Edition, 2016.
2. Animal Cell Culture and Technology, Butler, M., & Griffiths, B, Taylor & Francis, Second Edition, 2004.
3. Basic Cell Culture Protocols, Helgason, C., & Miller, C., Springer, Fourth Edition, 2013.
4. Principles of Tissue Engineering, Lanza, R., Langer, R., & Vacanti, J., Academic Press, Fourth Edition, 2013.

5. Animal Cell Biotechnology: Methods and Protocols, Pörtner, R., & Zeng, A. P., Humana Press, Third Edition, 2007.
6. Livestock Biotechnology: Breeding, Genetics, and Genomics, Abdullah, M., & Salim, H. M., Springer, Second Edition, 2020.
7. Biotechnology in Animal Husbandry, Pandey, A. K., & Singh, R. K., Daya Publishing House, First Edition, 2016.
8. Livestock Production and Biotechnology, Cai, Y., Nova Science Publishers, First Edition, 2017.
9. Applications of Biotechnology in Animal Health and Production, Maqbool, A., & Singh, S. P., Springer, First Edition, 2019.
10. Animal Biotechnology: Models in Discovery and Translation, Bhan, S., & Singh, S., CRC Press, First Edition, 2018.

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Course Type: Lab Course
Course Title: Lab Course-XIII (Based on MMC-X)
Course Code: 602BIO4104
Credits: 01 **Max. Marks: 50** **Hours:30**

Learning Objectives

LO 1 To master sterile techniques for handling cells and media to prevent contamination and maintain cell viability.

LO 2 To Learn to prepare cell culture media with the appropriate nutrients and supplements for different cell types.

LO 3 To Practice techniques for passaging and sub-culturing cells to maintain healthy cultures and promote cell growth.

LO 4 To Understand the principles and theory behind MAS, including the role of genetic markers in livestock breeding.

LO 5 To Become proficient in genotyping techniques used for molecular marker analysis, such as PCR, DNA sequencing, and genotyping arrays.

LO 6 To Learn to analyze molecular marker data, including marker-trait association analysis and genomic selection.

Course Outcomes

After completion of the course, the student will be able to-

CO 1 demonstrate proficiency in maintaining sterility during cell culture procedures to prevent contamination.

CO 2 Prepare cell culture media with the appropriate components and concentrations for specific cell types.

CO 3 Successfully maintain animal cell cultures, including regular passaging and subculturing, to promote cell growth and viability.

CO 4 ability to select appropriate molecular markers (e.g., SNPs, microsatellites) for MAS based on their linkage to traits of interest in specific livestock species.

CO 5 Proficiency in genotyping techniques used for molecular marker analysis, such as PCR, DNA sequencing, and genotyping arrays.

CO 6 ability to analyze molecular marker data, including marker-trait association analysis and genomic selection, using statistical software.

Practical No.	Unit
1	Packing and sterilization of glass and plastic wares for cell culture.
2	Preparation of reagents and media for cell culture.
3	Primary culture technique for chicken embryo fibroblast.
4	Secondary culture of chicken embryo fibroblast.
5	Cultivation of continuous cell lines.
6	Quantification of cells by trepan blue exclusion dye.
7	Isolation of lymphocytes and cultivation of lymphocytes
8	Study of effect of toxic chemicals on cultured mammalian cells
9	Study of effect of virus on mammalian cells.
10	Suspension culture technique
11	Cryopreservation of cell primary cultures and cell lines
12	Practicals based on genomic databases of livestock and its analysis.
13	A study of molecular markers by using RFLP and AFLP.

N.B.: Any Ten Practicals from above.

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Course Type: MMC XI

Course Title: Clinical Research, IPR, Bio-entrepreneurship and Start Up

Course Code: 602BIO4102

Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives:

LO 1. To develop experts or skilled professionals to handle large clinical data procedure with correct guidelines
LO 2. To acquire a basic understanding of the concepts and practices of clinical trials in pharmaceutical industry.
LO 3. To enable students to understand issues surrounding the risks and benefits of drugs.
LO 4. To encourage the students for start up development.
LO 5. To understand the basic cconcepts of pharmacology.
LO 6. To get the knowledge about toxicology studies.
LO 7. To learn about the basic concepts of IPR.
LO 8. To understand the process of data management and safety monitoring in clinical trials.

Course Outcomes:

After completion of course the student will be able to-
CO 1. Extend understanding good manufacturing practices and good clinical practices.
Co 2. Understand the principles of good laboratory practices.
Co 3. Know the new drug development process.
Co 4. Conduct the clinical trials of nascent drugs.
Co 5. Know safety monitoring and reporting in clinical trials.
Co 6. Understand the regulatory and ethical requirements in clinical research.
Co 7. Conduct the clinical trials of nascent drugs.
Co 8. Acquire the knowledge about stages of pharmacokinetics and pharmacodynamics.

Unit No.	Title of Unit & Contents	Hrs.
I	**Introduction to Clinical Research**	**10 Hrs.**
	1. Introduction to Drug Discovery and Drug development 2. Introduction to Clinical Research Industry 3. Types of Clinical research 4. Phases of clinical research 5. Drug development process 6. Manufacturing of drugs and Good Manufacturing Practices (GMP)	

Unit No.	Title of Unit & Contents	Hrs.
	7. Toxicology: Mutagenicity, teratogenicity and carcinogenicity, Systemic toxicology (Single dose and repeat dose toxicity studies)	
	Unit Outcomes: UO 1. Extend understanding of drug ddiscovery and drug development UO 2. Describe the types & phases of clinical research.	
II	**IPR**	**12 Hrs.**
	1. Basic concepts of Intellectual Property rights 2. Evolution of ethics in clinical research 3. Ethics and Ethical Guidelines for Clinical Trials and Good Clinical Practice (GCP) 4. Human rights in clinical research 5. Principles of Good Laboratory Practices 6. Good Manufacturing Practices & Good Clinical Practices. 7. Types of clinical trials, single blinding, double blinding 8. Open access 9. Randomized trials and their examples preclinical studies 10. Concepts and Application in clinical trials 11. Quality Assurance and Quality Control in Clinical Trials	
	Unit Outcomes: UO 1. Understand the ethics and ethical guidelines for clinical trials and good clinical practice. UO 2. Understand the quality assurance and quality control in clinical trials.	
III	**General Pharmacology**	**13 Hrs.**
	1. Introduction, definitions and scope of pharmacology 2. Routes of administration of drugs 3. New drug discovery process 4. New Drug Application and Approval. 5. Pharmacokinetics (absorption, distribution, metabolism and excretion) 6. Pharmacodynamics, stages of pharmacodynamics.	
	Unit Outcomes:	

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Unit No.	Title of Unit & Contents	Hrs.
	UO 1. Understand the different routes of drug administration. UO 2. Describes the concept of pharmacokinetics and pharmacodynamics.	
IV	**Bio-entrepreneurship**	**10 Hrs.**
	1. Concept of Bio-entrepreneurship 2. Scope for biotechnology students 3. Bio- entrepreneurship Importance 4. Steps of Bio-entrepreneurship development 5. Data Management in clinical Research 6. Safety monitoring in clinical trials. 7. Clinical Trial Start up activities: Site Feasibility Studies, Pre-study visit, Site initiation visit.	
	Unit Outcomes: UO 1. Understand the steps of bio-entrepreneurship development. UO 2. Gain the knowledge about various clinical trial start up activities.	

Learning Resources:

1. Handbook of Clinical Research, Julia Lloyd and Ann Raven, Churchill Livingstone Publications, 1994
2. Principles of Clinical Research, Giovanna di Ignazio & Di Giovanna, CRC Press / BSP Books, 2018
3. Basic and Clinical Pharmacology, B.G. Katzung, Prentice Hall International, 2021
4. Textbook of Clinical Trials, David Machin, Simon Day, & Sylvan Green, John Wiley and Sons, 2005
5. Basic Principles of Clinical Research and Methodology, S.K. Gupta, JPB Publication, 1st edition, 2007
6. Handbook of Good Clinical Research Practice, World Health Organization, 2005
7. Fundamentals of Clinical Trials, Lawrence M. Friedman & Curt, 5th edition, 2015
8. Designing Clinical Research, Dr. Stephen B Hulley, MD, MPH, Steven R Cummings, MD, Warren S Browner, MD, 4th edition, 2013
9. Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies, Craig Shimasaki, Academic Press, 1st Edition, 2008
10. Good Clinical Practice: A Question & Answer Reference Guide, Susanne Prokscha, SAGE Publications, Inc, 2nd Edition, 2017

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Course Type: Lab Course
Course Title: Lab Course XIV (Based on MMC-XI)
Course Code: 602BIO4105
Credits: 01 **Max. Marks: 50** **Hours: 30**

Leaning Objectives:

LO 1 To identify and describe various techniques for collecting biological specimens.
LO 2 To recognize commonly used instruments in experimental pharmacology.
LO 3 To gain knowledge of laboratory animals.
LO 4 To learn about types of preclinical experiments.
LO 5 To understand standard operating protocols in clinical research.
LO 6 To explore the use of anesthetics in laboratory animals.
LO 7 To learn how to apply for a patent.
LO 8 To gain insights into starting a startup.

Course Outcomes:

After completion of course the student will be able to-

UO 1 Describe and differentiate various techniques used for specimen collection.
UO 2 Identify & describe commonly used instruments in experimental pharmacology.
UO 3 Get the knowledge about knowledge of laboratory animal.
UO 4 Apply knowledge of experimental design principles to plan and conduct preclinical studies effectively.
UO 5 Describe about various routes of drug administration.
UO 6 Gain insights into the principles and practice of anaesthesia and analgesia in laboratory animals.
UO 7 Acquire knowledge of the essential steps and considerations involved in starting a startup.
UO 8 Develop skills in methods of collection of specimens.

Practical No.	Unit
1	To study different Techniques of specimen collection.
2	Commonly used instruments in experimental pharmacology.
3	Study of laboratory animals.
4	Types of preclinical experiments.
5	Techniques of blood collection from animals.
6	Standard operating protocols in clinical research/trails.
7	Study of different routes of drugs administration.
8	Study of use of anesthetics in laboratory animals.

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9	How to apply for a patent.
10	How to start a Start Up.
11	Visit to Biotechnology industry/ Research Institute.

N.B.: Any Ten Practicals from above.

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Department of Biotechnology

Course Type: MMC-XII

Course Title: Food and Nano Biotechnology

Course Code: 602BIO4103

Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives:

LO 1. To understand the fundamental principles of biotechnology and its applications in food production.

LO 2. To describe the various biotechnological processes involved in the synthesis of food ingredients, flavors, colors, and sweeteners.

LO 3. To analyze the importance of food safety measures, including the Hazard Analysis and Critical Control Points (HACCP) system, in ensuring the quality and safety of food products.

LO 4. To evaluate different methods of food preservation and their effectiveness in extending shelf life and maintaining food quality.

LO 5. To apply genetic engineering techniques to modify microorganisms and plants for enhanced food production and nutritional quality.

LO 6. To investigate the role of traditional fermentation processes in food production and their relevance in modern bioprocessing techniques.

LO 7. To recognize the potential of nanobiotechnology in improving food quality, safety, and sustainability.

LO 8. To develop critical thinking and problem-solving skills to address challenges and opportunities in the field of biotechnology for food ingredients.

Course Outcomes:

After completion of the course, the student will be able to-

CO 1 Demonstrate a comprehensive understanding of biotechnological principles and their applications in the food industry.

CO 2 Equipped with the knowledge and skills necessary to synthesize a wide range of food ingredients, flavors, colors, and sweeteners using biotechnological approaches.

CO 3 Implement food safety protocols, including haccp, to ensure the production of safe and high-quality food products.

CO 4 Select and apply appropriate food preservation methods based on product characteristics and storage requirements.

CO 5 Demonstrate proficiency in utilizing genetic engineering techniques to enhance the nutritional content and functional properties of food ingredients.

CO 6 Gain insight into traditional fermentation processes and their integration with modern bioprocessing technologies for food production.

CO 7 Aware of the potential applications of nanobiotechnology in addressing challenges related to food quality, safety, and sustainability.

CO 8 Contribute to the advancement of biotechnological innovations in the food industry through critical thinking, problem-solving, and research skills.

Unit No.	Title of Unit & Contents	Hrs.
I	**Biotechnology in Food Production**	**10 Hrs.**
	1. Metabolic Engineering of Bacteria for Food Ingredients 2. Biotechnology of Microbial Polysaccharides in Food 3. Microbial Biotechnology for Food Flavor Production 4. Food Safety: Introduction to HACCP System and Food Protection 5. Responsibility for Ensuring Food Safety 6. Food Additives: Definition, Types, and Functional Characteristics 7. Natural Colors in Food: Types and Applications 8. Sweeteners: Types and Applications 9. Causes of Food Spoilage 10. Food Preservation Methods	
	Unit Outcomes: UO 1 Understand and Apply Biotechnology in Food Production. UO 2 Ensure and Evaluate Food Safety and Quality	
II	**Food Applications and Functional Foods**	**12 Hrs.**
	1. Solid State Fermentations for food applications 2. Genetic Engineering of baker's yeast 3. Biotechnology of wine yeast 4. Genetic Modification of Plant Oils for Food uses 5. Biotechnology of -carotene from Dunaliella 6. SCP: Spirulina and Chlorella 7. Biotechnological approaches to improve nutritional quality and shelf life of fruits and vegetables	
	Unit Outcomes: UO 1 Understand Biotechnological Processes in Food Production. UO 2 Apply Biotechnological Principles in Food Industry	
III	**Food Safety, Traditional Fermentations and Novel Bioprocessing**	**13 Hrs.**
	1. Molecular Evolution and Diversity of food borne pathogens. 2. Application of Microbial Molecular Techniques for food systems.	

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Unit No.	Title of Unit & Contents	Hrs.
	3. Application of ELISA assays for detection and quantitation of toxins in foods and E.coli in food 4. Biosensors for food quality assessment 5. Biotransformation applicable to food industries 6. Fermentation technology for traditional food of the Indian subcontinent 7. Functional foods: Concept of Prebiotics, Probiotics and Nutraceuticals.	
	Unit Outcomes: UO 1 Proficiency in Molecular Techniques and Assays for Food Safety. UO 2 Comprehensive understanding of functional foods and their components and Ability to apply biotransformation processes in food industries.	
IV	**Nano Biotechnology**	**10 Hrs.**
	1. Introduction to Nano-Biotechnology 2. The Nanoscale Dimension and Paradigm 3. Types of Nanomaterials and Their Classifications, Structures and Characteristics of Nanomaterials: D, 2D, and 3D, Nanocrystal, Nanoparticle, Quantum dot, Quantum Wire and Quantum Well etc. 4. Polymer, Carbon, Inorganic, Organic and Biomaterials – Structures and characteristics 5. Green Synthesis of Nanoparticles Using Bacteria and Plants 6. Characterization of Nanoparticles 7. Applications of Nanobiotechnology 8. Relevance of nanotechnology in the food industry	
	Unit Outcomes: UO 1 Understand Nanobiotechnology Fundamentals and Applications. UO 2 Competence in evaluating and proposing strategies for green synthesis of nanoparticles	

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Learning Resources:

1. Food Biotechnology, CRC Taylor & Francis Kalidas Shetty G. Paliyath, 2nd edition, A Pometto R,E. Levin, 2005.
2. Food Microbiology, Adam M.R and Moss M.O, 2nd edition, New Age International Pub., 2006.
3. Food Microbiology, Frazier W.C and Westhoff D.C - 4th Edition., Tata McGraw Hill, 2013.
4. Food Processing and Preservation, Sivsankar B Prentice Hall of India, 2002.
5. Food Microbiology Protocols. Spencer J.F.T. and de Spencer A.L.R. ,Humana Press, 2008.
6. Modern Food Microbiology, Jay J.M., Chapman and Hall,4th Ed., New York ,NY, USA, 1994.
7. Bio-Nano technology concept and applications, Madhuri Sheron, Sunil Pande- Ane Books New Delhi, 2013.
8. Nanotechnology, Pearson Mark Ratner, 1st edition, Daniel Ratner, 2002.
9. Nanotechnology an Introduction, Ramsden, 1st edition, Elsevier, 2012.
10. Advances in food Biotechnology, Smith, M. A., & Dávila, G. (Eds.), John Wiley & Sons, 2018.
11. Food engineering: integrated approaches, Gómez-López, V. M. (Ed, CRC Press.2017
12. Applications of biotechnology in the food industry. In Biotechnology - Molecular Studies and Novel Applications for Improved Quality of Human Life ,Silva, C., & others. Intech Open,2019.
13. Emerging Applications of Nanotechnology in the Food Industry: A Critical Review. Nanomaterials in Food ,Pareek, S., & others. Elsevier,2020.
14. Nanotechnology in the Agri-Food Sector: Implications for the Future ,Sanz, T., Salvador, A., & Fiszman, S. M. ,Academic Press,2017.

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Department of Biotechnology

Course Type: Lab Course
Course Title: Lab Course -XV (Based on MMC -XII)
Course Code: 602BIO4106
Credits: 01 **Max. Marks: 50** **Hours: 30**

Leaning Objectives

LO 1 Understand the process of fermentation in food.
LO 2 Acquire skills in quantitative analysis.
LO 3 Develop skills in microscopic examination of food and milk using the breed method.
LO 4 Assess the quality of pasteurized milk
LO 5 Acquire practical skills in performing these food processing techniques.
LO 6 Learn techniques for isolating and characterizing probiotic bacteria.
LO 7 Understand the principles of nanoparticle synthesis and characterization
LO 8 Acquire skills in evaluating the efficacy of nanoparticles as antimicrobial agents

Course outcomes

After completion of the course, the student will be able to-

CO 1 Identify and characterize microorganisms involved in food fermentation processes, which can be applied to various food industries
CO 2 Quantify biomolecules and nutritional content in food samples, which is crucial for assessing nutritional quality and stability of food products.
CO 3 Analyze food samples for microbial contamination using microscopic techniques, aiding in food quality control
CO 4 Determine the adequacy of milk pasteurization through mbrt and phosphatase testing, ensuring microbiological safety.
CO 5 Gain knowledge and practical skills in isolating, characterizing, and evaluating the probiotic properties, facilitating their understanding of probiotic culture selection and application in food production
CO 6 Design and conduct sensory evaluation tests to assess differences and similarities in food products, enabling them to understand consumer preferences and product quality attributes
CO 7 Assess the antimicrobial potential of nanoparticles and understand their applications in food preservation and biomedical fields
CO 8 Gain knowledge and practical experience in isolating and detecting nanoparticles from plant extracts, contributing to their understanding of nanotechnology applications in food and biomedical sciences

Practical No.	Unit
1	Isolation and Characterization of food fermenting organisms from idli batter
2	Estimation of ascorbic acid from given food sample by the titrimetric method.
3	Analysis of mycotoxin (Aflatoxin) in fungus-contaminated food material.
4	Microscopic examination of Food/Milk by breed method.
5	Estimation of lactose from milk.
6	Quality characterization of pasteurized milk by MBRT method.
7	To judge efficiency of pasteurization of milk by Phosphatase test.
8	Detection of microbial count in Milk by SPC method.
9	Measurement of fat content using Soxhlet extraction or solvent extraction methods.
10	Estimation of protein content using Kjeldahl method or Dumas combustion method.
11	Demonstration of various food processing techniques such as blanching, pasteurization, sterilization, and freeze-drying.
12	Preparation of food products like jams, jellies, sauces, and pickles.
13	Isolation and biochemical testing of probiotic cultures (Lactobacilli) from food samples (curd, intestine, sauerkraut, dosa, etc)
14	Check the potential of bacterial culture as probiotic culture by testing bile i) salt tolerance ii) acid tolerance iii) heat tolerance
15	Conducting discrimination tests (e.g., triangle test, duo-trio test) and descriptive analysis to assess sensory characteristics.
16	Isolation and detection of nano particles from plant extract (silver nano particles)
17	Spectrophotometric analysis (UV/IR) of nano particles
18	Antimicrobial activity of nano particles

N.B.: Any Ten Practicals from above.

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Course Type: MEC-IV (A)
Course Title: Environment Biotechnology
Course Code: 602BIO4201
Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives

LO 1 To understand the structure and functions of ecosystems, including the roles of abiotic and biotic components.

LO 2 To describe the flow of energy through ecosystems and analyze food chains and food webs

LO 3 To classify different types of pollution and pollutants, including their properties and effects on the environment.

LO 4 To discuss sustainable management practices and conservation strategies for the environment.

LO 5 To understand the processes involved in wastewater treatment plants, including physical, chemical, and biological unit operations.

LO 6 To describe different types of bioremediation techniques, including microbial and phytoremediation.

LO 7 To demonstrate knowledge of remote sensing principles, terminologies, and applications in various fields.

LO 8 To understand the objectives and guidelines of Environmental Impact Assessment (EIA) and its classification.

Course Outcomes

After completion of the course, the student will be able to-

CO 1 Develop a comprehensive understanding of ecosystem dynamics and the factors influencing ecological balance.

CO 2 Analyze the role of biotic and abiotic components in shaping ecosystems and their resilience to disturbances.

CO 3 Apply knowledge of pollution classification and pollutants to assess environmental risks and propose mitigation measures

CO 4 Understand the significance of renewable energy sources and their potential contribution to reducing environmental impacts.

CO 5 Describe biotechnological solutions to address environmental issues of pollution.

CO 6 Explain emerging technologies that are important in the area of environmental biotechnology.

CO 7 Explain Remote sensing & GIS.

CO 8 Demonstrate competency in conducting Environmental Impact Assessments and proposing recommendations for sustainable development.

Unit No.	Title of Unit & Contents	Hrs.
I	**Ecology and Environment**	**12**
	1. Ecosystem structure and functions, 2. abiotic and biotic component. 3. Energy flow, 4. Food chain, food web. 5. Ecological Pyramids-types. 6. Biogeochemical cycles. 7. Ecological succession, 8. Ecads and ecotypes. 9. Sustainable management and conservation of environment	
	Unit Outcomes: UO 1 Develop a comprehensive understanding of ecosystem dynamics and the factors influencing ecological balance. UO 2 Analyze the role of biotic and abiotic components in shaping ecosystems and their resilience to disturbances.	
II	**Environmental Pollution**	**10**
	1. Classification of pollution 2. Classification of pollutants. 3. Air pollution and their properties, 4. Water pollutants and their properties. 5. Environmental pollution and associated hazards to crops, animals and humans. 6. Greenhouse effect and global warming.	

Unit No.	Title of Unit & Contents	Hrs.
	Unit Outcomes: UO 1 Apply knowledge of pollution classification and pollutants to assess environmental risks and propose mitigation measures UO 2 Understand the significance of renewable energy sources and their potential contribution to reducing environmental impacts.	
III	**Biotechnological processes**	**15**
	1. Waste water treatment plant- 2. Physical, Chemical and Biological Unit operations/processes-overview, 3. Activated Sludge Process, 4. Trickling Filters, 5. UASB reactor 6. Introduction to bioremediation, 7. Types of Bioremediations 8. Microbial bioremediation- Types 9. Phytoremediation- Types 10. Energy & Biofuels: Non-conventional or renewable sources of energy, 11. Energy from Biomass.	
	Unit Outcomes: UO 1 Describe biotechnological solutions to address environmental issues of pollution. UO 2 Explain emerging technologies that are important in the area of environmental biotechnology.	
IV	**Advancement in environmental technology**	**08**
	1. Remote sensing and GIS- Principal, terminologies and objectives. 2. Energy sources for remote sensing, 3. Types of remote sensing.	

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Unit No.	Title of Unit & Contents	Hrs.
	4. Applications of Remote Sensing- Agricultural, Forestry, Water Resource, Urban Planning, Wildlife Ecology, Disaster Assessment. 5. Environmental Impact Assessment: Introduction, Objectives, Classification, Guidelines.	
	Unit Outcomes: UO 1 Explain Remote sensing & GIS. UO 2 Demonstrate competency in conducting Environmental Impact Assessments and proposing recommendations for sustainable development.	

Learning Resources:

1. Environmental Biotechnology, 2nd edition, Allan Scragg, OUP Oxford, 2005
2. Environmental Biotechnology, Prof. Jogdand, Himalayan Publication, 2010
3. Environmental Biotechnology, Foster C.F. & John Ware D.A., Ellis Horwood Ltd., 1987
4. Biotechnology and Biodegradation, Karrely D., Chakrabarty K., & Omen G.S., Portfolio Publishing Co Inc., U.S., 1990
5. Bioremediation Engineering: Design and Application, John T. Cookson Jr., McGraw Hill, Inc., 1994
6. Environmental Biotechnology, 3rd edition, A.K. Chatterjee, Prentice Hall India Learning Private Limited, 2011
7. Environmental Biotechnology, Bimal Bhattachraya & Ritu Banerjee, Oxford University Press, 2007
8. Environmental Pollution Control Engineering, 4th edition, C.S. Rao, New Age International Publishers, 2021
9. Environmental Biotechnology: Theory and Application, 1st edition, Gareth Evans & Judith Furlong, John Wiley and Sons Ltd., 2002
10. Environmental Biotechnology: Concept and Application, 1st edition, edited by Hans-Joachim Jördening & Josef Winter, Wiley VCH Verlag GmbH & Co. KGaA, 2004

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Course Type: Lab Course
Course Title: Lab Course –XVI (Based on MEC-IV (A))
Course Code: 602BIO4203
Credits: 01 **Max. Marks: 50** **Hours: 30**

Learning Objectives

LO 1. Gain proficiency in various analytical methods for the determination of water and soil quality parameters.
LO 2. Acquire skills in isolating bacteria and fungi from different environmental sources.
LO 3. Develop competence in composting organic waste materials to produce nutrient-rich compost.
LO 4. Gain insight into the process of conducting environmental impact assessments and evaluating the potential environmental consequences of various projects, fostering environmental stewardship and responsibility.
LO 5. Understand the principles and techniques involved in ecological restoration projects.
LO 6. Learn techniques for the production of microbial-based biofertilizers.
LO 7. Explore symbiotic relationships between plants and beneficial microorganisms.
LO 8. Develop critical thinking skills by analyzing case studies related to environmental restoration projects and ecological assessments.

Course Outcomes

After completion of the course, the student will be able to-

CO 1 Proficiently employ various analytical techniques to determine water and soil quality parameters, ensuring accurate environmental assessments.
CO 2 Master the techniques for isolating bacteria and fungi from polluted soil, water, and air samples, showcasing proficiency in microbial ecology and diversity studies.
CO 3 Apply composting principles to effectively manage organic waste materials, producing nutrient-rich compost for soil amendment and waste reduction.

CO 4 Capable of conducting comprehensive environmental impact assessments, evaluating the potential ecological consequences of proposed projects and activities.

CO 5 Develop skills to design and implement ecological restoration plans, promoting biodiversity conservation and ecosystem resilience.

CO 6 Produce microbial-based biofertilizers using nitrogen-fixing bacteria, phosphate-solubilizing bacteria, and plant growth-promoting rhizobacteria, contributing to sustainable agricultural practices.

CO 7 Understand the significance of symbiotic relationships between plants and beneficial microorganisms, applying this knowledge to enhance plant growth and environmental sustainability.

CO 8 Analyze environmental case studies to understand real-world applications of environmental science and propose informed solutions to environmental challenges.

Practical No.	Unit
1.	Determination of total solids.
2.	Determination of alkalinity
3.	Determination of COD
4.	Determination of DO
5.	Determination of BOD
6.	Determination of hardness of water
7.	Isolation of bacteria from polluted soil.
8.	Isolation of bacteria from polluted water.
9.	Isolation of bacteria from polluted air.
10.	Isolation of fungi from polluted soil.
11.	Isolation of fungi from polluted water.
12.	Isolation of fungi from polluted air.
13.	Composting of organic waste materials to produce nutrient-rich compost for soil amendment.

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14.	Investigation of composting parameters such as temperature, moisture content, carbon-to-nitrogen ratio, and microbial activity.
15.	Study of symbiotic relationships between plants and beneficial microorganisms (e.g., mycorrhizal fungi, nitrogen-fixing bacteria) for enhancing plant growth and environmental sustainability.
16.	Production of microbial-based biofertilizers using nitrogen-fixing bacteria, phosphate solubilizing bacteria, and plant growth-promoting rhizobacteria (PGPR).
17.	Case study on Ecological restorartion projects
18.	Case study on Environmental Impact Assesment.

N.B.: Any Ten Practicals from above.

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Course Type: MEC-II (B)
Course Title: Omics Technology
Course Code: 602BIO4202
Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives

LO 1 To explain the principles behind genomics, transcriptomics, proteomics, and metabolomics, including the technologies used and their applications in biological research.

LO 2 To describe the process of generating omics data, including sample preparation, data acquisition, and quality control measures.

LO 3 To apply bioinformatics tools and methods to analyze omics data, including data preprocessing, normalization, statistical analysis, and interpretation of results.

LO 4 To interpret omics data to identify patterns, trends, and biological insights relevant to the research question.

LO 5 To design omics experiments, including selecting appropriate technologies, experimental conditions, and controls.

LO 6 To critically evaluate omics data and scientific literature to draw meaningful conclusions and propose hypotheses for further investigation.

LO 7 To aware the students about ethical issues related to omics analysis, including data privacy, consent, and responsible conduct of research.

LO 8 To apply omics analysis skills in research or professional settings, including academic research, biotechnology industry, healthcare, or regulatory agencies.

Course outcomes

After completion of the course, the student will be able to-

CO 1 demonstrate an understanding of genomics, transcriptomics, proteomics, metabolomics, and other omics technologies, including their principles, methodologies, and applications in biological research.

CO 2 generate omics data using relevant technologies and apply bioinformatics tools and methods to analyze and interpret omics data sets.

CO 3 design omics experiments, including selecting appropriate technologies, experimental conditions, and controls, to address specific biological questions.

CO 4 develop critical thinking skills and be able to evaluate omics data and scientific literature to identify research gaps, formulate hypotheses, and propose experimental approaches.

CO 5 demonstrate an awareness of ethical issues related to omics technologies, including data privacy, consent, and responsible conduct of research, as well as the societal implications of omics research.

CO 6 effectively communicate omics analysis results and conclusions through written reports, oral presentations, and visualizations to both scientific and non-scientific audiences.

CO 7 think about integrative approach of omics technologies and its application in research.

CO 8 Prepare the student for careers in academia, industry, healthcare, or regulatory agencies that require omics analysis skills, including the ability to adapt to new technologies and research paradigms in the rapidly evolving field of omics.

Unit No.	Title of Unit & Contents	Hrs.
I	**Introduction to omics technologies**	**06**
	1. Overview of omics technologies, 2. Historical perspective. 3. Importance and applications in biology. 4. Ethical issues in omics research. 5. Data sharing and privacy concerns. 6. Public perception and communication of omics research. 7. Advances in omics technologies.	
	Unit Outcomes: UO 1. To study historical perspective and fundamentals of omics technologies. UO 2. To study ethical issues and advances in omics technologies.	
II	**Genomics and Transcriptomics**	**12**
	1. Basics of genomics 2. Sequencing technologies- Next-generation sequencing technologies 3. genome assembly, and annotation 4. Comparative genomics 5. Data analysis method databases 6. tools for Genomics data analysis 7. Basics of transcriptomics 8. Microarrays 9. RNA-Seq and other transcriptome profiling techniques 10. Differential gene expression analysis	

Unit No.	Title of Unit & Contents	Hrs.
	Unit Outcomes: UO 1. To study NGS technologies fundamentals and data analysis in genomics. UO 2. To study transcriptomics , microarrays, and RNA-seq for the study of differential gene expression analysis.	
III	**Proteomics**	**12**
	1. Basics of proteomics, 2. Protein separation techniques 3. Mass spectrometry-based proteomics 4. protein identification and quantification 5. Data analysis methods 6. databases, tools for proteomics data analysis 7. Protein-protein interactions	
	Unit Outcomes: UO 1. To study fundamentals of protein purification and mass spectroscopy-based proteomics. UO 2. To learn use of proteomics databases and its application in data analysis.	
IV	**Metabolomics**	**15**
	1. Basics of metabolomics 2. Analytical techniques in metabolomics 3. Metabolite identification and quantification 4. Data analysis methods, 5. databases, tools for metabolomics data analysis Metabolic pathway analysis	
	Unit Outcomes: UO 1. To understand analytical techniques used in metabolites and metabolomics analysis. UO 2. To learn about databases of metabolomics and its application in metabolomics data analysis.	

Learning Resources:

1. Bioinformatics for Omics Data: Methods and Protocols, Bernd Mayer, Humana Press, 1st edition, 2011.
2. Statistical Methods in Bioinformatics: An Introduction, Warren J. Ewens and Gregory R. Grant, Springer, 2nd edition, 2010.
3. Introduction to Bioinformatics, Arthur M. Lesk, Oxford University Press, 4th edition, 2019.
4. Computational Biology: A Practical Introduction to BioData Processing and Analysis with Linux, MySQL, and R, Röbbe Wünschiers, O'Reilly Media, 1st edition, 2013.

5. Bioinformatics: Sequence and Genome Analysis, David W. Mount, Cold Spring Harbor Laboratory Press, 2nd edition, 2002.
6. Bioinformatics and Functional Genomics, Jonathan Pevsner, Wiley-Blackwell, 3rd edition, 2015.
8. Data Mining Techniques in Bioinformatics: Theory and Models, Xue-Wen Chen, Mohammed J. Zaki, and Hagit Shatkay, Wiley-Blackwell, 1st edition, 2008.
9. Genomics and Proteomics: Principles, Technologies, and Applications, Stewart Sell and Prem Seth, Wiley, 1st edition, 2004.
10. Transcriptomics and Gene Regulation, Nikolai V. Dokholyan, Brian D. Sykes, and Jeffrey Skolnick, Springer, 1st edition, 2006.
11. Metabolomics: Methods and Protocols, Wolfram Weckwerth and Aimin Liu,, Humana Press, 1st edition, 2018.

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Course Type: Lab Course-XIV
Course Title: (based on omics technologies)
Course Code: 602BIO4203
Credits: 01 **Max. Marks: 50** **Hours: 30**

Learning Objectives

LO 1. To learn techniques for DNA and RNA extraction, quantification, and quality assessment.
LO 2. To Understand principles of polymerase chain reaction (PCR) and agarose gel electrophoresis.
LO 3. To gain proficiency in using bioinformatics tools and databases for sequence alignment, genome assembly, variant calling, and functional annotation.
LO 4. To prepare samples for proteomic and metabolomic analysis, including protein extraction, purification, and metabolite extraction.
LO 5. To analyze proteomic and metabolomic data using bioinformatics tools and databases to identify proteins and metabolites,

Course outcomes

After completion of the course, the student will be able to-

CO 1 familiar with common experimental techniques used in genomics, such as DNA extraction, and PCR.
CO 2 use bioinformatics tools and databases to analyze genomic data, including sequence alignment, variant calling, and functional annotation.
CO 3 Students should be able to interpret genomic data and draw meaningful conclusions about genetic variation, gene function, and evolutionary relationships
CO 4 prepare samples for proteomic and metabolomic analysis, including protein extraction, digestion, and metabolite extraction.
CO 5 identify proteins and metabolites from mass spectrometry data using database search algorithms and other identification techniques.

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Practical No.	Unit
1.	Isolation of genomic DNA from bacteria, plant and animal tissues.
2.	To amplify specific DNA segments by using PCR and run the agarose gel electrophoresis to study the amplified products of DNA.
3.	Retrieve the genomic database of a particular bacteria/plant/animal for comparative studies, and other characterization studies.
4.	Take any suitable example to understand in silico process of gene prediction, genome annotation and data analysis.
5.	Isolation of RNAs from bacteria, plant and animal tissue by using Trizol method.
6.	Introductory practical on RNA-seq data analysis by using any online suitable tool.
7.	Isolation, precipitation, dialysis and purification of proteins from animal/plant tissues/bacteria.
8.	A study of proteomics databases, data retrieval for proteomics data analysis.
9.	To identify the Proteins from given proteomics database file by using any available online tool.
10.	To extract and purify the secondary metabolites from given plant material.
11.	A introductory study of metabolomics databases and its application in plant research and industry.

N.B.: Any Ten Practicals from above.

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PG First Year

Extra Credit Activities

Sr. No.	Course Title	Credits	Hours T/P
1	MOOCs	Min. of 02 credits	Min. of 30 Hrs.
2	Certificate Courses	Min. of 02 credits	Min. of 30 Hrs.
3	IIT Spoken Tutorial Courses	Min. of 02 credits	Min. of 30 Hrs.

Guidelines:

Extra -academic activities

1. All extra credits claimed under this heading will require sufficient academic input/ contribution from the students concerned.
2. Maximum 04 extra credits in each academic year will be allotted.
3. These extra academic activity credits will not be considered for calculation of SGPA/CGPA but will be indicated on the grade card.

Additional Credits for Online Courses:

1. Courses only from SWAYAM and NPTEL platform are eligible for claiming credits.
2. Students should get the consent from the concerned subject Teacher/Mentor/Vice Principal and Principal prior to starting of the course.
3. Students who complete such online courses for additional credits will be examined/verified by the concerned mentor/internal faculty member before awarding credits.
4. Credit allotted to the course by SWAYAM and NPTEL platform will be considered as it is.

Additional Credits for Other Academic Activities:

1. One credit for presentation and publication of paper in International/National/State level seminars/workshops.
2. One credit for measurable research work undertaken and field trips amounting to 30 hours of recorded work.
3. One credit for creating models in sponsored exhibitions/other exhibits, which are approved by the concerned department.
4. One credit for any voluntary social service/Nation building exercise which is in collaboration with the outreach center, equivalent to 30 hours
5. All these credits must be approved by the College Committee.

Additional Credits for Certificate Courses:

1. Students can get additional credits (number of credits will depend on the course duration) from certificate courses offered by the college.
2. The student must successfully complete the course. These credits must be approved by the Course Coordinators.
3. Students who undertake summer projects/ internships/ training in institutions of repute through a national selection process, will get 2 credits for each such activity. This must be done under the supervision of the concerned faculty/mentor.

Note:

1. The respective documents should be submitted within 10 days after completion of Semester End Examination.
2. No credits can be granted for organizing or for serving as office bearers/ volunteers for Inter-Class / Associations / Sports / Social Service activities.
3. The office bearers and volunteers may be given a letter of appreciation by the respective staff coordinators. Besides, no credits can be claimed for any services/activities conducted or attended within the college.
4. All claims for the credits by the students should be made and approved by the mentor in the same academic year of completing the activity.
5. Any grievances of denial/rejection of credits should be addressed to Additional Credits Coordinator in the same academic year.
6. Students having a shortage of additional credits at the end of the third year can meet the Additional Credits Coordinator, who will provide the right advice on the activities that can help them earn credits required for graduation.

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Examination Framework

Theory:

40% Continuous Assessment Tests (CATs) and 60% Semester End Examination (SEE)

Practical:

50% Continuous Assessment Tests (CATs) and 50% Semester End Examination (SEE)

Course	Marks	CAT & Mid Term Theory				CAT Practical		Best Scored CAT & Mid Term	SEE	Total
1	2	3				4		5	6	5 + 6
		Att.	CAT I	Mid Term	CAT II	Att.	CAT			
Research Methodology	100	10	10	20	10	-	-	40	60	100
DSC/DSE	75	05	10	15	10	-	-	30	45	75
Lab Course	50	-	-	-	-	05	20	-	25	50
Field Project	100	10	10	20	10	-	-	40	60	100

Note:

1. All Internal Exams are compulsory
2. Out of 02 CATs best score will be considered
3. Mid Term Exam will be conducted by the Exam Section
4. Mid Term Exam is of Objective nature (MCQ)
5. Semester End Exam is of descriptive in nature (Long & Short Answer)
6. CAT Practical (20 Marks): Lab Journal (Record Book) 10 Marks, Overall Performance 10 Marks.

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Semester End Examination Paper Pattern

Pattern - I

Course: Theory **Max. Marks: 45** **Time: 2 Hrs**

Q.1 **Answer the following questions (3 Marks each)** **12 Marks**

a) Based on Unit - I

b) Based on Unit - II

c) Based on Unit - III

d) Based on Unit - IV

Q.2 **Answer any THREE of the following (5 Marks each)** **15 Marks**

a) Based on Unit - I

b) Based on Unit - II

c) Based on Unit - III

d) Based on Unit - IV

Q.3 **Answer any ONE of the following** **08 Marks**

a) Based on Unit – I

b) Based on Unit – II

Q.4 **Answer any ONE of the following** **10 Marks**

a) Based on Unit - III

b) Based on Unit – IV

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Semester End Examination Paper Pattern

Pattern - I

Course : Theory **Max. Marks : 60** **Time: 2.30 Hrs**

Q.1 **Answer the following questions (4 Marks each)** **16 Marks**

a) Based on Unit - I

b) Based on Unit - II

c) Based on Unit - III

d) Based on Unit - IV

Q.2 **Answer any THREE of the following (6 Marks each)** **18 Marks**

a) Based on Unit - I

b) Based on Unit - II

c) Based on Unit - III

d) Based on Unit - IV

Q.3 **Answer any TWO of the following** **(8 Marks each)** **16 Marks**

(Based on any two Units)

a)

b)

c)

Q.4 **Answer any ONE of the following** **10 Marks**

(Based on remaining two Units)

a)

b)

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Semester End Examination Paper Pattern

Pattern - I

Course : Numerical **Max. Marks : 60** **Time: 2.30 Hrs**

Q.1 **Answer the following questions (4 Marks each)** **16 Marks**

a) Based on Unit - I

b) Based on Unit - II

c) Based on Unit - III

d) Based on Unit - IV

Q.2 **Answer any TWO of the following (9 Marks each)** **18 Marks**

(Based on any two units)

a)

b)

c)

Q.3 **Answer any ONE of the following** **16 Marks**

(Based on remaining two units)

a)

b)

c)

Q.4 **Answer any ONE of the following** **10 Marks**

(On any Unit)

a)

b)

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Summary of cross cutting issues:

Biotechnology encompasses a wide array of technologies that utilize biological processes to create innovative products and solutions. These technologies range from traditional practices like brewing and bread-making to modern techniques such as genetic engineering, hybridization, and gene manipulation. As a transformative technology for the new millennium, biotechnology plays a crucial role in various sectors, including agriculture, medicine, food processing, environmental conservation, and even nanoelectronics.

To ensure comprehensive student development, the biotechnology curriculum integrates several cross-cutting issues, focusing on professional ethics, gender equality, environmental sustainability, and human values. These critical topics are embedded in various courses to enhance employability, foster entrepreneurship, and equip students with ethical and practical skills for the future.

Cross-cutting issues relevant to Professional Ethics, Gender, Environment and Sustainability, and Human Values into the curriculum:

Sr. No.	Course Name	Code	Relevant to Professional Ethics/Environment	Description
1	Genetic Engineering	MMC-VII	Professional Ethics	Prepares students for job opportunities in research institutes and biotech industries.
2	Microbial Biotechnology	MMC-VIII	Professional Ethics	Equips students with skills for employability in fermentation industries.
3	Plant and Agriculture Biotechnology	MMC-IX	Professional Ethics	Opens pathways for careers in research institutes, agro-industries, and biotech industries.
4	Advanced Pharmaceutical Biotechnology	MEC-III (A)	Professional Ethics	Provides job opportunities in the pharmaceutical and biopharmaceutical sectors.
5	Enzyme and Protein Engineering	MEC-III (B)	Professional Ethics	Enhances expertise in enzyme and protein technology for various industrial applications.
6	Animal and Livestock Biotechnology	MMC-X	Professional Ethics	Prepares students for careers in animal cell culture laboratories.

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7	Clinical Research, IPR, Bio-entrepreneurship, and Start-Up	MMC-XI	Professional Ethics	Provides job opportunities in clinical research and biotech industries.
8	Food and Nano Biotechnology	MMC-XII	Professional Ethics	Equips students with skills for employability in the food, dairy, and fermentation industries.
9	Environmental Biotechnology	MEC-III (A)	Environment and Sustainability	Trains students to understand and address environmental problems, with opportunities to work as consultants or environment officers.
10	Omics Technology	MEC-III (B)	Professional Ethics	Provides insights into advanced omics technologies and their applications.
11	Research Project-I	RP-I	Professional Ethics	Encourages independent research, fostering ethical scientific inquiry and analysis.
12	Research Project-II	RP-II	Professional Ethics	Builds on research skills, emphasizing professional ethics in scientific research.

This reframed table highlights the integration of professional ethics, environment, and sustainability into biotechnology courses, ensuring students are prepared to tackle global challenges while adhering to ethical standards.

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Curricula developed and implemented have relevance to the local, national, regional and global developmental needs

The Biotechnology curriculum has been designed to align with developmental needs at the local, national, regional, and global levels. Each course focuses on addressing key challenges and opportunities in Biotechnology across various sectors, providing students with knowledge and skills to contribute to sustainable development and innovation.

Sr. No.	Course code	Course Name	Linkage with Local/National/Regional/Global development
1	MMC-VII	Genetic Engineering	Addresses global advancements in genetic manipulation for healthcare, agriculture, and industry.
2	MMC-VIII	Microbial Biotechnology	Solutions to local and global challenges in fermentation, waste management, and bioremediation.
3	MMC-IX	Plant and Agriculture Biotechnology	Supports national and regional agricultural development through crop improvement and sustainability.
4	MEC-III (A)	Advanced Pharmaceutical Biotechnology	Contributes to the pharmaceutical industry, enhancing national and global healthcare.
5	MEC-III (B)	Enzyme and Protein Engineering	Facilitates regional industrial applications of enzymes and proteins, enhancing global competitiveness.
6	MMC-X	Animal and Livestock Biotechnology	Addresses local and global challenges in animal health, breeding, and livestock improvement.
7	MMC-XI	Clinical Research, IPR, Bio-entrepreneurship, and Start-Up	Encourages bio-entrepreneurship, addressing national and global demands for innovative biotech solutions.
8	MMC-XII	Food and Nano Biotechnology	Links to regional and global food security challenges, with applications in food safety and nanoengineering.
9	MEC-III (A)	Environmental Biotechnology	Addresses pressing global environmental issues, offering local and regional solutions for sustainability.
10	MEC-III (B)	Omics Technology	Advances regional and global research in genomics, proteomics, and bioinformatics.
11	RP-I	Research Project-I	Promotes local and national research initiatives, preparing students for global challenges.

12	RP-II	Research Project-II	Fosters independent research aligned with national and global scientific progress.

Courses having focus on employability/ entrepreneurship/ skill development

The following biotechnology courses are designed to enhance employability, foster entrepreneurship, and develop essential skills. Each course is aligned with industry and research needs, equipping students with the tools required to succeed in their professional careers.

Sr. No.	**Name of the Course**	**Course Code**	**Activities/Content with a direct bearing on Employability/ Entrepreneurship/ Skill development**			**Year of introduction**
			Employability	**Entrepreneurship**	**Skill development**	
1	Genetic Engineering	MMC-VII	Prepares students for careers in biotech industries and research institutes.	Provides foundational knowledge for starting genetic modification or recombinant DNA technology ventures.	Develops practical skills in gene manipulation and recombinant DNA technology.	2018-19
2	Microbial Biotechnology	MMC-VIII	Opens career opportunities in fermentation industries and bioprocessing labs.	Encourages the creation of bioprocessing startups using microbial fermentation.	Provides hands-on experience in microbial genetics, fermentation technologies, and industrial applications.	2018-19

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3	Plant and Agriculture Biotechnology	MMC-IX	Enables employability in agro-industries, plant breeding companies, and research institutions.	Promotes entrepreneurship in crop improvement and plant tissue culture startups.	Trains students in plant tissue culture, genetic engineering, and crop improvement techniques.	2023-24
4	Advanced Pharmaceutical Biotechnology	MEC-III (A)	Prepares students for roles in pharmaceutical and biopharmaceutical companies.	Supports entrepreneurial initiatives in drug development and biopharmaceutical startups.	Focuses on advanced drug development techniques and biopharmaceutical production.	2018-19
5	Enzyme and Protein Engineering	MEC-III (B)	Offers employability in enzyme production, biocatalysis, and protein engineering sectors.	Encourages entrepreneurship in enzyme technology and industrial biotech applications.	Develops expertise in enzyme technology, protein modification, and biocatalysis.	2024-25
6	Animal and Livestock Biotechnology	MMC-X	Provides job opportunities in animal biotechnology labs, veterinary industries, and research institutes.	Supports startups in animal health, livestock improvement, and veterinary biotechnology.	Trains students in animal cell culture, genetic modification, and livestock biotechnology.	2023-24
7	Clinical Research, IPR, Bio-entrepreneurship, and Start-Up	MMC-XI	Creates employability in clinical research, IPR management, and biotech industries.	Encourages bio-entrepreneurship through clinical research ventures and biotech startups.	Develops knowledge of clinical trials, IPR management, and bio-entrepreneurship skills.	2023-24
8	Food and Nano	MMC-XII	Opens job opportunities in the food	Promotes entrepreneurship in food	Trains students in food	2018-19

	Biotechnology		industry, dairy industry, and nano-biotechnology sectors.	safety, dairy processing, and nanotechnology-based ventures.	biotechnology, fermentation technologies, and nanoengineering.	
9	Environmental Biotechnology	MEC-III (A)	Provides employability in environmental consultancy, waste management, and bioremediation industries.	Supports environmental solutions-based startups, such as bioremediation and sustainable development consultancies.	Develops skills in bioremediation, sustainable development, and environmental impact assessment.	2018-19
10	Omics Technology	MEC-III (B)	Offers career opportunities in genomics, proteomics, and bioinformatics sectors.	Encourages innovation and entrepreneurship in omics technologies and bioinformatics services.	Trains students in genomics, proteomics, and bioinformatics tools and techniques.	2024-25
11	Research Project-I	RP-I	Fosters research aptitude, leading to employability in research institutions.	Encourages independent innovation and entrepreneurship in biotechnology research.	Develops project management, research, and analytical skills through independent research.	2024-25
12	Research Project-II	RP-II	Enhances employability through advanced research experience in biotechnology fields.	Supports entrepreneurial thinking by promoting innovative research ideas and prototypes.	Builds advanced research skills, data analysis, and scientific writing abilities.	2018-19