



Anekant Education Society's

Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati

(Empowered Autonomous)

Four-year B.Sc. Degree Program in Microbiology

(Faculty of Science and Technology)

Choice-Based Credit System Syllabus

(2023 Pattern) (As per NEP 2020)

T. Y. B.Sc. Microbiology

SEM VI

To be implemented from Academic Year November 2025

Title of Programme: T.Y.B.Sc. Microbiology**Preamble**

Anekant Education Society's Tuljaram Chaturchand College has decided to change the syllabus of various faculties from June, 2023 by taking into consideration the guidelines and provisions given in the National Education Policy (NEP), 2020. The NEP envisions making education more holistic and effective and to lay emphasis on the integration of general (academic) education, vocational education and experiential learning. The NEP introduces holistic and multidisciplinary education that would help to develop intellectual, scientific, social, physical, emotional, ethical and moral capacities of the students. The NEP 2020 envisages flexible curricular structures and learning based outcomes for the development of the students. The credit structure and the courses framework provided in the NEP are nationally accepted and internationally comparable.

The rapid changes in science and technology and new approaches in different areas of Microbiology and related subjects, Board of Studies in Microbiology of Tuljaram Chaturchand College, Baramati, Dist.- Pune has prepared the syllabus of F. Y. B. Sc. Microbiology Semester - I as per Choice Based Credit System (CBCS) by following the guidelines of NEP 2020, NCERF, NHEQF, Prof. R.D. Kulkarni's Report, GR of Gov. of Maharashtra dated 20th April and 16th May 2023 and Circular of SPPU, Pune dated 31st May 2023.

Microbiology is a branch of science that studies "Life" taking an example of microorganisms such as bacteria, protozoa, algae, fungi, viruses, etc. These studies integrate cytology, physiology, ecology, genetics and molecular biology, evolution, taxonomy and systematics with a focus on microorganisms; in particular bacteria. The relevance and applications of these microorganisms to the surrounding environment including human life and Mother Nature becomes part of this branch. Since inception of this branch of science, Microbiology has remained a field of actively research and ever expanding in all possible directions; broadly categorized as pure and applied science. Different branches of Pure Microbiology based on taxonomy are Bacteriology, Mycology, Protozoology and Parasitology, Phycology and Virology; with considerable overlap between these specific branches over each other and also

with other disciplines of life sciences, like Biochemistry, Botany, Zoology, Cell Biology, Biotechnology, Nanotechnology, Bioinformatics, etc. Areas in the applied Microbial Sciences can be identified as: Medical, Pharmaceutical, Industrial (Fermentation, Pollution Control), Air, Water, Food and Dairy, Agriculture (Plant Pathology and Soil Microbiology); Veterinary, Environmental (Ecology, Geomicrobiology); and the technological aspects of these areas. Knowledge of different aspects of Microbiology has become crucial and indispensable to everyone in the society. Study of microbes has become an integral part of education and human progress. Building a foundation and a sound knowledge- base of Microbiological principles among the future citizens of the country will lead to an educated, intellectual and scientifically advanced society. Microbiological tools have been extensively used to study different life processes and are cutting edge technologies. There is a continual demand for microbiologists in the work force – education, industry and research. Career opportunities for the graduate students are available in manufacturing industry and research institutes at technical level.

Eligibility:

First Year B.Sc.:

1. Higher Secondary School Certificate (10+2) or its equivalent Examination with English and Biology; and two of the science subjects such as Physics, Chemistry, Mathematics, Geography, Geology, etc.

OR

2. Diploma in Pharmacy Course of Board of Technical Education conducted by Government of Maharashtra or its equivalent.

Programme Specific Outcomes (PSOs)

PSO1	Disciplinary Knowledge: Demonstrate comprehensive knowledge of the disciplines that form a part of a graduate programme. Execute strong theoretical and practical understanding generated from the specific graduate programme in the area of work.
PSO2	Critical Thinking and Problem solving: Exhibit the skills of analysis, inference, interpretation and problem-solving by observing the situation closely and design the solutions.
PSO3	Social competence: Display the understanding, behavioural skills needed for successful social adaptation, work in groups, exhibit thoughts and ideas effectively in writing and orally
PSO4	Research-related skills and Scientific temper: Develop the working knowledge and applications of instrumentation and laboratory techniques. Able to apply skills to design and conduct independent experiments, interpret, establish hypothesis and inquisitiveness towards research.
PSO5	Trans-disciplinary knowledge: Integrate different disciplines to uplift the domains of cognitive abilities and transcend beyond discipline-specific approaches to address a common problem
PSO6	Personal and professional competence: Performing dependently and also collaboratively as a part of a team to meet defined objectives and carry out work across interdisciplinary fields. Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics.
PSO7	Effective Citizenship and Ethics: Demonstrate empathetic social concern and equity centred national development, and ability to act with an informed awareness of moral and ethical issues and commit to professional ethics and responsibility.
PSO8	Environment and Sustainability: Understand the impact of the scientific solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.
PSO9	Self-directed and Life-long learning: Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes.

Anekant Education Society's
Tuljaram Chaturchand College of Art's Science and Commerce, Baramati
(Empowered Autonomous)
Board of Studies in Microbiology
(Academic Year 2025-26 to 2027-2028)

Sr.No.	Name Of Members	Designation
1	Dr. Pawar Sunil Trimbak f Head & Professor, Department of Microbiology, T. C. College, Baramati	Chairperson
2	Dr. Gajbhiye Milind Hemraj Professor, Department of Microbiology, T. C. College, Baramati	Member
3	Dr. Mrs. Mulay Yogini Ramkrushna Professor, Department of Microbiology, T. C. College, Baramati	Member
4	Mr. Doshi Dhawal Vidyachandra Asssistant Professor, Department of Microbiology, T. C. College, Baramati	Member
5	Ms. Jagtap Komal Ramchandra Asssistant Professor, Department of Microbiology, T. C. College, Baramati	Member
6	Ms. Bhosale Priti Chaurangnath Asssistant Professor, Department of Microbiology, T. C. College, Baramati	Member
7	Ms. Owl Sheetal P. Asssistant Professor, Department of Microbiology, T. C. College, Baramati	Member
8	Ms. Honrao Ruchita Rajkumar Asssistant Professor, Department of Microbiology, T. C. College, Baramati	Member
9	Ms. Gaikwad Kajal Mahadev Asssistant Professor, Department of Microbiology, T. C. College, Baramati	Member
10	Ms. Dhapate Puja Mahadeo Asssistant Professor, Department of Microbiology, T. C. College, Baramati	Member
11	Ms. Markale Prajakta Dattatray Asssistant Professor, Department of Microbiology, T. C. College, Baramati	Member
12	Ms. Deokate Nikita Tatyasaheb Asssistant Professor, Department of Microbiology, T. C. College, Baramati	Member

13	Ms. Jadhav Priti Pradeep Assistant Professor, Department of Microbiology, T. C. College, Baramati	Member
14	Ms. Jadhav Sayali Kalidas Assistant Professor, Department of Microbiology, T. C. College, Baramati	Member
15	Dr. Shinde Shubhangi	Vice-Chancellor Nominee Subject Expert from SPPU, Pune
16	Dr. Shinde Abhijeet. B	Subject Expert from Outside the Parent University
17	Dr. Petkar A. V.	Subject Expert from Outside the Parent University
18	Mr. Dhobale Avinash	Representative from industry/corporate sector/allied areas
19	Mr. Baradkar Shreekant	Member of the college Alumni
20	Ms. Gaikwad Payal	UG Student
21	Mr. Mane Yogeshwar	PG Student

Course Structure for F. Y. B.Sc. (2023 Pattern):

Semester	Course Type	Course Code	Course Name	Theory/ Practical	Credits	Marks (I + E)
I	Major Mandatory	MIB-101-MJM	Introduction to Microbiology	Theory	02	20+30
	Major Mandatory	MIB-102-MJM	Basic Techniques in Microbiology	Theory	02	20+30
	Major Mandatory	MIB-103-MJM	Laboratory Procedures in Microbiology	Practical	02	25+25
	Open Elective (OE)	MIB-116-OE	Microorganisms for Human Welfare	Theory	02	20+30
	Open Elective (OE)	MIB-117-OE	Food, Agricultural and Pharmaceutical Microbiology	Practical	02	25+25
	Vocational Skill Course (VSC)	MIB-121-VSC	Agricultural Microbiology	Theory	02	20+30
	Skill Enhancement Course (SEC)	MIB-126-SEC	Microbiology Laboratory Techniques	Practical	02	25+25
	Ability Enhancement Course (AEC)	ENG-131-AEC	Functional English-I	Theory	02	20+30
	Value Education Course (VEC)	MIB-135-VEC	Environmental Science-I	Theory	02	20+30
	Indian Knowledge System (IKS)	MIB-137-IKS	Ethno-Microbiology	Theory	02	20+30
	Co-curricular Course (CC)		NSS/NCC/Yoga/Cultural activities/Sports	Theory	02	20+30
	Total Credits Semester-I				22	
II	Major Mandatory	MIB-151-MJM	Chemistry & Bacterial cytology	Theory	02	20+30
	Major Mandatory	MIB-152-MJM	Fundamental Microbiology	Theory	02	20+30
	Major Mandatory	MIB-153-MJM	Techniques in Microbiology	Practical	02	25+25
	Minor	MIB-161-MN	Basic Medical Microbiology	Theory	02	20+30
	Open Elective (OE)	MIB-166-OE	Food Microbiology	Theory	02	20+30
	Open Elective (OE)	MIB-167-OE	Biofertilizer Production	Practical	02	20+30
	Vocational Skill Course (VSC)	MIB-171-VSC	Agriculture Microbiology	Practical	02	25+25
	Skill Enhancement Course (SEC)	MIB-176-SEC	Clinical pathology	Practical	02	25+25
	Ability Enhancement Course (AEC)	ENG-181-AEC	Functional English-II	Theory	02	20+30
	Value Education Course (VEC)	COS-185-VEC	and Technological Solutions	Theory	02	20+30
	Co-curricular Course (CC)	YOG/ PES/ CUL/NSS/ NCC-189- CC	NSS/NCC/Yoga/Cultural activities/Sports	Theory	02	20+30
	Total Credits Semester-II				22	
	Cumulative Credits Semester I + Semester II				44	

Course Structure for S. Y. B.Sc. (2023 Pattern):

Sem	Course Type	Course Code	Course Name	Theory/ Practical	Credits	Marks(I + E)
III	Major Mandatory	MIB-201-MJM	Bacterial Systematics	Theory	02	20+30
	Major Mandatory	MIB-202-MJM	Soil Microbiology	Theory	02	20+30
	Major Mandatory	MIB-203-MJM	Air Microbiology	Theory	02	20+30
	Major Mandatory	MIB-204- MJM	Practicals on Bacterial Systematics, Soil Microbiology, Air Microbiology	Practical	02	25+25
	Minor	MIB-211- MN	Basic Microbiology	Theory	02	20+30
	Minor	MIB-212- MN	Basic Microbiological Techniques	Practical	02	25+25
	Open Elective (OE)	MIB-216-OE	Scope & History of Microbiology	Theory	02	20+30
	Vocational Skill Course (VSC)	MIB-221-VSC	Dairy Microbiology	Theory	02	20+30
	Ability Enhancement Course (AEC)	MAR-231-AEC HIN-231-AEC SAN-231-AEC		Theory	02	20+30
	Field Project (FP)	MIB-235-FP	Field Project	Practical	02	25+25
	Co-curricular Course (CC)	YOG/PES/CUL/NSS /NCC-239-CC	NSS/NCC/Yoga/Cultural activities/Sports	Theory	02	20+30
	Generic IKS Course	GEN-245-IKS	Knowledge System (Generic)	Theory	02	20+30
	Total Credits Semester-III				24	
IV	Major Mandatory	MIB-251-MJM	Bacterial Physiology	Theory	02	20+30
	Major Mandatory	MIB-252-MJM	Introduction to Industrial Microbiology	Theory	02	20+30
	Major Mandatory	MIB-253-MJM	Water Microbiology	Theory	02	20+30
	Major Mandatory	MIB-254-MJM	Practical Based on Bacterial Physiology, Industrial Microbiology, Water Microbiology	Practical	02	25+25
	Minor	MIB-261-MN	Essentials of Microbiology	Theory	02	20+30
	Minor	MIB-262-MN	Microbiology laboratory essentials	Practical	02	25+25
	Open Elective (OE)	MIB-266-OE	Practicals on Scope & History of Microbiology	Practical	02	25+25
	Skill Enhancement Course (SEC)	MIB-276-SEC	Practicals on Dairy Microbiology	Practical	02	25+25
	Ability Enhancement Course (AEC)	MAR-281-AEC HIN-281-AEC SAN-281-AEC		Theory	02	20+30
	Community Engagement Project (CEP)	MIB-285-CEP	Community Engagement Project	Practical	02	25+25
	Co-curricular Course (CC)	YOG/ PES/ CUL/NSS/ NCC- 289-CC	NSS/NCC/Yoga/Cultural activities/Sports	Theory	02	20+30
	Total Credits Semester-IV				22	
	Cumulative Credits Semester III + Semester IV				46	

Course Structure for T. Y. B.Sc. (2023 Pattern)

Sem	Course Type	Course Code	Course Title	Theory/Practical	Credits
V	Major Mandatory	MIB-301-MJM	Genetics and Molecular Biology I	Theory	02
	Major Mandatory	MIB-302-MJM	Biochemistry I	Theory	02
	Major Mandatory	MIB-303-MJM	Immunology I	Theory	02
	Major Mandatory	MIB-304-MJM	Fermentation Technology I	Theory	02
	Major Mandatory	MIB-305-MJM	Practical course based on Medical Microbiology and Immunology	Practical	02
	Major Elective (MJE)	MIB-306-MJE(A)	Medical Microbiology I	Theory (Any Two)	02 + 02 = 04
	Major Elective (MJE)	MIB-306-MJE(B)	Food and Dairy Microbiology		
	Major Elective (MJE)	MIB-306-MJE(C)	Nanotechnology		
	Minor	MIB-311-MN	Agriculture Microbiology	Theory	02
	Minor	MIB-312-MN	Practical Course based on Agriculture Microbiology	Practical	02
	Vocational Skill Course (VSC)	MIB-321-VSC	Industrial Microbiology	Practical	02
	Field Project (FP)	MIB-335-FP	Field Project	Practical	02
				Total Credits (Semester-V)	22
VI	Major Mandatory	MIB-351-MJM	Genetics and Molecular Biology II	Theory	02
	Major Mandatory	MIB-352-MJM	Biochemistry II	Theory	02
	Major Mandatory	MIB-353-MJM	Immunology II	Theory	02
	Major Mandatory	MIB-354-MJM	Fermentation Technology II	Theory	02
	Major Mandatory	MIB-355-MJM	Practical course based on Biochemistry Genetics	Practical	02

	Major Elective (MJE)	MIB-356-MJE(A)	Medical Microbiology II	Theory (Any Two)	02 + 02 = 04
	Major Elective (MJE)	MIB-356-MJE(B)	Agriculture and Environmental Microbiology		
	Major Elective (MJE)	MIB-356-MJE(C)	Microbial Technology		
	Minor	MIB-361-MN	Dairy Microbiology	Theory	02
	Minor	MIB-362-MN	Practical course based on Dairy Microbiology	Practical	02
	On Job Training (OJT)	MIB-385-OJT	On Job Training	Practical	04
				Total Credits (Semester-VI)	22
				Total Credits (Semester V + VI)	44

CBCS Syllabus as per NEP 2020 for T. Y. B.Sc. Microbiology (2023 pattern) w. e. from Nov, 2025	
Name of the Programme	: B.Sc Microbiology
Programme Code	: USMI
Class	: T.Y.B.Sc.
Semester	: VI
Course Type	: Major Mandatory (Theory)
Course Code	: MIB-351- MJM
Course Title	: Genetics and Molecular biology II
No. of Credits	: 02
No. of Teaching Hours	: 30

Course Objective:

1. To introduce students to the fundamental mechanisms of genetic exchange in bacteria.
2. To explain the process and significance of **transformation** as a mode of horizontal gene transfer.
3. To describe the principles of **transduction** and the role of bacteriophages in gene transfer.
4. To elucidate the mechanism of **bacterial conjugation** and the role of the F plasmid and HFr strains.
5. To develop an understanding of **recombination mapping** and how it is used to determine gene order and distance.
6. To familiarize students with the experimental basis of mapping techniques such as co-transduction, co-transformation, and interrupted mating.
7. To highlight the applications of bacterial gene transfer and mapping in microbial genetics, biotechnology, and evolutionary studies

Course Outcome :

1. **Define** and **differentiate** the major mechanisms of genetic exchange — transformation, transduction, and conjugation.
2. **Explain** the discovery and experimental evidence supporting each type of gene transfer in bacteria.
3. **Describe** the molecular basis and steps involved in **natural and artificial transformation** in both Gram-positive and Gram-negative bacteria.

4. **Compare** generalized and specialized transduction and **interpret** their roles in bacterial genome evolution.
5. **Explain** the mechanism of conjugation, including the roles of F⁺ cells, F⁻ cells, and HFr strains in gene transfer.
6. **Calculate** recombination frequency and **construct** simple genetic maps based on experimental data.
7. **Apply** the concepts of gene transfer and mapping to understand bacterial variation, antibiotic resistance, and genetic engineering applications.

Credits	Unit	Topic	No. of Lectures
I	1	Gene Transfer Transformation	
		a) Discovery of natural transformation	01
		b) Natural transformation in Gram positive bacteria (<i>Streptococcus pneumoniae</i>)	03
		c) Natural transformation in Gram negative bacteria (<i>Haemophilus influenzae</i>)	03
		d) Artificial transformation	01
	2	Transduction	
		a) Discovery of transduction	02
		b) Generalized transduction (P22)	02
		c) Specialized transduction (Lambda phage)	03
II	1	Conjugation and Recombination Mapping	
		Conjugation	
		a) Discovery of conjugation	01
		b) F plasmid	01
		c) Cross F ⁺ × F ⁻	02
		d) Formation of HFr cell	02
		e) Cross HFr × F ⁻	02
	2	Recombination mapping	
		a) Principle of genetic mapping	01
		b) Concept of linkage and crossing over	02
		c) Map Unit – definition and calculation	01
		d) Recombination Frequency – formula, interpretation, and examples	02
		e) Relationship between map distance and recombination percentage	01

References:

1. Freifelder D. (2005). Molecular Biology. 2nd Edition. Narosa Publishing House Pvt. Limited, India.
2. Gardner E. J., Simmons M. J. and Snustad D. P. (2006). Principles of Genetics. 8th edition. John Wiley and Sons Publication. ISBN-13: 9788126510436 3. Lewin's GENES X (2011).
3. Krebs J., Kilpatrick S. T., Goldstein E. S. (Editors). 10th Edition. Sudbury, Mass.: Jones and Bartlett, c2011.
4. Lodish H., Berk A., Kaiser C. A., Krieger M., Bretscher A., Ploegh H., Martin K. C., Yaffe M. and Amon A. (2021). Molecular Cell Biology, 9th Edn. Macmillan Learning. ISBN: 9781319208523.
5. Russel P. J. (2000). Fundamentals of Genetics. Publisher: Benjamin/Cummings. ISBN: 9780321036261
6. Russel P. J. (2010). iGenetics: A Molecular Approach. 3rd Edition. Benjamin Cummings. ISBN: 9780321569769.
7. Stanier R. Y. (1999). General Microbiology. 5th Edition. Palgrave Macmillan.
8. Strickberger M.W. (2012). Genetics. 3rd Edition. New Delhi: PHI Learning Gardner
9. Watson J.D., Baker, T.A., Bell, S.P., Gann A., Levine M. and Losick R. (2014). Molecular Biology of the gene. 7th edition. Pearson. ISBN: 9780321762436
10. Robert Weaver, "Molecular biology", 3rd edn. Mc Graw Hill international edition

Mapping of course outcomes and programme outcomes:**Class : TYBSc (Sem VI)****Subject : Microbiology****Course : Genetics and Molecular biology II****Course code : MIB-351-MJM**

Weightage: 1= weak or low relation, 2= Moderate or partial relation, 3= Strong or direct relation

Course outcomes (COs)	Programme Outcomes (POs)												
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13
CO1	3	2	2	3	3	2	3	3	2	2	2	2	2

CO2	3	2	1	3	2	1	3	2	2	1	1	2	1
CO3	3	2	2	3	2	2	3	3	3	2	1	2	2
CO4	3	2	2	3	2	2	3	3	2	2	2	2	2
CO5	3	3	2	3	3	2	3	3	3	2	2	2	2
CO6	3	3	2	3	3	2	3	3	3	2	2	3	2
CO7	3	3	2	3	3	2	3	3	3	2	2	3	2

Justification for the Mapping:

PO1: Comprehensive Knowledge and Understanding

- CO1, CO2, and CO3 provide conceptual clarity of genetic exchange mechanisms in bacteria. CO4, CO5, and CO7 strengthen understanding of gene transfer processes and recombination mapping.

PO2: Practical, Professional, and Procedural Knowledge

- CO5, CO6, and CO7 involve practical mapping, conjugation, and recombination frequency calculations.
- CO3 develops procedural knowledge through natural and artificial transformation techniques.

PO3: Entrepreneurial Mindset and Knowledge:

- CO1, CO5, and CO7 relate to genetic manipulation and biotechnology applications, useful in pharmaceutical and diagnostic industries.

PO4: Specialized Skills and Competencies

- CO1, CO3, and CO6 develop specialized genetic mapping and analytical competencies.
- CO5 and CO7 emphasize experimental gene transfer methods relevant to applied microbiology.

PO5: Capacity for Application, Problem-Solving, and Analytical Reasoning

- CO1, CO4, CO5, and CO6 enhance analytical reasoning in understanding gene linkage, recombination, and genetic distance.

PO6: Communication Skills and Collaboration

- CO1 and CO3 promote effective communication of genetic data, results, and interpretation in lab reports.

PO7: Research-related Skills

- CO5, CO6, and CO7 foster experimental and analytical research abilities in bacterial genetics and mapping.
- CO2 supports data interpretation and evaluation of gene transfer experiments.

PO8: Learning How to Learn Skills

- CO3, CO4, CO5, and CO6 encourage continuous self-learning through experimental design, data interpretation, and review of genetic mapping tools.

PO9: Digital and Technological Skills

- CO6 and CO7 require use of computational or statistical methods for mapping analysis and recombination frequency calculations.

PO10: Multicultural Competence, Inclusive Spirit, and Empathy

- CO1 and CO4 promote understanding of microbial diversity across environmental and genetic contexts.

PO11: Value Inculcation and Environmental Awareness

- CO4 and CO7 highlight awareness of bacterial gene transfer in environmental adaptation and ecosystem stability.

PO12: Autonomy, Responsibility, and Accountability

- CO6 and CO7 encourage independent thinking, responsible data handling, and ethical research practices.

PO13: Community Engagement and Service

- CO1 and CO3 foster microbiological awareness through application of gene transfer knowledge in health, agriculture, and biotechnology.

CBCS Syllabus as per NEP 2020 for T. Y. B.Sc. Microbiology (2023 pattern) w. e. from Nov, 2025

Name of the Programme	: B.Sc. Microbiology
Program Code	: USMI
Class	: T. Y. B.Sc.
Semester	: VI
Course Type	: Theory
Course Name	: Biochemistry II
Course Code	: MIB-352-MJM
No. of Credits	: 02
No. of Lectures	: 30

Course Objectives:

1	Understand the structure and function of bacterial cell membranes and major transport mechanisms.
2	Explain passive and active transport processes and their biological significance in bacteria.
3	Describe the mechanisms and components involved in bacterial photosynthesis.
4	Analyze the oxygenic and anoxygenic photosynthetic pathways and regulation of the Calvin cycle.
5	Comprehend fundamental bioenergetic principles including the laws of thermodynamics and free energy concepts.
6	Identify key high-energy compounds important in cellular metabolism.
7	Understand the mitochondrial electron transport chain (ETC), ATP synthase structure and function, and related inhibitors.

Course Outcomes:

CO1	Students will be able to describe bacterial cell membrane composition and explain passive (diffusion, osmosis, facilitated transport) and active transport systems in bacteria.
CO2	Students will differentiate primary and secondary active transport, group translocation, and the role of ionophores in bacterial transport.

CO3	Students will explain the structure of the photosynthetic apparatus and distinguish oxygenic and anoxygenic photosynthetic mechanisms.
CO4	Students will outline the Calvin cycle steps, its regulation, and the ecological roles of photosynthetic bacteria.
CO5	Students will articulate the laws of thermodynamics relevant to bioenergetics and discuss entropy and free energy.
CO6	Students will list and describe the biochemical roles of various high-energy compounds such as pyrophosphate, enolic phosphates, and thioesters.
CO7	Students will diagram the mitochondrial ETC components, ATP synthase function, and describe the effects of inhibitors and uncouplers on oxidative phosphorylation.

Credit No.	Topics	Lectures
I	Unit 1: Membrane transport mechanisms	7
	Composition and Architecture of cell Membrane	1
	Passive transport: ➤ Diffusion ➤ Osmosis ➤ Facilitated transport	2
	Active transport: ➤ Primary active transport systems in bacteria ➤ Secondary active transport systems in bacteria	2
	Group translocation of sugars in bacteria	1
	Ionophores: Mechanism and examples	1
	Unit 2: Bacterial Photosynthesis	8
	Habitat and examples of photosynthetic bacteria	2
	Photosynthetic apparatus	2

	Oxygenic and Anoxygenic mechanisms	2
	Calvin cycle and its regulation	2
II	Unit 1: Bioenergetics	8
	Laws of thermodynamics	1
	Concepts of free energy, entropy	2
	High energy compounds: ➤ Pyrophosphate ➤ Enolic phosphates ➤ Acyl phosphates ➤ Thioester compounds ➤ Guanidinium compounds	5
	Unit 2: Electron transport chain	7
	Components of ETC	1
	Arrangement of different components in the inner membrane	1
	Structure and function of ATP synthase	1
	Inhibitors and uncouplers of ETC	1
	Oxidative phosphorylation	2
	Energetics of electron transport chain	1

References:

Topic	Reference Book(s)
Thermodynamics in biology, mitochondrial electron transport, and oxidative phosphorylation	➤ Nelson D. L. and Cox M. M. (2002) Lehninger's Principles of Biochemistry, Mac Millan Worth Pub. Co. New Delhi
Biochemical Calculations	➤ Segel Irvin H. (1997). Biochemical Calculations. 2nd Ed. John Wiley and Sons, New York.

Membrane transport, enzyme kinetics, bioenergetics, thermodynamics, and high-energy compounds.	➤ Biochemistry by Jeremy M. Berg, John L. Tymoczko, and Lubert Stryer, Ninth Edition, W.H. Freeman and Company, 2019
Cell membrane composition, transport systems, and bioenergetic processes including ATP synthase	➤ Molecular Biology of the Cell by Bruce Alberts et al., Sixth Edition, Garland Science, 2015
Bacterial transport mechanisms, energy metabolism, and photosynthesis	➤ Microbial Physiology by Albert G. Moat and John W. Foster, Fourth Edition, Wiley-Liss, 2002
Bacterial Photosynthesis	➤ White David (2000) Physiology and Biochemistry of Prokaryotes. 2nd Ed. Oxford University Press, New York. ➤ David A. Hall & Krishna Rao (1999) Photosynthesis (Studies in Biology) 6th Edition, Cambridge University Press, London
Energetics of electron transport chains, inhibitors, uncouplers, and ATP synthase function	➤ Bioenergetics by David G. Nicholls and Stuart J. Ferguson, Fourth Edition, Academic Press, 2013

Mapping of course outcomes and programme outcomes:

Class: T. Y. B.Sc. (Sem VI)	Subject: Microbiology
Course: Biochemistry II	Course code: MIB-352-MJM
Weightage: 1 = weak or low relation, 2 = Moderate or partial relation, 3 = Strong or direct relation	

	Program Outcomes												
Course outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13
CO1	3	3	1	2	3	2	2	2	2	1	1	2	1
CO2	3	3	1	3	3	2	2	2	2	1	1	2	1

CO3	3	2	1	3	2	2	2	2	1	1	1	2	1
CO4	3	2	1	3	3	2	2	2	1	1	1	2	1
CO5	3	2	1	3	3	2	2	3	2	1	1	3	1
CO6	3	3	1	3	3	2	2	2	2	1	1	2	1
CO7	3	3	1	3	3	2	3	2	2	1	1	3	1

Justifications:

- PO1 (Comprehensive Knowledge and Understanding): All COs involve deep understanding of biological and biochemical concepts, so all have strong (3) mapping.
- PO2 (Practical, Professional, and Procedural Knowledge): COs on mechanisms and biochemical roles involve practical and procedural knowledge, mostly strong or moderate (2-3).
- PO3 (Entrepreneurial Mindset and Knowledge): Generally low relevance (1) as COs are focused on core science.
- PO4 (Specialized Skills and Competencies): COs emphasizing technical and analytical understanding (CO2–CO7) show strong relation (3), CO1 moderate (2).
- PO5 (Application, Problem-Solving, and Analytical Reasoning): COs requiring critical thinking and problem solving (mostly in metabolism and bioenergetics) have strong links (3).
- PO6 (Communication Skills and Collaboration): Moderate relation (2) for all since explaining and discussing complex processes aids communication.
- PO7 (Research-related Skills): Moderate (2) or strong (3) for CO7 covering ETC and inhibitors; others moderate (2) due to analytical components.
- PO8 (Learning How to Learn Skills): Moderate (2–3) because understanding regulation and bioenergetics supports self-directed learning.
- PO9 (Digital and Technological Skills): Moderate (1–2) due to possible use of software in analyzing biochemical data.
- PO10 (Multicultural Competence, Inclusive Spirit, and Empathy): Low (1) as less related to the scientific content.
- PO11 (Value Inculcation and Environmental Awareness): Low (1) because core biochemical COs have less direct environmental focus.

- PO12 (Autonomy, Responsibility, and Accountability): Moderate (2–3) where higher order skills such as diagramming ETC and data interpretation apply.
- PO13 (Community Engagement and Service): Low (1), since COs focus on fundamental science rather than community work.

CBCS Syllabus as per NEP 2020 for T. Y. B.Sc. Microbiology (2023 pattern) w. e. from Nov, 2025	
Name of the Programme	: B.Sc. Microbiology
Programme Code	: USMI
Class: T. Y. B.Sc.	: T. Y. B.Sc
Semester	: VI
Course Type	: Major Mandatory (Theory)
Course Code	: MIB-353-MJM
Course Title	: Immunology II
No. of Credits	: 02
No. of Teaching Hours	: 30

A. Learning Objectives:

1. To enrich the students knowledge about immunity and infections.
2. To develop expertise in immunological processes.
3. To enrich student's knowledge and train them in immunology.
4. To understand the general and scientific responsibilities while working in medical field.
5. To develop opportunities in entrepreneurship.
6. To enhance the knowledge of immunology.
7. To inculcate the Students and Society for immunization.

B. Course outcomes: On completion of the course, the students will be able to:

1. Theoretical understanding of basic immunological processes.
2. Each student would be able to understand immune mechanism of our body.
3. Students would be able to apply his knowledge to society for human welfare.
4. Establishment and development as an entrepreneur.
5. Apply his knowledge to society for human welfare.
6. Establishment and development as an entrepreneur.
7. Explain the basic knowledge of immunity.

Credits	Unit	Topic	No. of working hours.
I	1	Antigen-Antibody Interactions: Principles of interactions: Antibody affinity and avidity. Visualization of antigen antibody complexes: a. Precipitation reactions: in fluid and in gel, Immuno-electrophoresis b. Agglutination reactions: Hemagglutination, bacterial agglutination, passive agglutination and agglutination-inhibition c. Immunofluorescence techniques: direct and indirect, FACS d. ELISA e. RIA	6
	2	Major Histocompatibility Complex: a. Structure of MHC in man b. Structure and functions of MHC class-I and class-II molecules c. MHC antigen typing (microcytotoxicity and mixed lymphocyte reaction)	3
	3	Cytokines: Types, General characters and role in immune activation Interferon's, Interleukins and TNFs	3
	4	Public Health Immunology - a. Types of vaccines and Antisera b. Current perspective of vaccines. c. Immunization schedule in India	3
II	1	Immunohematology a. Systems of blood group antigens b. ABO system: Biochemistry of blood group substances, Bombay blood group, Inheritance of ABH antigens d. Laboratory methods of blood group typing, Coomb's test f. Blood banking practices, transfusion reactions	6
	2	Hypersensitivity - a. Immediate and delayed type hypersensitivity	3

		b. Gell and Coomb's classification of hypersensitivity – mechanism with examples for type I, II, III and IV	
	3	Autoimmunity and Autoimmune diseases- a. Immunological tolerance b. Types of autoimmune diseases c. Diagnosis and treatment of autoimmune diseases: Myasthenia gravis and Rheumatoid arthritis	3
	4	Transplantation- Transplantation and Immunity a. Types of Grafts, b. Allograft rejection mechanisms c. Prevention of allograft rejection	3

References:

1. Abul K. Abbas and Andrew H. Lichtman. **Basic Immunology- Functions and Disorders of Immune System. 2nd Ed. 2004.** Saunders. Elsevier Inc. PA. USA.
2. Aderem, A., and Underhill, D.M.: Mechanisms of phagocytosis in macrophages. *Annu. Rev. Immunol.* 1999, 17:593–623.
3. Austin J. M. and Wood K. J. (1993) *Principles of Molecular and Cellular Immunology*, Oxford University Press, London.
4. Barret James D. (1983) **Text Book of Immunology 4th edition**, C. V. Mosby & Co. London.
5. Chatterji C. C. (1992) *Human Physiology Vol. 1 &2*, Medical Allied Agency, Calcutta.
6. De Smet, K., and Contreras, R.: Human antimicrobial peptides: defensins, cathelicidins and histatins. *Biotechnol. Lett.* 2005, 27:1337–1347.
7. Ganz, T.: Defensins: antimicrobial peptides of innate immunity. *Nat. Rev. Immunol.* 2003,
8. Garrison Fathman, Luis Soares, Steven M. Chai & Paul J. Utz, (2005), An array of possibilities for the study of autoimmunity, *Nature Rev.*, 435|2:605-611 Bendelac Albert, Paul B. Savage, and Luc Teyton, (2007)
9. Guyton A. C. and Hall J. E. (1996) *Text Book of Medical Physiology*, Goel Book Agency, Bangalore.
10. Janeway Charles A., Paul Travers, Mark Walport, Mark Shlomchik. **IMMUNOBIOLOGY INTERACTIVE.** 2005. Garland Science Publishing. USA.
11. Kindt T. J., Goldsby R. A., Osborne B. A., 2007, **Kuby Immunology 6th Ed.** W. H. Freeman & Co., New York

12. Pathak S. S. and Palan V. (1997) Immunology - Essential and Fundamental, Preen Publications Bombay.
13. Roitt Evan, Brostoff J. Male D. (1993) Immunology 6th Ed., Mosby & Co. London.
14. Roitt I. M. (1988) Essentials of Immunology, ELBS, London.
15. Roitt M. (1984) Essentials of Immunology, P. G. Publishers Pvt. Ltd., New Delhi.
16. Stites D. P., Stobo J. D., Fudenberg H. H. and Wells J. V., (1982), Basic and Clinical Immunology, 4th Ed., Lange Medical Publications, Maruzen Asia Pvt. Ltd., Singapore
17. Talwar G. P. (1983) Handbook of Immunology, Vikas Publishing Pvt. Ltd. New Delhi,
18. Zeev Pancer and Max D. Cooper, (2006), The Evolution of Adaptive Immunity, Ann. Rev. Immunol., 24: 497–518.
19. Abul K. Abbas and Andrew H. Lichtman. *Basic Immunology- Functions and Disorders of Immune System*. 2nd Ed. 2004. Saunders. Elsevier Inc. PA. USA.
20. Barret James D. (1983) *Text Book of Immunology* 4th edition, C. V. Mosby & Co. London.
21. kubey, *Immunology*, 5th edition.

Mapping of Program Outcomes with Course Outcomes

Class : TYBSc (Sem VI)

Subject : Microbiology

Course : Immunology II

Course code : MIB-353-MJM

Weight age: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

Course outcomes	Program Outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13
CO1	3	2	1	2	3	1	2	2	1	1	2	2	1
CO2	3	3	1	2	3	2	2	2	1	1	2	2	1
CO3	3	3	2	2	3	3	3	2	1	2	3	3	3
CO4	2	3	3	3	3	2	2	3	2	1	1	3	2
CO5	3	3	2	2	3	3	3	2	1	2	3	3	3
CO6	2	3	3	3	3	2	2	3	2	1	1	3	2
CO7	3	2	1	2	3	1	2	2	1	1	2	2	1

Justifications:

- PO1 (Comprehensive Knowledge and Understanding): Strong (3) because all COs entail foundational immunology concepts.

- PO2 (Practical Knowledge): Moderate to strong (2-3) for COs involving application and entrepreneurship.
- PO3 (Entrepreneurial Mindset): Strong (3) in CO4 and CO6 related to entrepreneurial development.
- PO4 (Specialized Skills): Moderate (2-3) as immunological knowledge requires technical skills.
- PO5 (Application, Problem-Solving): Strong (3) in almost all COs applying knowledge to welfare and entrepreneurship.
- PO6 (Communication and Collaboration): Moderate (2-3) especially in applying knowledge for human welfare (CO3, CO5).
- PO7 (Research-related Skills): Moderate (2-3) given inquiry to understand immune mechanisms and applications.
- PO8 (Learning How to Learn): Moderate (2-3) supporting self-directed learning and adaptation.
- PO9 (Digital/Tech Skills): Mostly weak to moderate (1-2), less emphasis here.
- PO10 (Multicultural Competence): Low (1), not directly relevant.
- PO11 (Value Inculcation and Environmental Awareness): Moderate (2-3) due to emphasis on welfare and ethics.
- PO12 (Autonomy, Responsibility): Strong (3) in entrepreneurship and application COs.
- PO13 (Community Engagement): Strong (3) where COs focus on societal welfare and engagement.

CBCS Syllabus as per NEP 2020 for T. Y. B.Sc. Microbiology (2023 pattern) w. e. from Nov, 2025	
Name of the Programme	:B.Sc. Microbiology
Programme code	: USMI
Class	: T.Y.B.Sc.
Semester	: VI
Course Type	: Theory
Course Code	: MIB-354-MJM
Course Title	: Fermentation Technology II
No. of Credits	: 02
No. of Teaching Hours	: 30

Course Objectives:

1. To cater the needs of students for building up their careers in pharmaceutical and fermentation industries.
2. To understand the basic industrial fermentation processes.
3. To understand the basic process of production of primary metabolites.
4. To develop expertise in industrial production of secondary metabolites.
5. To enrich student's knowledge about production of microbial biomass as fermentation product.
6. To understand the general method of production of human consumables viz., vaccines.
7. To understand the opportunities towards entrepreneurship.

Course Outcome:

- CO1: Theoretical understanding of production process of primary metabolites.
- CO2: Students will be able to understand the importance of industrially important microbial products.
- CO3: Students will be able to understand the processing of raw materials for the production of secondary metabolites.
- CO4: Students will be able to understand and advanced techniques of production of fermentation products other than primary and secondary metabolites such as vaccines.
- CO5: Students will be able to understand the basic difference between microbial fermentation and transformation.

CO6: Students will be able to understand the production of fermented dairy products.

CO7: Establishment and development as an entrepreneur.

Credit No.		Topic and Learning Points	Teaching Hours
I	Unit 1	Introduction to Solid state fermentation and Submerged fermentation	1
	Unit 2	Uses of the following primary metabolites and their large-scale production (with respect to microbial producers, production process & recovery, and flowsheet): i. Vitamins B12 ii. Lysine iii. Organic acids (Citric acid, Acetic acid & Lactic acid)	1 1 4
	Unit 3	Uses of the following secondary metabolites and their large-scale production (with respect to microbial producers, production process & recovery, and flowsheet): i. Ethanol ii. Alcoholic beverages (Beer and Wine) iii. Antibiotics (Penicillin and Streptomycin)	1 4 3
II	Unit 1	Uses of the following primary metabolites and their large-scale production (with respect to microbial producers, production process & recovery, and flowsheet): i. Amylase ii. Protease	3
	Unit 2	Uses of the following fermentation products and their large-scale production (with respect to microbes involved, production process, and flowsheet): i. Baker's and Distiller's yeast ii. Edible mushroom iii. Dairy products:	5

		a. Cheese b. Yoghurt	
	Unit 3	Uses and large-scale production of the following: i. Viral vaccines (Polio, Rabies) ii. Bacterial vaccine (Tetanus toxoid) iii. Immune Sera	3 1 2
	Unit 4	Steroid transformation by microbes	1

References:

1. Gajbhiye M. H. (Editor) (2025) *Fundamentals of Fermentation Technology*, Cambridge Scholars Publishing, UK.
2. A. H. Patel. (1985), *Industrial Microbiology*, Macmillan India Ltd.
3. *Bioreactor Design and Product Yield* (1992), BIOTOL series, Butterworths Heinemann.
4. Casida, L. E., (1984), *Industrial Microbiology*, Wiley Easterbs, New Delhi
5. Dilip K. Arora editor, *Fungal Biotechnology in agriculture, food and environmental applications (Mycology)*, 2005. Marcel Dekker, Inc. New York. Basel
6. Indian Pharmacopia and British Pharmacopia.
7. Lydersen B., N. a. D' Elia and K. M. Nelson (Eds.) (1993) *Bioprocess Engineering: Syatems, Equipment and Facilities*, John Wiley and Sons Inc.
8. *Operational Modes of Bioreactors*, (1992) BIOTOL series, Butterworths Heinemann.
9. Peppler, H. L (1979), *Microbial Technology*, Vol I and II, Academic Press, New York.
10. Peter F. Stanbury. *Principles Of Fermentation Technology*, 2E, Elsevier (A Division of Reed Elsevier India Pvt. Limited), 2009
11. Prescott, S.C. and Dunn, C. G., (1983) *Industrial Microbiology*, Reed G. AVI tech books.
12. Reed G. Ed. Prescott and Dunn's *Industrial Microbiology*. 4th Ed., CBS Pub. New Delhi.
13. Shuichi and Aiba. *Biochemical Engineering*. Academic Press. 1982.

14. Stanbury, P. F. & Whittaker, A. (1984) *Principles of Fermentation Technology*, Pergamon press.
15. Sudhir U. Meshram, Gangadhar B Shinde, *Applied Biotechnology*. I.K. International Pvt. Ltd. 2009.
16. Moo-Young M. (2004) *Comprehensive biotechnology*, Vol- 1 to 4, Pergamon press Ltd, England.
17. Flickinger, M. C. and Drew, S. W. (1999). *Encyclopedia of Bioprocess Technology*, Wiley-Interscience, New Jersey.
18. Van Damme E. J. (1984) *Biotechnology of Industrial Antibiotics*, Marcel Dekker Inc. New York.
19. Wiseman A.(1985) *Topics in Enzyme and Fermentation - Biotechnology*, Vol. 1 and 2, John Wiley and Sons, New York.

Mapping of course outcomes and programme outcomes:

Mapping of course outcomes and programme outcomes:	
Class: T. Y. B.Sc. (Sem VI)	Subject: Microbiology
Course: Fermentation Technology II	Course code: MIB-354-MJM
Weightage: 1 = weak or low relation, 2 = Moderate or partial relation, 3 = Strong or direct relation	

Course outcomes	Program Outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13
CO1	3	3	1	2	3	1	2	2	2	1	1	2	1
CO2	3	3	1	2	3	2	2	2	2	1	1	2	1
CO3	3	3	1	2	3	1	2	2	2	1	1	2	1
CO4	3	3	1	3	3	2	2	2	2	1	1	3	1
CO5	3	2	1	2	2	1	2	2	1	1	1	2	1
CO6	3	3	1	2	3	2	2	2	2	1	1	2	1
CO7	2	3	3	3	2	2	2	3	2	1	1	3	2

Justifications:

PO1: (Comprehensive Knowledge): All COs strongly require foundational and sector-specific knowledge.

PO2: (Practical Knowledge): Strong application in industrial processes and entrepreneurship-related activities.

PO3: (Entrepreneurial Mindset): Primarily reflected in CO7 emphasizing development as entrepreneur; lesser in others.

PO4: (Specialized Skills): Notably strong for CO4 and CO7 due to advanced production techniques and entrepreneurship.

PO5: (Application & Problem-Solving): Essential across all, especially practical production and innovation processes.

PO6: (Communication): Moderate linkage given the need to communicate industrial and entrepreneurial concepts.

PO7: (Research Skills): Moderate as production process understanding and innovations require research.

PO8: (Learning Skills): Needed for adapting to new processes especially in CO7.

PO9: (Digital & Tech Skills): Moderate relation due to use of technology in production and entrepreneurship.

PO10 -PO11: (Multicultural, Values): Low relation as focus is technical and entrepreneurial.

PO12: (Autonomy & Accountability): Strengthened in CO7 requiring project and business management.

PO13: (Community Engagement): Moderate in entrepreneurship promoting societal development.

CBCS Syllabus as per NEP 2020 for T. Y. B.Sc. Microbiology (2023 pattern)

CBCS Syllabus as per NEP 2020 for T. Y. B.Sc. Microbiology (2023 pattern) w. e. from Nov, 2025	
Name of the Programme	: B.Sc. Microbiology
Program Code	: USMI
Class	: T. Y. B.Sc.
Semester	: VI
Course Type	: Practical
Course Name	: Practical course based on Biochemistry Genetics
Course Code	: MIB-355-MJM
No. of Credits	: 02
No. of Practicals	: 15

Course Objectives:	
1	Understand the principles and methods of enzyme purification, including precipitation, dialysis, and activity determination.
2	Examine the effects of pH and temperature on enzyme activity and stability.
3	Learn the technique of enzyme immobilization and its applications.
4	Master isolation and enumeration methods for bacteriophages.
5	Gain proficiency in bacterial genomic DNA isolation and estimation.
6	Understand preparation of competent <i>E. coli</i> cells, transformation procedures, and selection of transformants.
7	Develop skills in mutation isolation using replica plating and experience real-world lab/industry setups.
Course Outcomes:	
CO1	Students will be able to purify enzymes from fermentation broth, quantify specific activity, and construct purification charts.
CO2	Students will analyze how pH and temperature influence enzyme activity and interpret results experimentally.

CO3	Students will demonstrate immobilization of enzymes like invertase and understand its benefits for industrial applications.
CO4	Students will isolate and count bacteriophages using appropriate microbiological techniques.
CO5	Students will isolate and estimate bacterial genomic DNA quantitatively and qualitatively.
CO6	Students will prepare competent <i>E. coli</i> cells, perform transformation, and select for transformed colonies.
CO7	Students will use replica plating techniques to isolate mutant bacterial strains and relate these to practical research and industry contexts.

No. of Practicals	Topics	No. of Teaching Hours
1 - 4	Enzyme Purification: ➤ Precipitation of amylase from fermentation broth ➤ Dialysis ➤ Determination of specific activity of crude and purified amylase ➤ Establishment of Purification chart	16
5	Effect of pH on enzyme activity	4
6	Effect of Temperature on enzyme activity	4
7	Immobilization of Invertase	4
8	Comparison of activity of free cell and immobilised cell	4
9	Isolation and enumeration of bacteriophages	4
10	Genomic (bacterial) DNA isolation	4
11	Genomic (bacterial) DNA estimation	4
12	Preparation of competent <i>E. coli</i> cells	4
13	Transformation of <i>E. coli</i> and selection of transformants	4

14 - 15	Visit to Research laboratory/Industry	8
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References:	
Topic	Reference Book
Enzyme purification, activity assays, dialysis, and data analysis.	➤ Experiments in the Purification and Characterization of Enzymes: A Laboratory Manual by David T. Dennis, Susan L. Dennis, Sixth Edition, Academic Press, 2014.
Enzyme purification, kinetic studies, effect of pH and temperature on enzymes, and immobilization techniques	➤ Biochemistry Laboratory: Modern Theory and Techniques by Rodney F. Boyer, Third Edition, Pearson Education
Bacterial DNA isolation, preparation of competent cells, transformation, and mutant isolation protocols	➤ Molecular Biology Techniques: A Classroom Laboratory Manual by Heather Miller, D. Scott Witherow, Sue Carson, Second Edition, Cold Spring Harbor Laboratory Press, 2012
Bacteriophage isolation, enumeration	➤ Microbiology: A Laboratory Manual by James Cappuccino and Natalie Sherman, Eleventh Edition, Pearson Education, 2014
Strategies and methods for protein (enzyme) purification including precipitation, dialysis, and immobilization	➤ Guide to Protein Purification by Murray P. Deutscher, Third Edition, Academic Press, 2010
Enzyme purification, bacteriophage isolation, and bacterial genetics techniques	➤ Practical Microbiology and Biochemistry by Krishna Gopal, Second Edition, Atma Ram & Sons, 2018.

Enzyme purification and characterization protocols	➤ Methods in Enzymology, Volume 182: Enzyme Purification and Related Techniques edited by Sidney P. Colowick and Nathan O. Kaplan, Academic Press, latest edition
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Mapping of course outcomes and programme outcomes:

Class: T. Y. B.Sc. (Sem VI)	Subject: Microbiology
Course: Practical course based on Biochemistry Genetics	Course code: MIB-355-MJM
Weightage: 1 = weak or low relation, 2 = Moderate or partial relation, 3 = Strong or direct relation	

	Program Outcomes												
Course outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	P O 13
CO1	3	3	1	3	3	2	3	2	2	1	1	3	1
CO2	3	3	1	3	3	2	2	2	2	1	1	2	1
CO3	3	2	1	3	3	2	2	2	1	1	1	2	1
CO4	3	3	1	3	3	2	3	2	1	1	1	2	1
CO5	3	3	1	3	3	2	3	3	2	1	1	3	1
CO6	3	3	1	3	3	3	3	3	2	1	1	3	1
CO7	3	3	1	3	3	3	3	3	2	1	1	3	1

Justifications:

PO1: (Comprehensive Knowledge and Understanding): All COs involve deep theoretical and methodological knowledge in enzyme and molecular microbiology techniques, thus strong relation (3).

PO2: (Practical, Professional, and Procedural Knowledge): COs cover practical lab procedures including purification, transformation, and DNA isolation, providing strong application (mostly 3).

PO3: (Entrepreneurial Mindset and Knowledge): Limited direct entrepreneurial relevance, thus marked as weak (1).

PO4: (Specialized Skills and Competencies): Technical and analytical skills emphasized in all COs giving strong relation (3).

PO5: (Capacity for Application, Problem-Solving, and Analytical Reasoning): Critical thinking and problem-solving required in experimental interpretation; thus, strong relation (3).

PO6: (Communication Skills and Collaboration): Moderate (2-3) as reporting findings and teamwork are integral in lab settings.

PO7: (Research-related Skills): Emphasis on research methodologies, inquiry, and data analysis justify strong relation (3) especially for CO1, CO4, CO5, CO6, and CO7.

PO8: (Learning How to Learn Skills): Moderate to strong (2-3) as students develop independent learning and adaptability through experiments.

PO9: (Digital and Technological Skills): Moderate relation (2) via use of data analysis and possibly software in estimating DNA.

PO10: (Multicultural Competence, Inclusive Spirit, and Empathy): Low relation (1) since content is primarily technical.

PO11: (Value Inculcation and Environmental Awareness): Low relation (1), minimal direct connection.

PO12: (Autonomy, Responsibility, and Accountability): Strong relation (3) reflecting independence and accountability in lab work.

PO13: (Community Engagement and Service): Low relation (1) due to focus on laboratory techniques rather than direct community involvement.

CBCS Syllabus as per NEP 2020 for T. Y. B.Sc. Microbiology (2023 pattern) w. e. from Nov, 2025	
Name of the Programme	:T.Y.B.Sc. Microbiology
Program Code	:USMI
Class	:T.Y.B.Sc.
Semester	:VI
Course Type	:Elective theory
Course Name	:Medical Microbiology-II
Course Code	:MIB-356-MJE (A)
No. of Credits	:02
No. of Lectures	:30

Course Objectives (CO)

- 1 Understand the basic principles of chemotherapy including selective toxicity, drug bioavailability, MIC, MBC, and LD₅₀ values.
- 2 Learn various routes of drug administration and their pharmacological significance.
- 3 Describe the mode of action of antimicrobial agents against bacteria, fungi, viruses, and protozoa.
- 4 Comprehend the mechanisms of drug resistance and the biochemical reasons behind it.
- 5 Study important protozoan parasites such as *Plasmodium* and *Entamoeba* with emphasis on life cycle, pathogenicity, and chemotherapy.
- 6 Understand major fungal pathogens like *Candida* and *Aspergillus*—their morphology, pathogenesis, diagnosis, and control measures.
- 7 Gain knowledge of human viral pathogens (HIV, SARS-CoV-2) including virion structure, replication, diagnosis, epidemiology, and prophylaxis

1. Course Outcomes (CO)

CO1: Explain the concept of selective toxicity and evaluate parameters related to drug efficacy and safety.

CO2: Demonstrate understanding of different antimicrobial drug classes and correlate their mode of action with target microorganisms.

CO3: Analyze how structural and functional alterations in pathogens contribute to antimicrobial resistance.

CO4: Identify and differentiate important protozoan, fungal, and viral pathogens based on morphological and diagnostic features.

CO5: Assess clinical symptoms, laboratory diagnosis, and preventive measures of major microbial diseases.

CO6: Apply knowledge of chemotherapy and prophylaxis in proposing suitable treatment strategies for infectious diseases.

CO7: Develop a comprehensive understanding of host–pathogen–drug interactions for effective disease management and control.

Credit No.		Topic	No. of lectures
1		Introduction to Chemotherapy:	15
	Unit 1	Concept of Selective toxicity, Bioavailability of Drug, MIC, MBC & LD-50 value	02
		Routes of drug administration	02
	Unit2.	Mode of action of following antimicrobial agents on	
		Bacteria:	
		• Cell wall (Betalactams, Cycloserine, Bacitracin)	02
		• Cell membrane (Polymyxin, Monensin)	02
		• Protein synthesis (Streptomycin, Tetracyclin)	02
		• Nucleic Acids (Nalidixic acid, Rifamycin)	01
		• Enzyme inhibitors (Trimethoprim, Sulfadruugs)	02
		Fungi (Griseofulvin, AmphotericinB)	01
		Viruses (Acyclovir, Remdesivir)	01
		Protozoa (Metronidazole, Mepacrine)	01
	Unit3.	Mechanism and reasons of drug resistance	
		Alteration in target site, Blockage of transport of drug, Inactivation of drug Metabolic bypass	01

2	Study of Protozoan, Viral and fungal parasites		15
	Unit1.	Study of following groups of parasites (with respect to – Classification, lifecycle, Morphological characteristics, Viability characteristics, Pathogenicity, Pathogenesis, Symptoms, Laboratory diagnosis (serological diagnosis wherever applicable), Prophylaxis and Chemotherapy)	
		<i>Plasmodium</i> <i>Entamoeba</i>	03 02
	Unit 2	Study of following groups of fungal pathogens (with respect to– Morphological and cultural characteristics, Classification, Pathogenicity, Pathogenesis, Symptoms, Laboratory diagnosis, Prophylaxis and Chemotherapy):	
		<i>Candida</i> , <i>Aspergillus</i>	02 02
	Unit 3	Study of human pathogenic viruses: (with respect to – Virion characteristics, Viability characteristics, Pathogenicity, Pathogenesis, Symptoms, Laboratory diagnosis including serological diagnosis, Epidemiology, Prophylaxis and Chemotherapy):	
		HIV Dengue Virus Influenza Virus	02 02 02

References:

1. Tortora, G.J., Funke, B.R., Case, C.L., 1992. Microbiology: An introduction 5th Edition, Benjamin Pub. Co. NY

2. Roitt, P.I: Mims, C.J. Medical Microbiology
3. Chakraborty, P., 2003 A textbook of Microbiology, 2nd Edition New Central Book Agency, India.
4. Medical Microbiology edited by Samuel Baron. Fourth Edition. (University of Texas Medical Branch of Galveston)
5. Sherris, John C, Ed, Medical Microbiology: an Introduction to infectious diseases. Elsevier Publication II nd edition.
6. Virulence mechanisms of bacterial pathogens (Second edition) by Roth, Bolin, Brogden Minion and Michael.
7. Davis B.D., Delbacco, 1990 Microbiology 4th edition, J.B. Lippincott Co. NY
8. Wolfgang K. Joklik, 1992, Zinsser Microbiology 20th Edition, McGraw-Hill Professional Publishing.
9. Dey, N. C and Dey, TK. 1988, Medical Bacteriology, Allied Agency, Calcutta, 17th Edition
10. Ananthnarayana, R. and C. E, Jayaram Panikar, 1996 Textbook of microbiology, 5th edition, Orient Longman

Mapping of Program Outcomes with Course Outcomes

Weightage: 1=weak or low relation, 2=moderate or partial relation, 3=strong or direct relation

CO	Programme outcome (POS)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO10	PO11	PO12	PO13
CO1.	3	2	1	2	2	1	2	1	2	1	2	2	1
CO2	3	3	2	2	2	1	2	1	2	1	2	2	1
CO3	3	3	2	2	3	2	3	2	2	1	2	2	1
CO4	3	2	2	3	2	2	2	2	2	1	2	2	2
CO5	3	2	2	3	3	2	2	2	2	1	3	2	2
CO6	3	3	2	3	3	2	2	2	2	1	3	2	2
CO7	3	3	2	3	3	3	3	2	2	2	3	3	2

Justification for Mapping

PO1: Comprehensive Knowledge and Understanding:

All COs directly contribute through conceptual understanding of microbial diseases, drug mechanisms, and resistance (high mapping 3).

PO2: Practical, Professional, and Procedural Knowledge:

Most COs involve understanding of laboratory diagnosis, drug evaluation, and treatment strategies — strong mapping (2–3).

PO3: Entrepreneurial Mindset and Knowledge.

Moderate links, as understanding drug mechanisms and control strategies fosters innovation in pharma/biotech sectors.

PO4: Specialized Skills and Competencies.

High mapping where diagnostic, analytical, and therapeutic application skills are demonstrated (2–3).

PO5: Capacity for Application, Problem-Solving, and Analytical Reasoning.

COs 3, 5, 6, and 7 especially develop problem-solving and reasoning through case-based analysis (mostly 3).

PO6: Communication Skills and Collaboration:

Moderate link; interpretation of results and teamwork in diagnostic/lab settings promote collaborative communication (1–3).

PO7: Research-related Skills.

Analytical and investigative approaches in CO3, CO6, and CO7 relate directly to research and data interpretation

PO8: Learning How to Learn Skills

Moderate relation through updating knowledge of emerging pathogens and drug resistance mechanisms.

PO9: Digital and Technological Skills.

Application of diagnostic tools, bioinformatics, and databases for drug resistance and disease management (2).

PO10: Multicultural Competence, Inclusive Spirit, and Empathy:

Weak–moderate link; understanding global disease burden enhances empathy and inclusiveness.

PO11: Value Inculcation and Environmental Awareness.

Linked through ethical drug use, public health awareness, and biosafety measures

PO12: Autonomy, Responsibility, and Accountability.

Strong for CO6–CO7; responsible clinical decision-making and adherence to medical ethics (2–3).

PO13: Community Engagement and Service:

Moderate link in CO4–CO7; understanding disease prevention and public health contributes to community welfare (2).

CBCS Syllabus as per NEP 2020 for T. Y. B.Sc. Microbiology (2023 pattern) w. e. from Nov, 2025	
Name of the Programme	: B.Sc. Microbiology
Program Code	: USMI
Class	: T.Y.B.Sc.
Semester	: VI
Course Type	: Major Elective Theory (MJE)
Course Name	: Agricultural and Environmental Microbiology
Course Code	: MIB-356-MJE (B)
No. of Credits	: 02
No. of Lectures	: 30

Course Objectives:

1. To understand the fundamental mechanisms of nitrogen fixation, phosphate solubilization, potassium mobilization, and iron chelation in biofertilizers.
2. To explore the production techniques, methods of application, and the various uses of different biofertilizers, including *Azotobacter*, *Rhizobium*, Blue Green Algae, and Phosphate Solubilizing Microorganisms.
3. To examine the mechanism behind nitrogen fixation, its role in sustainable agriculture, and the microbial organisms involved in this process.
4. To investigate the types of biopesticides, their advantages, and their role in integrated pest management systems.
5. To explore the concept of bioremediation and how plants and microbes contribute to the degradation of pollutants like xenobiotics and hydrocarbons.
6. To study bioaugmentation, including the use of microbial cultures and enzymes to enhance the bioremediation process.
7. To understand the process of bioleaching, including microorganisms involved and its application in the extraction of metals like copper and gold.

Course Outcomes:

CO1: Students will be able to describe and understand the mechanisms of nitrogen fixation, phosphate solubilization, potassium mobilization, and iron chelation in biofertilizers.

CO2: Students will be proficient in the production, application, and uses of biofertilizers such as Azotobacter, Rhizobium, Blue Green Algae, and Phosphate Solubilizing Microorganisms.

CO3: Students will gain the ability to apply knowledge of nitrogen fixation and its role in sustainable farming practices.

CO4: Students will learn to differentiate between various types of biopesticides and their applications in pest control, and will appreciate their advantages over traditional chemical pesticides.

CO5: Students will gain an understanding of bioremediation techniques and the roles that plants and microorganisms play in cleaning up pollutants, particularly xenobiotics and hydrocarbons.

CO6: Students will be able to explain the concept of bioaugmentation and its practical use for enhancing environmental cleanup using microbial cultures and enzymes.

CO7: Students will acquire knowledge of bioleaching, including the microorganisms used, the process involved, and its advantages in the mining of valuable metals like copper and gold.

Credit No.	Unit No.	Topic	Lecture
1	Unit 1	Biofertilizers	15
		Introduction, Definition, Production, Methods of application and uses of following biofertilizers: <i>a. Azotobacter</i> <i>b. Rhizobium</i> c. Blue green algae d. Phosphate solubilizing microorganisms	05
		Introduction, Definition, Mechanism of following : a. Nitrogen Fixation b. Phosphate solubilization c. Potassium mobilization d. Iron chelation	06
	Unit 2	Biopesticides	04
		a. Introduction	

		b. Types of biopesticide: Microbial, plant- incorporated- protectants (PIPs) and Biochemical pesticides. c. Advantages	
2		Environmental microbiology	15
	Unit 1	Bioremediation: a. Introduction b. Definition c. Role of plants & Microbes in Bioremediation of: Xenobiotics and Hydrocarbons d. Genetically Modified microorganisms in bioremediation.	05
		Bioaugmentation: a. Introduction b. Definition c. Use of microbes and enzymes for bioaugmentation d. Applications	04
	Unit 2	Bioleaching: a. Introduction b. Definition c. Types: Direct and Indirect leaching d. Microorganisms used e. Bioleaching process: Pyrite, Chalcopyrite, Slop, In-situ, and Heap leaching. f. Bioleaching of - Copper & Gold d. Advantages of Bioleaching	06

References:

1. Ajay Singh, Owen P. Ward, 2004 edition, Applied Bioremediation and Phytoremediation (Soil Biology). Springer
2. David S. Ingram, N.F. Robertson (1999). Plant Disease. 1st Edn.: Collins
3. George Nicholas Agrios (2005). Plant Pathology. 5th Edn. Academic Press Inc.

4. John Postgate, (1998). Nitrogen Fixation. Cambridge University Press, K. S. Bilgrami, H. A. Dube (1984). A textbook of modern plant pathology. 7th Edn
5. Martin Alexander (1999). Biodegradation and Bioremediation. Academic Press
6. Matthew Dickinson, (2003). Molecular Plant Pathology. Garland Publishing Inc.
7. Martin Alexander (1999). Biodegradation and Bioremediation. Academic Press
8. Matthew Dickinson, (2003). Molecular Plant Pathology. Garland Publishing Inc.
9. N. S. Subba Rao. (1995). Soil Microorganisms and Plant growth. 3rd Edn. Science Pub Inc
10. R. Barry King, John K. Sheldon, Gilbert M. Long, 1997 Practical

Mapping of course outcomes and programme outcomes:

Class: T.Y.B.Sc. (Sem VI)

Subject: Microbiology

Course: Agricultural and Environmental Microbiology (Theory)

Course code: MIB-356-MJE (B)

Weightage: 1= weak or low relation, 2= Moderate or partial relation, 3= Strong or direct relation

	Programme Outcomes (POs)												
Course outcomes (COs)	PO 1	PO 2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO9	PO1 0	PO11	PO1 2	PO1 3
CO1	3												
CO2		2						2					
CO3					3								
CO4				3							3	2	
CO5				3				2				2	
CO6					3								
CO7		3							2				

Justification for the mapping

PO1: Comprehensive Knowledge and Understanding: CO1 Understanding biochemical mechanisms of nitrogen fixation, phosphate solubilization, and other processes requires a strong foundational knowledge of microbiology and biochemistry. This aligns with comprehensive academic understanding.

PO2: Practical, Professional, and Procedural Knowledge:

CO2 The focus on the production and application of biofertilizers is related to practical knowledge and procedural understanding, specifically

CO7 Bioleaching is a practical technique used in mining, which requires procedural and professional knowledge of microbiological techniques in resource extraction.in laboratory settings and field application.

PO4: Specialized Skills and Competencies:

CO4,CO5 This CO develops specialized knowledge in biopesticides, requiring a higher level of expertise in pest control methods and environmental considerations, which contributes to specialized competencies.Specialized skills refer to the deep understanding of specific topics.

PO5: Capacity for Application, Problem-Solving, and Analytical Reasoning:

CO3 The application of nitrogen fixation knowledge to sustainable farming practices involves problem-solving skills, as students

CO6 This outcome involves applying scientific knowledge to real-world problems, specifically in environmental cleanup, thus honing problem-solving and analytical reasoning skill

PSO8: Learning How to Learn Skills:

CO2, CO5, The outcome mentioned **learning how to produce, apply, and use biofertilizers such as *Azotobacter*, *Rhizobium*, Blue-Green Algae, and Phosphate Solubilizing Microorganisms (PSMs)** is fundamental to sustainable agriculture. Let's break this down and justify the importance of teaching these skills:

PSO9: Digital and Technological Skills:

CO7 The outcome mentioned **Bioleaching** is a process where microorganisms are used to extract valuable metals from ores, a method that is gaining increasing attention due to its environmental and economic advantages over traditional mining techniques.

PSO11:Value Inculcation and Environmental Awareness:

CO5 Bioremediation focuses on environmental cleanup, which directly contributes to environmental awareness and value inculcation, emphasizing sustainability and ecological balance.

PSO12:Autonomy, Responsibility, and Accountability:

CO4, CO5 This objective focuses on teaching students about **biopesticides**, which are naturally derived substances used for pest control. These could be biological agents like microorganisms, plants, or enzymes, as opposed to conventional **chemical pesticides**.

CBCS Syllabus as per NEP 2020 for T. Y. B.Sc. Microbiology (2023 pattern) w. e. from Nov, 2025	
Name of the Programme	: B.Sc. Microbiology
Programme code	: USMI
Class	: T.Y.B.Sc.
Semester	: VI
Course Type	: Theory (Elective)
Course Code	: MIB-356-MJE (C)
Course Title	: Microbial Technology
No. of Credits	: 02
No. of Teaching Hours	: 30

Course Objectives

1. Understand different types of fermentation including solid-state, submerged, batch, continuous, and fed-batch.
2. Learn the design principles and operational features of various bioreactors such as stirred tank, tubular, fluidized bed, hollow fiber, microfluidics-based, stem cell, and recombinant protein reactors.
3. Comprehend key components of bioreactors including structure, pH and temperature control, aeration and agitation systems, aseptic maintenance, and sterilization protocols.
4. Acquire knowledge on waste-water management including physical, chemical, and biological treatment methods.
5. Understand advanced waste water treatment technologies including tertiary treatment, in situ bioremediation, removal of reverse osmosis concentrates, and effluent treatment plant (ETP) design.
6. Develop the ability to analyze and compare different bioreactor designs for specific industrial applications.
7. Gain insights into the integration of fermentation technology with environmental sustainability practices.

Course Outcomes

- CO1 Students will be able to describe and differentiate types of fermentations and fermenter operations (batch, continuous, fed-batch).
- CO2 Students will explain the design, working, and applications of diverse bioreactor systems including stirred tank, tubular, fluidized bed, hollow fiber, microfluidic, and specialized reactors.
- CO3 Students will identify and explain the functions of bioreactor components such as aerators, impellers, baffles, and sterilization mechanisms.
- CO4 Students will summarize wastewater treatment methods and their applications in industrial fermentation effluent management.

- CO5 Students will analyze advanced wastewater treatment technologies and integrate ETP design principles.
- CO6 Students will evaluate bioreactor selection and process design considering efficiency, scale-up, and environmental impact.
- CO7 Students will understand the role of fermentation and bioreactor technology within broader environmental management and sustainability frameworks.

Credit No.		Topic and Learning Points	Teaching Hours
I		Types of Fermentations and Bioreactors	
	Unit 1	Introduction to Solid state, Submerged, Batch, Continuous and Fed-Batch fermentation	2
	Unit 2	Design of Continuous stirred tank reactor, Batch fermenter, Continuous fermenter, fed batch fermenter: a) Stirred tank fermenter b) Tubular fermenter c) Fluidized bed fermenter d) Hollow fiber reactors e) Bioreactors on Chip- Microfluidics f) Stem cell and Recombinant protein reactors	8
	Unit 3	Components of Bioreactors a) Structure (body, pH & temperature control) b) Aeration and agitation: Aerator (sparger), Agitation (Impellers, baffles) c) Achievement and maintenance of aseptic conditions d) Sterilization of fermenter, air supply and exhaust gas	5
II		Waste-water Management Technology	
	Unit 1	Waste water Treatment Methods a) Physical treatment b) Chemical treatment c) Biological treatment d) Sludge treatment	7

	Unit 2	Unit 2: Advanced treatment methods and ETP designs a) Tertiary waste water treatment methods b) In situ Bio-remediation c) Removal of Reverse Osmosis Concentrate (ROC) d) Effluent Treatment Plant (ETP) designs	8
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References:

1. Gajbhiye M. H. (Editor) (2025) *Fundamentals of Fermentation Technology*, Cambridge Scholars Publishing, UK.
2. A. H. Patel. (1985), *Industrial Microbiology*, Macmillan India Ltd.
3. *Bioreactor Design and Product Yield* (1992), BIOTOL series, Butterworths Heinemann.
4. Casida, L. E., (1984), *Industrial Microbiology*, Wiley Easterns, New Delhi
5. Dilip K. Arora editor, *Fungal Biotechnology in agriculture, food and environmental applications (Mycology)*, 2005. Marcel Dekker, Inc. New York. Basel
6. Indian Pharmacopia and British Pharmacopia.
7. Lydersen B., N. a. D' Elia and K. M. Nelson (Eds.) (1993) *Bioprocess Engineering: Syatems, Equipment and Facilities*, John Wiley and Sons Inc.
8. *Operational Modes of Bioreactors*, (1992) BIOTOL series, Butterworths Heinemann.
9. Peppler, H. L (1979), *Microbial Technology*, Vol I and II, Academic Press, New York.
10. Peter F. Stanbury. *Principles Of Fermentation Technology*, 2E, Elsevier (A Division of Reed Elsevier India Pvt. Limited), 2009
11. Prescott, S.C. and Dunn, C. G., (1983) *Industrial Microbiology*, Reed G. AVI tech books.
12. Reed G. Ed. Prescott and Dunn's *Industrial Microbiology*. 4th Ed., CBS Pub. New Delhi.
13. Shuichi and Aiba. *Biochemical Engineering*. Academic Press. 1982.
14. Stanbury, P. F. & Whittaker, A. (1984) *Principles of Fermentation Technology*, Pergamon press.
15. Sudhir U. Meshram, Ganghdhar B Shinde, *Applied Biotechnology*. I.K. International Pvt. Ltd. 2009.

16. Moo-Young M. (2004) *Comprehensive biotechnology*, Vol- 1 to 4, Pergamon press Ltd, England.
17. Flickinger, M. C. and Drew, S. W. (1999). *Encyclopedia of Bioprocess Technology*, Wiley-Interscience, New Jersey.
18. Van Damme E. J. (1984) *Biotechnology of Industrial Antibiotics*, Marcel Dekker Inc. New York.
19. Wiseman A.(1985) *Topics in Enzyme and Fermentation* - Biotechnology, Vol. 1 and 2, John Wiley and Sons, New York.

Mapping of course outcomes and programme outcomes:

Class: TYBSc (Sem VI)

Subject: Microbiology Course: Microbial Technology

Course code: MIB-356-MJE(C)

Weightage: 1= weak or low relation, 2= Moderate or partial relation, 3= Strong or direct relation

Course outcomes	Program Outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13
CO1	3	3	1	2	3	2	2	2	2	1	2	2	1
CO2	3	3	1	3	3	2	2	2	2	1	2	3	1
CO3	3	3	1	3	3	2	3	2	2	1	2	3	1
CO4	3	3	1	2	3	2	2	2	2	1	3	2	1
CO5	3	3	1	3	3	2	3	2	2	1	3	3	1
CO6	3	3	1	3	3	2	3	2	2	1	3	3	1
CO7	3	3	1	2	3	2	3	2	2	1	3	3	2

Justifications:

PO1: (Comprehensive Knowledge and Understanding)

Strong (3) for all COs as they require deep theoretical and practical knowledge of fermentation and bioreactor systems.

PO2: (Practical, Professional Knowledge):

Strong (3) due to focus on operational and industrial applications of bioreactors and wastewater treatment.

PO3: (Entrepreneurial Mindset):

Lower (1) since direct entrepreneurship focus is limited, but innovation aspects exist.

PO4: (Specialized Skills and Competencies):

Moderate to strong (2-3) reflecting technical and analytical competencies in bioprocess design and treatment technologies.

PO5: (Application, Problem-Solving, Analytical Reasoning):

Strong (3) because COs deal with complex system design, selection, and environmental challenges.

PO6: (Communication and Collaboration):

Moderate (2) needed for teamwork and communication in industrial and environmental contexts.

PO7: (Research-related Skills):

Moderate to strong (2-3) as students analyze and design bioreactor systems and treatment processes.

PO8: (Learning How to Learn):

Moderate (2) to adapt evolving biotechnologies.

PO9: (Digital and Technological Skills):

Moderate (2) due to use of technological tools in analysis and design.

PO10: (Multicultural Competence):

Low (1) as content is technical.

PO11: (Value Inculcation and Environmental Awareness):

Strong (3) particularly in wastewater treatment and sustainability frameworks.

PO12: (Autonomy, Responsibility, Accountability):

Strong (3) reflecting independent project design and process management.

PO13: (Community Engagement and Service):

Moderate (1-2) mainly where environmental sustainability impacts society.

CBCS Syllabus as per NEP 2020 for T. Y. B.Sc. Microbiology (2023 pattern) w. e. from Nov, 2025	
Name of the Programme	: B.Sc Microbiology
Program Code	: USMI
Class	: T.Y.B.Sc
Semester	:VI
Course Type	: Minor (Theory)
Course Title	: Dairy Microbiology
Course Code	: MIB-361-MN
No. of Credits	: 02
No. of Teaching Hours	: 30

Course Objective:-

1. To enrich students knowledge about the fundamental definition of milk and its significance in dairy microbiology.
2. To teach students the diverse range of microorganisms present in dairy products and their roles in product quality and safety.
3. To enrich students knowledge to grasp the concept of clean milk and its importance in maintaining microbial quality and safety in dairy products.
4. To introduce students understanding about the physicochemical properties of milk and their impact on microbial growth, processing, and product development.
5. To enhance students understanding about the alkaline phosphatase tests to assess milk pasteurization efficiency and ensure compliance with regulatory standards.
6. To make students knowledgeable about adulteration tests, including water content, urea, and formalin detection, to prevent fraudulent practices and ensure consumer safety.
7. To develop skills in students to master the preparation techniques for yogurt (curd), cheese, and Paneer, including microbial inoculation, fermentation, curdling, and product maturation.

Course Outcomes:

- CO1. Students will be able to understand the fundamental definition of milk and its role in dairy microbiology, allowing for informed discussions on the importance of milk in various dairy products.
- CO2. Students will be able to apply knowledge gained to assess and promote the concept of clean milk, demonstrating a commitment to maintaining high microbial quality and safety standards in dairy production.
- CO3. Students will be able to identify and analyze a diverse range of microorganisms present in dairy products, showcasing a comprehensive understanding of their roles in influencing product quality and ensuring safety.
- CO4. Students will be able to analyze the physicochemical properties of milk and apply this knowledge to predict and control microbial growth, facilitating informed decision-making in dairy processing and product development.
- CO5. Students will be able to demonstrate proficiency in conducting alkaline phosphatase tests, ensuring the ability to assess milk pasteurization efficiency and comply with regulatory standards for dairy product safety.
- CO6. Students will be able to develop practical skills in adulteration tests to detect and prevent fraudulent practices, ensuring a commitment to consumer safety and product authenticity in the dairy industry .
- CO7. Students will be able to understand the importance of preparation techniques for yogurt (curd), cheese, and Paneer, showcasing advanced skills in microbial inoculation, fermentation, curdling, and product maturation for diverse and high-quality dairy products.

Credit No		Topic & Learning Points	Teaching Hours
I	Unit 1	Introduction to Dairy Microbiology	15
		1. Definition of milk	1
		2. Composition of milk	1
		3. Types of milk	1
		4. Concept of clean milk	1
		5. Microbial diversity in milk	2
		6. Physicochemical properties of milk	2
		7. Spoilage of milk	1
		8. Succession of microorganisms in milk leading to spoilage	2
		9. Stormy fermentation, Ropiness, Sweet Curdling	2
		10. Color & Flavor defects	2
II	Unit 1	Quality control test in Dairy	9
		1. Milk fat estimation test	1
		2. Alkaline Phosphatase test	2
		3. Mastitis test	1
		4. Dye reduction test	1
		5. Adulteration test: Water content testing, Urea testing, Formalin detection	2
		6. Microbiological aspects of quality control & quality assurance in production of milk & milk products	2
	Unit 2	Production of Dairy Products	6
		1. Yogurt (Curd)	2
		2. Cheese	2
3. Paneer		2	
Total			30

References :

1. Smith, S., & Sherman, N. (2019). Dairy Microbiology: A Practical Approach. John Wiley & Sons
2. Quigley, L., & O'Sullivan, O. (Eds.). (2017). Dairy Microbiology and Biochemistry: Recent Developments. Nova Science Publishers.
3. Jay, J. M., Loessner, M. J., & Golden, D. A. (2005). Modern Food Microbiology (7th ed.). Springer.
4. Tamime, A. Y. (Ed.). (2008). Probiotic Dairy Products (2nd ed.). John Wiley & Sons.
5. Sudha, M. L., & Reddy, S. Y. (2019). Food Safety and Quality in Dairy Industry. Springer.
6. Hui, Y. H. (Ed.). (2008). Handbook of Food Science, Technology, and Engineering: Dairy Science, Eggs, Meat, Poultry, and Seafood (Vol. 2). CRC Press.
7. Andrews, A. T. (Ed.). (2017). Food Safety Regulatory Compliance: Catalyst for a Lean and Sustainable Food Supply Chain. Academic Press.

Mapping of Program Outcomes with Course Outcomes:**Class: T.Y.BSc (Sem VI)****Subject: Microbiology****Course: Dairy Microbiology****Course code: MIB-361-MN**

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)												
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13
CO 1	3									3			
CO 2		3			2							3	3
CO 3	3									3			
CO 4	3				3						3	3	
CO 5		3		3					3				
CO 6		2	3	2	3				3		3		
CO 7	3	3	3	3		3	2	3					3

Justification for the mapping:***PO1* Comprehensive knowledge and understanding:**

CO1: Provides students with a fundamental understanding of milk and its role in dairy microbiology, forming the basis for comprehensive knowledge about dairy products.

CO3: Enhances comprehensive knowledge by focusing on identifying and analyzing microorganisms in dairy products, contributing to a deeper understanding of their impact on product quality and safety.

CO4: Contributes to comprehensive knowledge by exploring the physicochemical properties of milk and how they influence microbial growth, facilitating informed decision-making in dairy processing.

CO7: Broadens comprehensive knowledge by covering preparation techniques for various dairy products, showcasing advanced skills in microbial processes and product development.

***PO2* Practical, Professional and Procedural Knowledge :**

CO2: Emphasizes the application of knowledge to assess and promote clean milk, demonstrating a commitment to professional standards and safety in dairy production.

CO5 and CO6: Focus on practical skills such as conducting tests for pasteurization efficiency and adulteration detection, providing students with hands-on experience in ensuring product quality and safety.

CO7: Enhances practical knowledge by covering preparation techniques for dairy products, including microbial inoculation, fermentation, and product maturation, which are essential aspects of professional dairy processing.

***PO3* Entrepreneurial Mindset and knowledge:**

CO6: Addresses the entrepreneurial aspect by focusing on detecting and preventing fraudulent practices, emphasizing the importance of consumer safety and product authenticity in the dairy industry.

CO7: Contributes to entrepreneurial knowledge by covering preparation techniques for diverse and high-quality dairy products, preparing students to innovate and develop unique products in the market.

PO4 Specialized skills and competencies:

CO5 and CO6: Involve proficiency in conducting specific tests related to pasteurization efficiency and adulteration detection, which are specialized competencies necessary for ensuring product safety and quality.

CO7: Emphasizes the development of practical skills in preparing various dairy products like yogurt, cheese, and Paneer, showcasing expertise in microbial processes and product development.

PO5 Capacity for Application ,Problem-Solving ,and Analytical Reasoning :

CO2: Requires students to apply their understanding of milk and dairy microbiology to assess and promote clean milk, demonstrating the application of theoretical knowledge to practical situations.

CO4: Involves analyzing physicochemical properties of milk to predict and control microbial growth, requiring analytical reasoning to make informed decisions in dairy processing.

CO6: Focuses on developing skills in adulteration tests to detect fraudulent practices, which involves problem-solving to address issues related to product authenticity and consumer safety.

PO6 Communication Skills and Collaboration:

CO7: involves the preparation techniques for various dairy products, which often require coordination and collaboration among team members in a dairy processing setting.

PO7 Research –Related skills :

CO7: Involves understanding the latest developments in dairy processing techniques, indicating a focus on research-related skills.

PO8 Learning How to Learn Skills:

CO7: Encourages students to stay informed about the latest developments in dairy science, fosters a continuous learning mindset?

PO9 Digital and Technological Skills :

CO5: Proficiency in conducting tests like alkaline phosphatase tests may involve using digital instruments or software for data analysis and interpretation. Students may learn to operate and interpret results from digital equipment used in quality control processes.

CO6: Adulteration tests may involve using digital tools or technologies such as spectroscopy or chromatography for identifying adulterants in dairy products.

PO10 Multicultural Competence ,Inclusive Spirit , and Empathy:

CO1: Understanding the cultural significance of milk and dairy products in different societies can foster multicultural competence. Acknowledging and appreciating diverse cultural perspectives regarding the consumption and utilization of milk can promote an inclusive spirit among students..

CO3: Considering the diversity of microorganisms found in dairy products may involve understanding cultural variations in traditional fermentation practices and the role of specific microorganisms in different cuisines.

PO11 Value Inculcation and Environmental Awareness:

CO4: The physicochemical properties of milk and their influence on microbial growth can lead to more efficient and sustainable dairy processing practices. By optimizing processing conditions and reducing waste generation, students contribute to environmental conservation efforts.

CO6: Preventing fraudulent practices such as milk adulteration not only ensures consumer safety and product authenticity but also promotes ethical and environmentally responsible behavior.

PO12 Autonomy , Responsibility and Accountability :

CO2: Students will demonstrate autonomy by independently evaluating the need for and implementing measures to maintain high standards in dairy production.

CO4: Analyzing the physicochemical properties of milk empowers students to predict and control microbial growth, enabling them to make informed decisions in dairy processing.

PO13 Community Engagement and Services:

CO2: Engaging with local dairy farmers, processors, and communities to promote clean milk practices can be a form of community engagement..

CO7: Collaborating with local dairy producers or artisanal cheese makers to share knowledge and techniques for dairy product preparation can foster community engagement.

CBCS Syllabus as per NEP 2020 for T. Y. B.Sc. Microbiology (2023 pattern)

CBCS Syllabus as per NEP 2020 for T. Y. B.Sc. Microbiology (2023 pattern) w. e. from Nov, 2025	
Name of the programme	: B.Sc. Microbiology
Programme Code	: USMI
Class	: T.Y.B.Sc.
Semester	:VI
Course Type	: Minor (Practical)
Course Title	: Practical course based on Dairy Microbiology
Course Code	: MIB-362-MN
No. of Credits	:02
No. of Teaching Hours	:60

Course Objectives:

1. To understand the principles and methodologies used in the analysis of milk and milk products, including the detection of adulterants and microbial contamination.
2. To develop skills in conducting various microbiological and chemical tests to assess milk quality and the presence of microorganisms or contaminants.
3. To familiarize students with standard procedures for estimating milk composition, including fat content and somatic cell count.
4. To provide practical knowledge on the preparation of fermented dairy products like curd and paneer.
5. To impart knowledge on the microbiological techniques such as phosphatase tests and methylene blue reduction tests to evaluate milk quality.
6. To equip students with the ability to interpret the results of microbial tests such as standard plate count and direct microscopic count for dairy products.
7. To enable students to critically evaluate dairy farm operations and prepare detailed reports on their observations during a dairy farm visit.

Course Outcomes:

- CO1 Students will be able to accurately perform and interpret various tests to evaluate the quality of milk, such as the phosphatase and methylene blue reduction tests.

- CO2 Students will gain proficiency in detecting the presence of milk adulterants, including water, hydrogen peroxide, baking soda, ammonium sulfate, and sugar.
- CO3 Students will be able to estimate milk fat content and perform somatic cell count analyses to assess milk's quality and its suitability for processing.
- CO4 Students will demonstrate the ability to prepare fermented milk products such as curd and paneer, applying both traditional and modern techniques.
- CO5 Students will develop an understanding of microbial contamination in milk through methods like standard plate count, direct microscopic count, and the mastitis test.
- CO6 Students will be capable of analyzing and identifying potential health risks in milk and milk products, contributing to better quality control in dairy production.
- CO7 Students will be able to conduct field visits to dairy farms, assess the operations, and prepare comprehensive reports that highlight key findings and improvement areas.

Sr.No.	Name of Experiments	Teaching Hours
Tests for Analysis of Milk		
1	Phosphatase Test	4
2	MBRT Test	4
3	Mastitis Test	4
4	Milk Fat Estimation Test	4
5-6	Standard Plate Count a. Milk b. Milk Powder	8
7	Direct Microscopic Count	4
8	Somatic Cell Count	4
9-11	Milk Adulteration Test for: a. Water b. Hydrogen peroxide c. Baking soda d. Ammonium Sulfate e. Sugar f. Detergent	12

12	Preparation of fermented milk products- Curd	4
13	Isolation & Characterization of Lactic acid bacteria from curd	4
14	Enumeration of yeast & mold in milk product- Curd	4
15	Differentiation between Normal milk and Synthetic milk.	4
	Total	60

References:

1. Jay, J. M. (2000). *Modern Food Microbiology* (6th ed.). Springer.
2. Bhat, S. G., & Bhat, M. A. (2007). *Dairy Microbiology Handbook: The Microbiology of Milk and Milk Products* (3rd ed.). Wiley.
3. Gupta, R. (2014). *Dairy Technology: Principles of Milk Properties and Processes*. Springer.
4. Marwaha, R. S., & Raina, V. S. (2015). *Milk and Milk Products: Technology, Chemistry, and Microbiology*. Wiley.
5. Deeth, H. C., & Trent, J. (2006). *Food Chemistry and Microbiology*. Springer.
6. Sharma, R. R., & Gupta, A. (2011). *Food and Dairy Microbiology: The Microbial Ecology of Dairy Products*. CRC Press.
7. Boor, K. J. (2004). *Microbiological Methods for Milk and Dairy Products*. Wiley.
8. Collier, M. E., & Lintner, J. A. H. (2002). *Practical Dairy Microbiology*.

Mapping of Program Outcomes with Course Outcomes

Class : T.Y.B.Sc (Sem VI)

Subject: Microbiology

Course : Dairy Microbiology

Course Code : MIB-362-MN

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

Course Outcomes	Programme Outcomes (POs)												
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13
CO 1						2	2	2	2		2	3	2
CO 2						2		2				3	
CO 3												3	2
CO 4	2	3	3	3	3							3	
CO 5	3	3	2										
CO 6	3	3	2										
CO 7	2	3	2										

Justification of Mapping:

PO1: Assessing milk safety & quality

PO1 is strongly related to outcomes that involve direct testing and analysis of milk quality, such as milk quality tests, detection of adulterants, and microbial contamination detection. These outcomes are crucial for ensuring the safety and quality of milk, aligning directly with PO1. Outcomes like milk fat estimation and health risk analysis also support PO1 by providing key quality indicators. The field visit provides indirect insights into milk safety practices, offering moderate relevance to PO1.

PO2: Practical, professional, and procedural

PO2 is strongly related to all course outcomes, as each involves hands-on application of techniques and professional procedures. From milk quality testing and adulterant detection to the preparation of dairy products and microbial contamination detection, all outcomes require practical skills and adherence to professional standards. The field visit also fosters practical engagement with real- world dairy operations, emphasizing procedural knowledge. Overall, PO2 is integral to each outcome, ensuring that students develop the necessary practical expertise.

PO3: Entrepreneurial Mindset and Knowledge

PO3 is moderately related to most outcomes, as it encourages innovative thinking in areas such

as adulterant detection and microbial contamination, where new methods could be developed. The preparation of dairy products like curd and paneer has a stronger link, as entrepreneurial skills are essential for product innovation and market development. Outcomes focused on practical applications, like milk quality tests and health risk analysis, benefit from an entrepreneurial approach to problem-solving and process improvement. However, the field visit has a weaker connection, as it mainly involves observation rather than entrepreneurial thinking.

PO4: Specialized Skills and competencies

PO4 is strongly related to all outcomes, as each involves the application of specialized knowledge and technical skills. From conducting milk quality tests and detecting adulterants to analyzing milk fat and microbial contamination, these outcomes require specific competencies in dairy science and laboratory techniques. The preparation of fermented dairy products also demands specialized skills in dairy processing. While the field visit involves more observational learning, it still provides insights into industry practices that contribute to the development of specialized competencies.

PO5: Capacity for Application, Problem-Solving

PO5 is strongly related to outcomes like milk quality tests, adulterant detection, and microbial contamination detection, where problem-solving is essential to interpret results and ensure safety. Estimating milk fat and somatic cell count also requires applying knowledge to solve specific quality-related problems. The preparation of dairy products and analyzing milk quality involves troubleshooting techniques and adapting processes. The field visit offers some problem-solving opportunities, but its focus is more on observation than hands-on problem resolution.

PO6: Communication Skill and Collaboration

PO6 is strongly related to outcomes like field visits and report preparation, where clear communication and collaboration are essential for sharing findings and working with others. Milk quality tests, adulterant detection, and microbial contamination detection also require effective communication of results, though collaboration is less emphasized in these technical

processes. The preparation of fermented dairy products may involve teamwork and communication within production settings. Analyzing milk quality and health risks also requires the clear communication of findings, especially in reporting and advising on safety concerns.

PO7: Research-related Skills

PO7 is moderately related to outcomes like milk quality tests, adulterant detection, and microbial contamination detection, where research skills can help refine techniques or explore new methods. Estimating milk fat and somatic cell count and analyzing milk quality also benefit from research skills in improving accuracy or developing better procedures. The preparation of dairy products may involve research to innovate or optimize processes. The field visit has a weaker connection to PO7, as it focuses more on observation and practical learning rather than research activities.

PO8: Learning How to Learn Skills

PO8 is moderately related to all outcomes, as each requires ongoing learning and adaptation to improve techniques and methodologies. Outcomes like milk quality testing, adulterant detection, and microbial contamination detection encourage continuous learning to enhance accuracy and efficiency. The preparation of dairy products and health risk analysis also benefit from developing the ability to learn and apply new knowledge. While the field visit provides learning opportunities, it is less focused on formal learning and more about real-world exposure.

PO9: Digital and Technological Skill Use of certain technologies and digital tools for these tests

PO9 is moderately related to outcomes that involve laboratory testing and analysis, such as milk quality tests and microbial contamination detection, where digital tools and technologies are often used for precise measurements and data analysis. Estimating milk fat and somatic cell count also requires the use of digital tools for accurate readings. The preparation of dairy products and field visits are less reliant on digital technology, though digital tools may assist in documentation or analysis. Overall, PO9 is more strongly connected to technical outcomes that involve digital tools for testing and analysis.

PO10 : Multicultural Competence, Inclusive Spirit, and Empathy

PO10 is moderately related to all outcomes, as each involves understanding diverse practices and perspectives in the dairy industry. The field visit provides the most direct exposure to

different cultural and operational practices, fostering empathy and inclusivity. Outcomes like detecting adulterants and analyzing milk quality may involve understanding local variations in practices or consumer needs. While less directly related, each outcome benefits from an inclusive approach to ensuring safe and quality milk for diverse populations.

PO11: Value Inculcation and Environmental Awareness

PO11 is moderately related to outcomes such as microbial contamination detection and milk quality tests, where environmental considerations play a role in ensuring safe, sustainable practices. The preparation of dairy products also links to this PO, as environmental awareness is essential in optimizing resource usage and minimizing waste. Detecting adulterants and analyzing milk quality may involve understanding the broader implications of food safety on public health and the environment. The field visit offers insights into sustainable dairy farming practices, enhancing environmental awareness.

PO12: Autonomy, Responsibility, and Accountability

PO12 is strongly related to all outcomes, as each involves taking responsibility for accurate testing, analysis, and decision-making in dairy practices. Conducting milk quality tests, detecting adulterants, and microbial contamination detection all require students to demonstrate accountability in ensuring safety and quality. Estimating milk fat and somatic cell count, as well as preparing dairy products, necessitates taking ownership of processes and outcomes. The field visit emphasizes responsibility in observing and understanding real-world dairy operations, promoting autonomous learning and professional accountability.

PO13: Community Engagement and Service

PO13 is moderately related to outcomes like the field visit, where students engage with local dairy farms and communities to understand industry practices. Analyzing milk quality and detecting adulterants aligns with serving the community by ensuring safe and healthy dairy products. The preparation of fermented dairy products also connects to community service by contributing to local food systems. While other outcomes focus more on technical skills, all contribute to the broader goal of ensuring quality and safety for the community