Department of Microbiology
Master of Science (M.Sc. Microbiology)

GUJARAT VIDYAPITH: AHMEDABAD
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Department of Microbiology

Course Structure For M.Sc. Microbiology (2-years PG)
Effective from June 2025

Summary

Broad Category of Course	**Sem-1**	**Sem-2**	**Sem-3**	**Sem-4**	**Total**
Major (Core)	3 (T) +2 (P) = 05	3 (T) +2 (P) = 05	3 (T) +2 (P) = 05	20 (P)	
Major (Core)	3 (T) +2 (P) = 05	3 (T) +2 (P) = 05	3 (T) +2 (P) = 05		
Major (Core)	3 (T) +2 (P) = 05	3 (T) +2 (P) = 05	3 (T) +2 (P) = 05		
Major (Core)	3 (T) +2 (P) = 05	3 (T) +2 (P) = 05	3 (T) +2 (P) = 05		
Total	20	20	20	20	80

SCHEME OF PAPERS

M.Sc. Semester-1

Sr. No	Broad Category of Course/ Course code	Subject Name	Hours		Credit	
			T	P	T	P
1	Major (Core) MMIC101, MMIC101-P	Microbiology (Microbial Diversity)	45	60	3	2
2	Major (Core) MMIC102, MMIC102-P	Microbiology (Microbial Physiology)	45	60	3	2
3	Major (Core) MMIC103, MMIC103-P	Microbiology (Bio- instrumentation)	45	60	3	2
4	Major (Core) MMIC104, MMIC104-P	Microbiology (Immunology)	45	60	3	2
5	Community Life	Community Life				
Total			**180**	**240**	**12**	**8**

T= Theory, P= Practicals

Available Total Credits= 20 Total required hours per semester=420
Total available hours per semester=517.5 hours
Available hours per week= 34.5 hours
Calculation of required hours per week
12 credits for theory=12 hours
8 credits for practicals=16 hours
Total required hours per week=28 hours
6.5 hours (tutorial class, remedial class, library class and other co-curricular activities during these hours).

SCHEME OF PAPERS

M.Sc. Semester-2

Sr. No	Broad Category of Course/ Course code	Subject Name	Hours		Credit	
			T	P	T	P
1	Major (Core) MMIC201, MMIC201-P	Microbiology (Enzymology)	45	60	3	2
2	Major (Core) MMIC202, MMIC202-P	Microbiology (Molecular Biology and Bacterial Genetics)	45	60	3	2
3	Major (Core) MMIC203, MMIC203-P	Microbiology (Recombinant DNA Technology)	45	60	3	2
4	Major (Core) MMIC204, MMIC204-P	Microbiology (Bio-informatics)	45	60	3	2
5	Community Life	Community Life				
Total			**180**	**240**	**12**	**8**

T= Theory, P= Practicals

Available Total Credits= 20 Total required hours per semester=420
Total available hours per semester=517.5 hours
Available hours per week= 34.5 hours
Calculation of required hours per week
12 credits for theory=12 hours
8 credits for practicals=16 hours
Total required hours per week=28 hours
6.5 hours (tutorial class, remedial class, library class and other co-curricular activities during these hours).

SCHEME OF PAPERS

M.Sc. Semester-3

Sr. No	Broad Category of Course/ Course code	Subject Name	Hours		Credit	
			T	P	T	P
1	Major (Core) MMIC301, MMIC301-P	Microbiology (Bioprocess Technology)	45	60	3	2
2	Major (Core) MMIC302, MMIC302-P	Microbiology (Environmental Biotechnology)	45	60	3	2
3	Major (Core) MMIC303, MMIC303-P	Microbiology (Microbial Products and Technology)	45	60	3	2
4	Major (Core) MMIC304, MMIC304-P	Microbiology (Biomethanation)	45	60	3	2
5	Community Life	Community Life				
Total			**180**	**240**	**12**	**8**

T= Theory, P= Practicals

Available Total Credits= 20 Total required hours per semester=420
Total available hours per semester=517.5 hours
Available hours per week= 34.5 hours
Calculation of required hours per week
12 credits for theory=12 hours
8 credits for practicals=16 hours
Total required hours per week=28 hours
6.5 hours (tutorial class, remedial class, library class and other co-curricular activities during these hours).

SCHEME OF PAPERS

M.Sc. Semester-4

Sr. No	Broad Category of Course/ Course code	Subject Name	Hours		Credit	
			T	P	T	P
1	Major (Core) MMIC401-P	Microbiology (Dissertation)	-	600	-	20
Total			**-**	**600**	**-**	**20**

T= Theory, P= Practicals

PROGRAMME OUTCOMES (POs) FOR MASTER OF SCIENCE (M.Sc.)

POs	Integrated Justification
PO1: Advanced Scientific Knowledge	The program develops a sophisticated understanding and integrated application of **Microbiology and allied sciences**. Students acquire core competencies to address complex problems in research and professional settings through advanced scientific concepts and interdisciplinary approaches.
PO2: Research & Problem-Solving Skills	Students are equipped to **independently conceptualize, analyze, and solve complex** problems of societal and global relevance. They gain critical knowledge that enables systematic research, formulation of hypotheses, and application of scientific reasoning.
PO3: Experimental & Analytical Proficiency	The curriculum emphasizes mastery in **designing and conducting scientific experiments using advanced tools and methodologies.** Students critically evaluate and interpret data to derive reliable, reproducible scientific conclusions.
PO4: Interdisciplinary Approach	Graduates are prepared to lead and collaborate in multidisciplinary teams, integrating insights from various scientific fields to develop practical applications in areas such as **healthcare, environment, and biotechnology**.
PO5: Environmental Consciousness & Sustainability	The program cultivates the ability to apply **microbiological knowledge to global sustainability challenges**. Students are encouraged to propose evidence-based solutions that align with environmental ethics and sustainable development goals.
PO6: Ethics & Professional Values	Upholding the highest standards of scientific integrity and **Gandhian values**, students are trained in responsible research practices and ethical decision-making in both academic and industry settings.
PO7: Effective Scientific Communication	The program ensures graduates can clearly **articulate scientific findings to diverse audiences**. They **are trained to publish research, communicate** within multidisciplinary teams, and advocate for **science-based societal advancement**.
PO8: Modern Technological Applications	**Students independently master and apply advanced technological tools**, data analytics, and computational methods to execute complex research projects and remain proficient in modern scientific practices.
PO9: Teamwork & Leadership in Research	The curriculum **fosters leadership, professionalism**, and collaboration. Graduates contribute effectively to scientific teams, manage research projects, and uphold social responsibility in their professional roles.
PO10: Lifelong Learning & Adaptability	Graduates demonstrate **independent learning and actively seek new knowledge and technologies**. The program nurtures a mindset of continual professional development to stay at the forefront of scientific progress.
PO11: Project Management & Entrepreneurial Thinking	Students are encouraged to **apply scientific knowledge to manage research initiatives efficiently**. The program promotes entrepreneurial thinking for developing innovative, technology-driven solutions.
PO12: Social & Community Engagement	Emphasizing the interplay between science and society, the program instills values of service and community engagement. **Graduates advocate for science-driven change** and communicate complex ideas to non-specialist audiences to address societal challenges.

PROGRAMME SPECIFIC OUTCOMES (PSOs) FOR MASTER OF SCIENCE (M.Sc.-Microbiology)

PSO Number	Program Specific Outcome	Justification
PSO1: Mastery in Microbial Techniques and Innovations	Graduates will acquire proficiency in classical and modern microbiological techniques, including microbial isolation, identification, cultivation, genetic manipulation, and bioinformatics applications for advancing microbiological research.	**Aligned POs**: **PO1, PO3, PO8** **Justification**: This PSO directly reflects the need for **advanced scientific knowledge (PO1)**, **experimental & analytical proficiency (PO3)**, and **technological applications (PO8)** in modern microbiology.
PSO2: Application of Microbiology to various fields	Graduates will apply microbiological knowledge to develop practical solutions in medical microbiology, food and dairy microbiology, industrial fermentation, environmental biotechnology, and agriculture.	**Aligned POs**: **PO2, PO4, PO5, PO11** **Justification**: This outcome addresses problem-solving (PO2), interdisciplinary approach (PO4), sustainability (PO5), and entrepreneurial thinking (PO11) through applied microbiological innovations.
PSO3: Ethical Scientific Inquiry and Communication	Graduates will demonstrate ethical reasoning in research, effective communication of microbiological findings, and community-oriented scientific outreach with a commitment to social responsibility.	**Aligned POs**: **PO6, PO7, PO9, PO10, PO12** **Justification**: This aligns with ethics (PO6), scientific communication (PO7), teamwork and leadership (PO9), lifelong learning (PO10), and community engagement (PO12), preparing students as responsible and socially aware microbiologists.

CO Attainment Matrix

Benchmark (Target attainment) is 60% for M.Sc. Program

Attainment Criteria	Level	Description
≥ 60% students scored ≥ Benchmark	Level 3	**High Attainment** – Most students achieved the expected outcome.
50–59% students scored ≥ Benchmark	Level 2	**Moderate Attainment** – Outcome partially achieved.
40–49% students scored ≥ Benchmark	Level 1	**Low Attainment** – Minimal outcome achieved.
< 40% students scored ≥ Benchmark	Level 0	**Not Attained** – Remedial action required

Semester-1

M.Sc. Semester-1	**MMIC -101**	**Microbial Diversity**	Compulsory
Credit- 03, Total Number of Teaching Hours- 45Hrs			

Course Outcome (CO)
After studying this course the student will be able to
CO1: Relate major biological events with microbial evolution and state basics of microbial taxonomy and classification. **CO2**: State the diversity of microbes and their key metabolic processes. **CO3**: Describe extremophiles and their adaptations to harsh environments. **CO4**: Examine conservation methods and biotechnological uses of microbial diversity.

CO–PO-PSO Mapping Matrix

CO	**PO**													**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Average**	**1**	**2**	**3**	**Average**
1	3	2	–	–	–	–	–	–	–	2	–	2	**2.25**	2	2	3	**2.33**
2	3	3	2	–	2	–	–	–	–	–	–	2	**2.4**	3	3	2	**2.67**
3	3	2	–	3	3	–	–	–	–	–	–	3	**2.8**	2	2	1	**1.67**
4	3	3	–	2	3	–	2	–	2	3	2	3	**2.5**	3	3	2	**2.67**

(2-Medium Correlation; 3 – Strong Correlation)

Teaching Pedagogy
1. Constructivism 2. Social Constructivism 3. Behaviorism 4. Problem Based Learning 5. Project Based Learning 6. Inquiry-Based Learning
Teaching Methods and Tools
1. Lecture 2. Digital and Multimedia Presentations, 3. Diagrams and Layouts, 4. Group discussion 5. Online Resources and Digital Content 6. Fairs and Competition 7. Experimentation, 8. Hands on training 9. Group Work and Collaborative Learning 10. Demonstrations 11. Tutorials

Unit Wise Detailed Syllabus		
Units		**Number of Teaching Hours**
Unit -1 Microbial Evolution and Taxonomy		11
1.1	Origin of earth and life	
1.2	Microbial evolution and biogeochemical cycles	
1.3	Impact of oxygen, Endosymbiotic evolution, Origin of ozone layer, Evolutionary chronometers	
1.4	Sequence of Major events during biological evolution	
1.5	Taxonomy of Eubacteria and Archaea- Nomenclature, classification, Identification	
1.6	Nomenclature, Bergey's Manual- The nature of bacterial identification schemes, prokaryote or eukaryote, the four major categories of bacteria, groups within the four major categories of bacteria	
Unit 2 Basics of Microbial Diversity		11
2.1	Prokaryotic diversity: Bacteria- Purple and Green bacteria, Cyanobacteria, Prochlorophytes, Spirilla, Pseudomonads, Free-living aerobic nitrogen fixing bacteria, and Filamentous Actinomycetes Eukarya- Algae, Protozoa	
2.2	Microbial metabolism of Hydrogen	
2.3	Aerobic metabolism of Glucose	
2.4	Aerobic metabolism of Methane and Methanol	
2.5	Microbial metabolism of carbon dioxide	
Unit 3 Extremophiles		11
3.1	Extremes of environmental conditions allowing bacterial growth and survival	
3.2	Extremophilic microbes- acidophiles, alkaliphiles, psychrophiles, halophiles, thermophiles, Taxonomy and physiology of Extremely Halophilic Archaea	
3.3	Microbial diversity of rumen	
3.4	Microbial diversity of desert ecosystem	
Unit-4 Conservation strategies and Exploitation of Microbial Diversity		12
4.1	The challenges of studying microbial diversity	
4.2	Microbial diversity loss- causes and restoration	
4.3	National Biodiversity Strategy and Action Plan	
4.4	Biotechnology of artificial cells including application to artificial organs	
4.5	Biotechnology applied to Raw Mineral Processing, Microbially Enhanced Oil Recovery	
4.6	Microbial diversity and biodegradation of xenobiotics	
4.7	Exploitation of fungal and cyanobacterial diversity	
4.8	Societal issues of biotechnology	

Assessment Method	
Internal/Online Assessment (40%)	1. Written test (20 Marks) 2 .Quiz / Group Discussion (10 Marks) 3. Assignments / Seminar (10 Marks)
External Assessment (60%)	Term End Theory examination (Written test 60 Marks)

References-

Brock Biology of Microorganisms" 16th Edition By- Madigan, T.M.; Bender K.S.; Buckley D. H.; Sattley W.M. and Stahl D.A. (2020) Published by Pearson Education.

"Evolution" – Douglas J. Futuyma, Publisher: Sinauer Associates / Oxford University Press Year: 2017 (4th Edition)

"Principles of Microbial Diversity" – James W. Brown, Publisher: ASM Press, Year: 2014

"Microbial Taxonomy" – R. C. Dubey, Publisher: S. Chand Publishing, Year: Latest edition varies (2019)

"Microbiology" by Prescott, Harley, & Klein (2007) – Chapters on microbial taxonomy & diversity Publisher- McGraw-Hill Higher Education

"Microbiology" by Prescott, Harley, & Klein (2007) – Chapters on microbial taxonomy & diversity McGraw-Hill Higher Education

"Extremophiles: Where It All Began" by Koki Horikoshi (2016) Publisher- Springer, Japan

"Microbial Ecology of Extreme Environments" edited by B. Hallsworth (2017) Springer International Publishing

"Microbial Diversity: Current Perspectives and Potential Applications" by Satyanarayana et al. (2005) IK International Pvt Ltd. in Delhi.

"Microbial Degradation of Xenobiotics" by S.N. Singh (Springer) (2012) Publisher- Springer Berlin, Heidelberg

"Biotechnology and Society" by Hallam Stevens (2016) University of Chicago Press

Microbiology: Dynamics & Diversity, - Perry JJ and Staley JT, Saunders College Publishing, US (1997)

Bergey's Manual of Determinative Bacteriology, by John G Holt, Noel R Krieg, Peter HA Sneath, James T Staley and Stanley T Williams, Lippincott Williams & Wilkins, Maryland (2000)

Molecular Biotechnology: Principles and Applications of Recombinant DNA, by Bernard R. Glick, Jack J Pasternak, Cheryl L Patten (2010).

The Prokaryotes-A Handbook on The Biology of Bacteria: Ecophysiology, Isolation, Identification, Application, Second Edition, Volume-I Editors-Balows, A.; Truper, H.G.; Dworkin, M.; Harder, W. and Schleiffer, K.H. Springer-Verlag Publication, New York (2013)

Online Resources

International Code of Nomenclature of Prokaryotes (ICNP) → https://lpsn.dsmz.de – *List of Prokaryotic names with Standing in Nomenclature*

Open Access Educational Platforms

NCBI Bookshelf: https://www.ncbi.nlm.nih.gov/books/

Books on microbial genetics, taxonomy, and evolutionary biology.

MIT OpenCourseWare – Astrobiology / Origin of Life:https://ocw.mit.edu → Search for "origin of life" or "microbial evolution"
NASA Earth Observatory (for ozone and atmospheric evolution): earthobservatory.nasa.gov
NCBI Bookshelf → **https://www.ncbi.nlm.nih.gov/books**
ASM (American Society for Microbiology) Microbe Library**https://asm.org –**
FAO – Rumen Microbiology and Fermentation→ **http://www.fao.org –**
"Desert Microbiology" – Topics in ***Environmental Microbiology*** journals

Scientific Databases & Journals
PubMed Central: https://www.ncbi.nlm.nih.gov/pmc/
Search terms: *endosymbiotic evolution*, *oxygen revolution*, *molecular chronometers*.
Microbiology Society – Journal Access: https://www.microbiologyresearch.org/

Taxonomy Specific Resources
LPSN (List of Prokaryotic names with Standing in Nomenclature) https://lpsn.dsmz.de/
Official database for current bacterial taxonomy.
Bergey's Manual Trust – Springer Link Accesshttps://link.springer.com/bergeys

Review Articles:
Greening et al. (2016) *"Diversity and physiology of hydrogen-consuming microorganisms"*, FEMS Microbiology Reviews→ https://doi.org/10.1093/femsre/fuv040
Semrau et al. (2010) *"Methanotrophs and copper"* in *FEMS Microbiology Reviews* → https://doi.org/10.1111/j.1574-6976.2010.00233.x
Berg IA (2011) *"Ecological aspects of carbon dioxide fixation in bacteria"*, FEMS Microbiology Letters→ https://doi.org/10.1111/j.1574-6968.2011.02120.x

M.Sc. Semester-1	**MMIC -101P**	**Microbial Diversity**	Compulsory
Credit- 02, Total Number of Teaching Hours- 60Hrs			

Course Outcome (CO)
After studying this course the student will be able to
CO1: Distinguish microorganisms based on their physiological and metabolic traits. CO2: Compare microbial diversity across fungi and various natural habitats.

CO–PO-PSO Mapping Matrix

CO	**PO**													**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Average**	**1**	**2**	**3**	**Average**
1	3	3	3	2	2	–	–	3	2	–	–	2	**2.5**	3	2	2	**2.33**
2	3	3	3	2	–	2	3	2	2	3	2	3	**2.54**	2	3	2	**2.33**

(2-Medium Correlation; 3 – Strong Correlation)

Teaching Pedagogy
1. Constructivism 2. Social Constructivism 3. Behaviorism
Teaching Methods and Tools
1. Direct Teaching using Black board, 2. Experimentation, 3. Hands on training

Practical Syllabus	
Practical	
1	Study of Physiological diversity of microorganisms (Bacteria)
2	Study of Metabolic diversity of microorganisms (Bacteria)
3	Study of fungal diversity
4	Diversity study of various habitats

Assessment Method	
Internal/Online Assessment (40%)	Internal Practical Examination (40 Marks)
External Assessment (60%)	Term End Practical examination (60 Marks)

M.Sc. Semester-1	**MMIC-102**	**Microbial Physiology**	Compulsory
Credit- 03, Total Number of Teaching Hours- 45Hrs			

Course Outcome (CO)
After studying this course the student will be able to
CO1: Describe the principles of microbial growth kinetics, factors affecting growth, measurement techniques, and methods to control microbial proliferation. **CO2:** Describe membrane structure and transport mechanisms, and examine microbial adaptations, gene regulation, and cell-to-cell communication. **CO3:** State the structural and functional aspects of fungi, including their nutrition, metabolism, growth, and reproduction. **CO**4: Relate various microbial metabolic strategies, including respiration and autotrophic pathways for energy generation and nutrient assimilation.

CO–PO-PSO Mapping Matrix

CO	**PO**													**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Average**	**1**	**2**	**3**	**Average**
1	3	3	2	–	2	–	–	–	–	2	–	–	**2.4**	3	2	2	**2.33**
2	3	2	3	–	–	–	–	3	–	–	–	2	**2.6**	3	2	3	**2.67**
3	3	2	–	2	2	–	–	–	–	–	–	–	**2.25**	2	3	2	**2.33**
4	3	3	2	–	3	–	2	3	–	3	2	2	**2.55**	3	3	2	**2.67**

(2-Medium Correlation; 3 – Strong Correlation)

Teaching Pedagogy
1. Constructivism 2. Social Constructivism 3. Behaviorism
Teaching Methods and Tools
1. Direct Teaching using Black board, 2. Presentations, 3. Multimedia resources, 4. Diagrams and Layouts, 5. Group discussion and activity, 6. Experimentation, 7. Hands on training

Unit Wise Detailed Syllabus		
Units		**Number of Teaching Hours**
	Unit-1: Microbial Growth	11
1.1	Bacterial growth and its kinetics: Definition, trophophase and idiophase, Diauxic growth, Maximum growth rate, Specific growth rate, Yield co-efficient	
1.2	Continuous growth and its kinetics: Continuous culture, Dilution rate, Residual substrate concentration	
1.3	Factors affecting growth: Temperature, pH, Oxygen, Salt concentration, Pressure, Water activity, Radiation	
1.4	Growth measurement: Direct methods and indirect methods	
1.5	Control of microbial growth: Physical agents and chemical agents	
	Unit-2: Membrane Transport, Physiological Adaptations and Intercellular Signalling	11
2.1	Cytoplasmic Membrane and Transport- Membrane Structure, The Functions of cytoplasmic membrane, Nutrient Transport	
2.2	Physiological Adaptation and Intercellular signaling- Overview of Regulation of gene expression, Bioluminescence, Signal Transduction and its Molecular mechanisms, Mechanism of drug resistance, Quorum Sensing, Cellular Differentiation, Microbial Stress Responses	
	Unit-3: Physiological and Metabolism Diversity of Fungi	12
3.1	Introduction to fungal physiology	
3.2	Morphology of yeasts and fungi- Filamentous fungi, Yeasts	
3.3	Ultrastructure and function of fungal cells- The fungal cell surface, Subcellular architecture and organelle function	
3.4	Fungal nutrition and cellular biosynthesis- Chemical requirements for growth, Fungal cultivation media, Nutrient uptake and assimilation, Overview of fungal biosynthetic pathways, Fungal cell wall growth	
3.5	Fungal metabolism- Carbon catabolism, Nitrogen metabolism	
3.6	Fungal growth and reproduction- Physical requirements for growth, Cellular reproduction, Population growth, Fungal cell death	
	Unit-4: Diversity of Heterotrophic and Autotrophic Metabolism	11
4.1	Metabolic Strategies for Generating Cellular Energy	
4.2	Respiration- Oxydative Phosphorylation, Aerobic Chemoorganotrophic Process, Anaerobic Respiration	
4.3	Autotrophy (The Calvin Cycle, Other Autotrophic pathways, Nitrogen Metabolism)	

Assessment Method	
Internal/Online Assessment (40%)	1. Written test (20 Marks) 2 .Quiz / Group Discussion (10 Marks) 3. Assignments / Seminar (10 Marks)
External Assessment (60%)	Term End Theory examination

	(Written test 60 Marks)

References-

Walker, G.M. and White, N.A. 2017. Introduction to fungal physiology. In: K. Kavangh, ed. Fungi: biology and applications. John Wiley & Sons

Microbial Physiology (4th Ed.) 2002, Albert G. Moat, John W. Foster, Micheal P. Spector Willey-Liss, A John Willey and Sons, Inc

The Cell, A Molecular Approach (4th Ed.) 2007, Geoffrey M. Cooper, Robert E. Hausman, ASM Press, Washington D.C.

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Lehninger, Principles of Biochemistry (4th Ed.) 2005, David L. Nelson, Micheal M. Cox, W. H. Freeman and company, New york

Microbs (2006) Schaechter, M, Ingraham, J.L. and Neidhardt, F.C. ASM Press, Washington DC

Microbiology: An Introduction (2004), Tortora, G.J., Funke B.R. and Case C.L., Benjamin Cummings, San Francisco

Prescott. Harley and Kleings, Microbiology (7th Ed.) Willey Sherwood Woolverton, McGraw Hill International Edition

Principles of Microbiology (2nd Ed.) Ronals M. Atlas

M.Sc. Semester-1	**MMIC -102P**	**Microbial Physiology**	Compulsory
Credit- 02, Total Number of Teaching Hours- 60Hrs			

Course Outcome (CO)
After studying this course the student will be able to
CO1: Use practical skills for measuring microbial growth, death rates, and biomass using standard physiological methods. **CO2:** Examine how environmental and nutritional factors influence microbial growth through hands-on experimentation.

CO–PO-PSO Mapping Matrix

CO	**PO**													**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Average**	**1**	**2**	**3**	**Average**
1	3	3	3	–	2	–	2	–	–	2	–	–	**2.5**	3	2	2	**2.33**
2	3	2	3	–	–	2	2	3	2	3	2	3	**2.77**	3	3	2	**2.67**

(2-Medium Correlation; 3 – Strong Correlation)

Teaching Pedagogy
1. Constructivism 2. Social Constructivism 3. Behaviorism
Teaching Methods and Tools
1. Direct Teaching using Black board, 2. Experimentation, 3. Hands on training

Practical Syllabus	
Practicals	
1	Growth Kinetics: Calculation of Generation time, Growth rate, µMax Substrate utilization (Glucose -Coles method)
2	Growth Measurement by Biomass (Fungal culture), Gravimetric Method
3	Factors affecting growth: pH, Temperature, Aeration, Agitation, Carbon source, Nitrogen source
4	Measurement of Water Activity (Aw)
5	Measurement of Death Rate of Bacteria
6	Whole cell mass determination of yeast and fungi under different conditions

Assessment Method	
Internal/Online Assessment (40%)	Internal Practical Examination (40 Marks)
External Assessment (60%)	Term End Practical examination (60 Marks)

M.Sc. Semester-1	**MMIC -103**	**Bioinstrumentation**	Compulsory
Credit- 03, Total Number of Teaching Hours- 45Hrs			

Course Outcome (CO)
After studying this course the student will be able to
CO1: State the principles, working, and applications of advanced microscopy techniques and molecular tools like PCR and sequencing. **CO**2: Describe various spectroscopic techniques including IR, NMR, ESR, Mass, and X-ray spectroscopy, emphasizing their principles and applications in biological analysis. **CO**3: Relate the principles and instrumentation of classical and advanced chromatographic techniques used for molecular separation and analysis. **CO**4: Examine centrifugation and electrophoretic techniques, understanding their mechanisms and roles in separating and analyzing biological samples.

CO–PO-PSO Mapping Matrix

CO	**PO**													**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Average**	**1**	**2**	**3**	**Average**
1	3	3	3	-	-	2	2	-	-	-	-	-	**2.6**	3	2	2	**2.33**
2	3	3	3	-	-	-	2	3	-	-	-	-	**2.8**	3	2	2	**2.33**
3	3	2	3	-	-	-	-	2	-	-	-	-	**2.5**	3	3	2	**2.67**
4	3	3	3	-	-	-	2	3	2	3	-	-	**2.7**	3	2	2	**2.33**

(2-Medium Correlation; 3 – Strong Correlation)

Teaching Pedagogy
1. Constructivism 2. Social Constructivism 3. Behaviorism
Teaching Methods and Tools
1. Direct Teaching using Black board, 2. Presentations, 3. Multimedia resources, 4. Diagrams and Layouts, 5. Group discussion and activity, 6. Experimentation, 7. Hands on training

Unit Wise Detailed Syllabus		
Units		**Number of Teaching Hours**
Unit -1 Principle, Instrumentation and Techniques		11
1.1	Principle and application of scanning and transmission electron microscopy, scanning tunneling microscopy, confocal microscopy	

1.2	PCR and Sequencing Techniques	
Unit 2 Specialized Spectroscopy: (Principle, Instrumentation and Applications)		12
2.1	Infrared Spectroscopy, Flame emission Spectroscopy and Atomic absorption spectroscopy	
2.2	Nuclear Magnetic Resonance Spectroscopy, Electron Spin Resonance Spectroscopy, Mass Spectroscopy- MALDI-TOF and X- Ray Spectroscopy.	
Unit 3 Separation Techniques :1: (Principle, Instrumentation and Applications)		11
3.1	Chromatography: Paper; TLC; Conventional Column Chromatography- Ion- Exchange; Affinity; Adsorption	
3.2	Specialized Technique-I: GLC- Column; Detectors. HPLC: Pumps; Columns; Instrumentation	
3.3	Specialized Technique-II: HPTLC, FPLC	
Unit-4 Separation Techniques: 2: (Principle, Instrumentation and Applications)		11
4.1	Centrifugation Techniques: Types of centrifugation; Rate Zone; Isopycnic; High speed; Ultra; preparative; Gradient	
4.2	Electophoretic Techniques: Native, SDS, Agarose and 2D; Zone EP; Isoelectric; Slab Gel; DISC EP; Immuno EP; Pulsed Field; Cellular Gel EP.	

Assessment Method	
Internal/Online Assessment (40%)	1. Written test (20 Marks) 2 .Quiz / Group Discussion (10 Marks) 3. Assignments / Seminar (10 Marks)
External Assessment (60%)	Term End Theory examination (Written test 60 Marks)

References-

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M.Sc. Semester-1	**MMIC -103P**	**Bioinstrumentation**	Compulsory
Credit- 02, Total Number of Teaching Hours- 60Hrs			

Course Outcome (CO)
After studying this course the student will be able to
CO1: Quantify biomolecules using colorimetric, chromatographic, and spectrophotometric techniques. **CO**2: Explain hands-on experience with advanced bioinstrumentation tools for the separation, analysis, and characterization of biological compounds.

CO–PO-PSO Mapping Matrix

CO	**PO**													**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Average**	**1**	**2**	**3**	**Average**
1	3	3	3	-	-	2	2	-	-	-	-	-	**2.6**	3	2	2	**2.33**
2	3	2	3	-	-	-	2	3	2	3	-	-	**2.57**	3	3	2	**2.67**

(2-Medium Correlation; 3 – Strong Correlation)

Teaching Pedagogy
1. Constructivism 2. Social Constructivism 3. Behaviorism
Teaching Methods and Tools
1. Direct Teaching using Black board, 2. Experimentation, 3. Hands on training

Practical Syllabus	
Practicals	
1	Estimation of Carbohydrates by Anthrone's Method.
2	Estimation of Reducing Sugars by DNSA Method.
3	Estimation of Carbohydrate by Nelson Somogyi's Method
4	Estimation of Protein by Folin Lowry's Method.
5	Separation and detection of Compounds by Chromatography: Paper, TLC Separation of bacterial lipids/amino acids/sugars/organic acids by TLC or Paper Chromatography, ETC.
6	Analysis of Elements by Flame Photometer
7	Separation of serum protein by horizontal submerged gel electrophoresis.
8	Quantitative estimation of hydrocarbons/pesticides/organic
9	Demonstration of HPLC, HPTLC and AAS.
10	Demonstration of Fermenters
11	Separation of biomolecules by gel filtration

Assessment Method	
Internal/Online Assessment (40%)	Internal Practical Examination (40 Marks)
External Assessment (60%)	Term End Practical examination (60 Marks)

M.Sc. Semester-1	**MMIC -104**	**Immunology**	Compulsory
Credit- 03, Total Number of Teaching Hours- 45Hrs			

Course Outcome (CO)
After studying this course the student will be able to
CO1: Describe the structure and function of immune system components, and the principles of humoral and cell-mediated immunity, along with antigen-antibody structure and properties. **CO**2: State the mechanisms and applications of antigen-antibody interactions and the complement system, including their diagnostic and biological significance. **CO**3: Describe the genetic basis of immune responses through MHC and HLA systems, and describe immune mechanisms in cancer and their therapeutic applications. **CO**4: Predict immune disorders, hypersensitivities, and autoimmune diseases, along with the production and application of monoclonal antibodies and modern vaccine technologies.

CO–PO-PSO Mapping Matrix

CO	**PO**													**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Average**	**1**	**2**	**3**	**Average**
1	3	3	–	–	–	2	2	–	–	–	–	–	**2.5**	2	3	2	**2.33**
2	3	3	3	–	–	–	3	3	–	–	–	–	**3**	2	3	2	**2.33**
3	3	3	–	3	–	–	3	–	3	–	–	–	**3**	2	3	3	**2.67**
4	3	3	3	–	–	3	–	2	2	3	–	3	**2.75**	3	3	3	**3.00**

(2-Medium Correlation; 3 – Strong Correlation)

Teaching Pedagogy
1. Constructivism 2. Social Constructivism 3. Behaviorism
Teaching Methods and Tools
1. Direct Teaching using Black board, 2. Presentations, 3. Multimedia resources, 4. Diagrams and Layouts, 5. Group discussion and activity, 6. Experimentation, 7. Hands on training

Unit Wise Detailed Syllabus		
Units		**Number of Teaching Hours**
Unit -1		10
	General principles of immunology: Structure, composition and function of cells and organs involved in immune system. Immune response (humoral and cell mediated) innate immunity, acquired immunity	
	Antigens – antibodies: Antigens-structure and properties; types-iso and allo; haptens adjuvants, antigen specificity. Membrane receptors for antigens; immunoglobulins; structure-heterogeneity-types and subtypes-properties; theories of antibody production	
Unit 2		10
	Antigen and antibody interactions: In vitro methods-agglutination, precipitation, complement fixation, immunofluorescence, ELISA, radio immunoassay; in vivo methods; phagocytosis, opsonization, neutralization	
	Complement system; complement components. complement activation - pathways,regulation of complement system, biological consequences of complement activation, complement deficiencies	
Unit 3		15
	Immunogenetics: Structure, distribution and functions of histocompatibility antigens.Major histocompatibility gene complex (MHC) and the HLI-A system; gene regulation and immune response (IR) genes; HL-A and tissue transplantation- tissue typing methods for organ and tissue transplantations in humans; graft versus host reaction and rejection.	
	Tumor immunology: Tumor immunology - tumor antigens, Host immune response to tumors, antibody dependent cell cytotoxicity (ADCC), tumor escape mechanisms Immuno diagnosis and therapy	
Unit-4		10
	Immunopathology: Classification of immunopathological disorders. General account of immune deficiency disorders. Primary and secondary, phagocytic cell disorder. Gammopathies. Complement deficiencies. Hypersensitivity reactions: type I, II, III and IV the respective diseases, immunological methods of their diagnosis. Autoimmunity mechanism and diseases	
	Immuno biotechnology: Isolation of spleen cells, Myeloma cell lines used as fusion partner, fusion method, detection and application of monoclonal antibodies, types of vaccines, whole - organism vaccines, recombinant vector vaccines, DNA vaccines, synthetic peptide vaccines, subunit vaccines, immunization procedures, adverse reactions to vaccines	

Assessment Method	
Internal/Online Assessment (40%)	1. Written test (20 Marks) 2 .Quiz / Group Discussion (10 Marks) 3. Assignments / Seminar (10 Marks)
External Assessment (60%)	Term End Theory examination (Written test 60 Marks)

References-

Essentials of Immunology by Riott I .M. 1998. ELBS, Blackwell Scientific Publishers, London

Immunology 2 nd Edition by Kuby J. 1994. W.H. Freeman and Co. New York

Immunology - Understanding of Immune System by Claus D. Elgert. 1996. Wiley - Liss, New York

Fundamentals of Immunology by William Paul

Cellular and Molecular Immunology. 3rd Edition by Abbas

Immunobiology: The Immune System in Health and Disease. 3rd Edition by Travers

Immunology- A short Course. 2 nd Edition by Benjamin

Manual of Clinical Laboratory and Immunology 6th Edition. 2002 by Noel R. Rose, Chief Editor: Robert G. Hamilton and Barbara Detrick (Eds.) , ASM Publications

Pocket Guide to Clinical Microbiology. 2nd Edition. 1998 by Patrick R. Murray, ASM Publications

M.Sc. Semester-1	**MMIC -104P**	**Immunology**	Compulsory
Credit- 02, Total Number of Teaching Hours- 60Hrs			

Course Outcome (CO)
After studying this course the student will be able to
CO1: To develop practical proficiency in immunological techniques such as ELISA, immunodiffusion, and immunoelectrophoresis for antigen-antibody interaction studies. **CO**2: To enable students to perform quantitative and qualitative assays for detecting and analyzing antibodies, antigens, and immune complexes.

CO–PO-PSO Mapping Matrix

CO	**PO**													**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Average**	**1**	**2**	**3**	**Average**
1	3	3	3	–	–	2	2	–	–	–	–	–	**2.6**	3	2	2	**2.33**
2	3	2	3	–	–	–	2	3	2	3	–	3	**2.625**	3	3	2	**2.67**

(2-Medium Correlation; 3 – Strong Correlation)

Teaching Pedagogy
1. Constructivism 2. Social Constructivism 3. Behaviorism
Teaching Methods and Tools
1. Direct Teaching using Black board, 2. Experimentation, 3. Hands on training

Practical Syllabus	
Practicals	
1	Ouchterlony double diffusion (Ab titration)
2	Ouchterlony double diffusion (Antigen – Antibody titration)
3	DOT ELISA
4	Single radial Immuno diffusion
5	Rocket immune electrophoresis
6	RA test
7	Immuno electrophoresis
8	Quantitative precipitin assay
9	Antibody labelling

Assessment Method	
Internal/Online Assessment (40%)	Internal Practical Examination (40 Marks)
External Assessment (60%)	Term End Practical examination (60 Marks)

Semester-2

M.Sc. Semester-2	**MMIC -201**	**Enzymology**	Compulsory
Credit- 03, Total Number of Teaching Hours- 45Hrs			

Course Outcome (CO)
After studying this course the student will be able to
CO1: Describe classification, specificity, and models explaining enzyme-substrate interactions and mechanisms of enzymatic action. **CO**2: State the kinetic behavior of enzymes in single- and multi-substrate reactions, including steady-state, non-steady-state kinetics, and allosteric regulation. **CO**3: Describe enzyme inhibition types, structural analysis of active sites, and principles of protein ligand binding and cooperativity. **CO**4: Describe techniques of enzyme and cell immobilization and their applications in industrial and research settings.

CO–PO-PSO Mapping Matrix

CO	**PO**													**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Average**	**1**	**2**	**3**	**Average**
1	3	2	–	–	–	–	–	–	–	2	–	2	**2.25**	2	2	2	**2.00**
2	3	3	2	–	–	–	–	3	–	–	–	–	**2.75**	2	3	2	**2.33**
3	3	3	3	–	–	–	–	3	–	–	–	–	**3**	2	2	2	**2.00**
4	3	3	3	3	-	3	2	2	-	3	2	3	**2.7**	3	3	2	**2.67**

(2-Medium Correlation; 3 – Strong Correlation)

Teaching Pedagogy
1. Constructivism 2. Social Constructivism 3. Behaviorism
Teaching Methods and Tools
1. Direct Teaching using Black board, 2. Presentations, 3. Multimedia resources, 4. Diagrams and Layouts, 5. Group discussion and activity, 6. Experimentation, 7. Hands on training

Unit Wise Detailed Syllabus		
Units		**Number of Teaching Hours**
Unit -1 Structure and Functions of Enzymes		10
1.1	Introduction to Enzymes (History, naming and classification of Enzymes)	
1.2	Specificity of Enzyme action- Active site of enzymes, The Fischer's 'Lock and Key' hypothesis, The Koshland 'Induced fit' hypothesis, and Hypothesis involving strain or transition-state stabilization	
Unit 2 Enzyme Kinetics		12
2.1	Kinetics of Single-substrate-enzyme catalysed reactions- The relationship between initial velocity and substrate concentration- Derivation and significance of the 'Henri and Michaelis-Menten' equation; The 'Briggs-Haldane' modification of the 'Michaelis-Menten' equation; Derivation of the 'Line Weaver-Berk' equation and plots; The 'Eadie-Hofstee' and 'Hanes' plots; The 'Eisenthal and Cornish-Bowden' plots; Derivation of the 'Haldane' relationship for reversible reactions. Rapid-Reaction kinetics: Pre-steady state kinetics & Relaxation kinetics	
2.2	Kinetics of Multi-substrate-enzyme catalysed reactions- Examples of possible mechanisms- Introductory knowledge of Ping-Pong bi-bi mechanism; Random-order mechanism; and Compulsory-order mechanism Investigation of Reaction Mechanisms using Steady-state methods: The use of Primary plots; and the use of inhibitors which compete with substrate for binding sites Investigation of Reaction mechanisms using non-steady-state methods: Isotope exchange at equilibrium and Rapid-reaction studies	
2.3	Sigmoidal Kinetics and Allosteric Enzymes- The 'Monod- Wyman-Changeux (MWC) Model; The 'Koshland-Nemethy-Filmer (KNF) Model; Differentiation between models for cooperative binding in proteins;	
Unit 3 Mechanisms of Enzyme-catalysed Reactions		12
3.1	Enzyme Inhibition- Reversible Inhibition- Competitive Inhibition - Characteristics of competitive inhibition, Michaelis-Menten and Lineweaver-Burk plot showing the effect of a competitive inhibitor, Steady-state Kinetics of a single-substrate single-binding-site single-intermediate enzyme-catalysed reaction in the presence of a Competitive inhibitor Uncompetitive inhibition - Characteristics of Uncompetitive inhibition, Lineweaver-Burk plot showing the effect of a uncompetitive inhibitor, Steady-state Kinetics of a singe-substrate single-binding-site single- intermediate enzyme-catalysed reaction in the presence of a uncompetitive inhibitor Non-competitive inhibition- Characteristics of non-competitive inhibition, Lineweaver-Burk plot showing the effect of a non-competitive inhibitor, Steady-state Kinetics of a single-substrate single-binding-site single- intermediate enzyme-catalysed reaction in the presence of a non-competitive inhibitor	

	Mixed inhibition - Characteristics of mixed inhibition, Lineweaver-Burk plot showing the effect of a mixed inhibitor, Steady-state Kinetics of a single-substrate single-binding-site single-intermediate enzyme-catalysed reaction in the presence of a mixed inhibitor Partial inhibition; Substrate inhibition and Michaelis-Menten and Lineweaver-Burk plots showing the effects of substrate inhibition; Allosteric inhibition	
3.2	Study of active site structure: Binding sites and catalytic sites- enzyme-substrate complex, substrate analogues, Enzyme modification by chemical procedure affecting amino acid side chains, by treatment with proteases, by site-directed mutagenesis, Effect of changing pH	
3.3	Protein-ligand binding and cooperativity: General considerations of binding of a ligand to a protein having a single ligand-binding site Types of cooperativity, Positive homotrophic cooperativity and derivation of the 'Hill' equation, The Adair equation for the binding of a ligand to a protein having two binding sites for that ligand- General considerations, under no interaction between the binding sites, under positive homotropic cooperativity; under negative homotropic cooperativity. The Adair equation for the binding of a ligand to a protein having three and four binding sites for that ligand Study of cooperative effects Binding of oxygen to hemoglobin	
Unit-4 Application and purification of Enzymes		11
4.1	Immobilization Techniques for Enzymes: Carrier- Definition, Durability and adverse effects Immobilization procedures- adsorption, covalent coupling, cross linking, entrapment, encapsulation	
4.2	Immobilization Techniques for Cell : Immobilization procedures- Adsorption, Covalent Bonding, Cell to cell crosslinking, Microencapsulation,	

Assessment Method	
Internal/Online Assessment (40%)	1. Written test (20 Marks) 2 .Quiz / Group Discussion (10 Marks) 3. Assignments / Seminar (10 Marks)
External Assessment (60%)	Term End Theory examination (Written test 60 Marks)

References-

"Biochemistry" – Jeremy M. Berg, John L. Tymoczko, Lubert Stryer, *Publisher:* W.H. Freeman, *Edition:* 8th Edition, 2015

"Lehninger Principles of Biochemistry" – David L. Nelson & Michael M. Cox, *Publisher:* Macmillan / W.H. Freeman, *Edition:* 8th Edition, 2021

Enzymes- Biochemistry, Biotechnology, Clinical Chemistry- by Trevor Palmer (2004), Affiliated East-West Press Pvt. Ltd, New Delhi.
Immobilized Enzymes and Cells- Rosevear, Kennedy, J and cabral, MS, Adam Hilger, Bristol and Philadelphia (1987)
Microbial Enzymes and Biotechnology, 2nd Edition, William M Fogarty and Catherine T Kelly, Elsevier Applied Science Publishers, New York.
Immobilized Enzymes- Michael D Trevan, John Wiley & Sons, New York. (1980)
Online Resources-
Enzyme Nomenclature Database (IUBMB), https://enzyme.expasy.org/
NCBI Bookshelf – Biochemistry Resources, https://www.ncbi.nlm.nih.gov/books/

M.Sc. Semester-2	**MMIC -201P**	**Enzymology**	Compulsory
Credit- 02, Total Number of Teaching Hours- 60Hrs			

Course Outcome (CO)
After studying this course the student will be able to
CO1: Measure enzyme kinetics parameters such as Km and Vmax using standard biochemical assays. **CO**2: Analyze the activity of key enzymes like acid phosphatase, alkaline phosphatase, and urease.

CO–PO-PSO Mapping Matrix

CO	**PO**													**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Average**	**1**	**2**	**3**	**Average**
1	3	3	3	–	–	–	–	3	–	3	–	–	**3**	3	2	2	**2.33**
2	3	2	3	–	–	–	–	3	–	–	–	–	**2.75**	3	3	2	**2.67**

(2-Medium Correlation; 3 – Strong Correlation)

Teaching Pedagogy
1. Constructivism 2. Social Constructivism 3. Behaviorism
Teaching Methods and Tools
1. Direct Teaching using Black board, 2. Experimentation, 3. Hands on training

Practical Syllabus	
Practicals	
1	Determination of Acid-Phosphatase activity.
2	Determination of Alkaline-Phosphatase activity.
3	Determination of Urease activity
4	Determination of Km and Vmax

Assessment Method	
Internal/Online Assessment (40%)	Internal Practical Examination (40 Marks)
External Assessment (60%)	Term End Practical examination (60 Marks)

M.Sc. Semester-2	**MMIC -202**	**Molecular biology and Bacterial Genetics**	Compulsory
Credit- 03, Total Number of Teaching Hours- 45Hrs			

Course Outcome (CO)
After studying this course the student will be able to
CO1: Describe the structure of DNA and RNA, and explore the mechanisms of bacterial DNA replication, transcription, translation, and post-translational modifications. **CO**2: State various types of genetic mutations, mechanisms of mutagenesis and DNA repair, and the molecular basis of genetic recombination in bacteria. **CO**3: Describe the processes of bacterial conjugation, transformation, and transduction, including molecular mechanisms and their evolutionary significance. **CO**4: Describe plasmid biology, transposition mechanisms, and regulatory systems like lac and trp operons that control gene expression in bacteria.

CO–PO-PSO Mapping Matrix

CO	**PO**													**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Average**	**1**	**2**	**3**	**Average**
1	3	3	–	–	–	–	3	2	–	2	–	–	**2.6**	2	3	2	**2.33**
2	3	3	2	–	–	–	–	2	–	–	–	–	**2.5**	2	3	2	**2.33**
3	3	3	3	3	–	–	–	–	–	–	–	–	**3**	2	3	3	**2.67**
4	3	3	2	3	–	3	–	2	–	3	3	3	**2.77**	3	3	2	**2.67**

(2-Medium Correlation; 3 – Strong Correlation)

Teaching Pedagogy
1. Constructivism 2. Social Constructivism 3. Behaviorism
Teaching Methods and Tools
1. Direct Teaching using Black board, 2. Presentations, 3. Multimedia resources, 4. Diagrams and Layouts, 5. Group discussion and activity, 6. Experimentation, 7. Hands on training

Unit Wise Detailed Syllabus		
Units		**Number of Teaching Hours**
Unit -1		11
1.1	Structure and organization of bacterial genome and Replication:	
	1. Structure of DNA- DNA is usually a double helix, Complementarities of two chains, Tautomeric forms of each base, DNA denatures as well as renatures, viruses have 1S (single stranded) DNA chromosomes, 1S (single stranded) DNA has compact structure 2. Crystallographic proof of double helix in DNA Alternative forms of right-handed DNA, 'Z' form of DNA Methylation of 'C' and 'A' in DNA and its effects on the forms of DNA, Spontaneous deformation of double helix in solution Sequence specific bending and Kinking of DNA 3. Bacterial DNA replication	
1.2	Transcription and translation of bacterial genes	
	1. The structure and function of RNA- types of RNA, RNA precursors, RNA structure, RNA processing and modification 2. Transcription- Molecular mechanism; Bacterial RNA polymerase, Transcription Initiation, Polymerization reaction, Transcription Termination 3. Translation- Protein structure, Ribosome structure, the Genetic code, Translation initiation, elongation and termination, Polycistronic mRNA 4. Post translational modification and Protein folding- Mechanism of post translational modification of protein, Protein folding mechanism- Chaperones, Protein disulfide isomerases, Membrane proteins	
Unit 2		11
2.1	Mutations and DNA repair	
	1. Phenotypic classes of mutants, genotypic classes of mutants, conditionally lethal mutations, Silent mutations and its reasons, leaky mutations, methodology for the detection and selection of Auxotrophic mutants- phenotypic lag and phenomic lag, Suppressor mutations and its types. 2. Mutagenesis: U.V. (physical mutagenic agent), Chemical mutagen- Base Analogues (5 Bromo Uracil and 2 Amino Purine), Oxidative deaminating agents (Nitrous acid, Hydroxyl amine), alkylating agents and intercalating agents. 3. Repair: Direct repair-Photo reactivation and Removal alkyl group by Alkyl Transferases; Indirect repair- SOS repair, Mismatch repair, Excision repair, Adaptive response to alkylating agents; Post-replicative repair.	
2.2	Recombination models:	
	Requirements and Molecular Models of Recombination- Holiday double stranded DNA molecules, single stranded invasion	

	model, Molecular basis for Recombination in E.coli- chi sites and RecBCD Nuclease, Synapse formation and RecA protein, Ruv protein	
Unit 3		11
3.1	Conjugation	
	1. Mechanism of DNA transfer during Conjugation in Gram –ve bacteria- Transfer tra genes, the oriT sequence, function of plasmid primases in transfer, Mobilizable plasmids 2. Chromosome transfer by plasmids- Formation of Hfr strains, transfer of chromosomal DNA by integrated Plasmids, chromosome mobilization and Prime factors 3. Transfer systems of Gram +ve bacteria- Plasmid attracting Pheromones	
3.2	Transformation	
	1. Natural Transformation 2. Competence 3. Uptake of DNA during Natural Transformation 4. Mechanism of DNA uptake during Transformation 5. Role of Natural Transformation 6. Artificially induced competence- Calcium ion induction and Electroporation	
3.3	Transduction	
	1. Phage λ and lysogeny 2. Generalized and specialized Transduction and its consequences	
Unit-4		12
4.1	Extra chromosomal inheritance	
	1. Nomenclature and classification of Plasmids, Plasmid structure, phenotypic traits encoded by Plasmids. 2. Properties of Plasmids: Replication-theta and rolling circle mechanism; Functions of ori region- Regulation of copy number, Host range of Plasmids; Mechanisms to prevent curing of Plasmids- Resolution of multimeric Plasmids and Partitioning; Incompatibility- due to replication control and partitioning.	
4.2	Transpositon	
	1. Structure of Transposons 2. Types of bacterial Transposons- IS elements, Composite transposons, Non-composite transposons 3. Molecular models for transposition- Replicative transposition, Cut and paste transposition, Relationship between replicative and cut and paste transposition and their target regulation	
4.3	Control	
	1. Lac operon- Positive control, Negative control, Catabolite repression and role of CAP 2. Tryptophan operon- Attenuation control	

Assessment Method	
Internal/Online Assessment (40%)	1. Written test (20 Marks) 2 .Quiz / Group Discussion (10 Marks) 3. Assignments / Seminar (10 Marks)
External Assessment (60%)	Term End Theory examination (Written test 60 Marks)

References-

Benjamin Lewin (2004), Gene VIII, Pearson Prentice Hall, Pearson Education, Inc. Upper Saddle, NT 07458.

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Gardner EJ, Simmons MJ and Snustad DP (2008) Principles of Genetics, 8th edition, Wiley India.

Griffiths AJF, Wessler SR, Lewontin RC and Carroll SB (2007) Introduction to Genetic Analysis, 9th
edition, W. H. Freeman & Co.

Hardin J and Bertoni GP (2009) The World of the Cell, 7th edition, Pearson Benjamin Cummings Publishing, San Francisco.

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Sambrook J, Fritsch EF and Maniatis T (2001) Molecular Cloning-A Laboratory, Manual, 3rd edition, Cold Spring Harbor Laboratory Press.

Snyder L and Champness W (2007) Molecular Genetics of Bacteria, 3rd edition, ASM Press
Washington DC, USA.

Stanier RY, Ingraham JL, Wheelis ML and Painter PR (2005) General Microbiology 5th edition, McMillan.

Tortora GJ, Funke BR and Case CL (2008) Microbiology: An Introduction. 9th edition, Pearson Education.

Watson JD, Baker TA, Bell SP, Gann A, Levine M and Losick R (2004) Molecular Biology of Gene 5th edition, Pearson Publication.

Watson JD, Baker TA, Bell SP, Gann A, Levine M and Losick R (2008) Molecular Biology of the Gene, 6th edition, Cold Spring Harbour Lab. Press, Pearson Publication 2. Becker WM, Kleinsmith LJ.

Willey JM, Sherwood LM and Woolverton CJ (2008) Prescott, Harley and Klein's Microbiology, 7th edition, McGraw Hill Higher Education

M.Sc. Semester-2	**MMIC -202P**	**Molecular biology and Bacterial Genetics**	Compulsory
Credit- 02, Total Number of Teaching Hours- 60Hrs			

Course Outcome (CO)
After studying this course the student will be able to
CO1: Investigate isolation and characterization of bacterial mutants using chemical and physical mutagenesis techniques. **CO**2: Analyze mutation frequency and patterns through experimental methods like gradient plates, replica plating, and fluctuation tests.

CO–PO-PSO Mapping Matrix

CO	**PO**													**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Average**	**1**	**2**	**3**	**Average**
1	3	3	3	–	–	–	–	3	–	2	–	–	**2.8**	3	2	2	**2.33**
2	3	2	3	–	–	–	–	3	–	–	–	–	**2.75**	3	3	2	**2.67**

(2-Medium Correlation; 3 – Strong Correlation)

Teaching Pedagogy
1. Constructivism 2. Social Constructivism 3. Behaviorism
Teaching Methods and Tools
1. Direct Teaching using Black board, 2. Experimentation, 3. Hands on training

Practical Syllabus	
Practicals	
1	Isolation of pigment/antibiotic/Lac mutants of *S.marcescens/E.coli* using chemical mutagen/physical mutagen (U.V.).
2	Isolation of drug resistant mutants of *E.coli/ S.marcescens* by gradient plate technique.
3	Isolation of drug/biochemical mutants of *E.coli* by replica plating technique
4	Determination of Mutation rate.
5	Fluctuation test.

Assessment Method	
Internal/Online Assessment (40%)	Internal Practical Examination (40 Marks)
External Assessment (60%)	Term End Practical examination (60 Marks)

M.Sc. Semester-2	**MMIC -203**	**Recombinant DNA Technology**	Compulsory
Credit- 03, Total Number of Teaching Hours- 45Hrs			

Course Outcome (CO)
After studying this course the student will be able to
CO1: Describe the structure, isolation, and purification of genetic material, and explore the principles behind gene manipulation and enzymatic tools used in recombinant DNA technology. **CO**2: Describe the components of recombinant DNA technology, including restriction enzymes, ligases, cloning strategies, and transformation methods. **CO**3: Describe various vector systems and the construction of genetically modified organisms, while addressing biosafety levels and regulatory frameworks. **CO**4: Use recombinant DNA technology in healthcare, agriculture, and industry, and evaluate associated ethical and societal concerns.

CO–PO-PSO Mapping Matrix

CO	**PO**													**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Average**	**1**	**2**	**3**	**Average**
1	3	3	3	–	–	–	–	3	–	2	–	–	**2.8**	3	2	2	**2.33**
2	3	3	3	–	–	–	–	3	–	–	3	–	**3**	3	3	2	**2.67**
3	3	3	3	3	3	3	–	3	2	3	2	2	**2.7**	2	3	3	**2.67**
4	3	3	3	3	3	3	2	2	3	3	3	3	**8.5**	2	3	3	**2.67**

(2-Medium Correlation; 3 – Strong Correlation)

Teaching Pedagogy
1. Constructivism 2. Social Constructivism 3. Behaviorism
Teaching Methods and Tools
1. Direct Teaching using Black board, 2. Presentations, 3. Multimedia resources, 4. Diagrams and Layouts, 5. Group discussion and activity, 6. Experimentation, 7. Hands on training

Unit Wise Detailed Syllabus		
Units		**Number of Teaching Hours**
Unit -1		11
	Elements of rDNA Technology: Core techniques and essential enzymes used in recombination: restriction endonucleases, type I, II, III, recognition sequences, properties, nomenclature, classification of type II endonucleases, their activity. DNA ligase, DNA polymerase, polynucleotide kinase, phosphatase, reverse transcriptase its activity and mode of action. Restriction digestion, ligation and transformation.	
Unit 2		11
	Vectors: Properties, incompatibility, isolation and purification techniques, plasmid vectors and their properties, PBR 322 – its construction and derivatives. Bacteriophage lambda as a vector: Essential features, organization of genome, general structure, rationale for vector construction, improved vectors, gt series, EMBL vectors, invitro packaging, cosmids, phasmids, filamentous phage vectors.	
Unit 3		11
	Specialized cloning strategies: Expression vectors, genomic DNA libraries, chromosome walking and jumping, cDNA libraries, short gun cloning, directed cloning, Recombinant DNA technology with reference to cloning and production interferon and insulin. Miscellaneous applications of Genetically engineered microorganisms (GEMS) / genetically modified organisms (GMO's).	
	Molecular mapping of genome: PCR methods and Applications DNA sequencing methods, Dideoxy and Chemical method. Sequence assembly. Automated sequencing. Genetic and physical maps, physical mapping and map –based cloning, fluorescence in situ hybridization for genome analysis, Chromosome microdissection and microcloning,	
Unit-4		12
	Molecular markers in genome analysis: RFLP, RAPD and AFLP analysis, molecular markers linked to disease resistance genes Application of RFLP in forensic, disease prognosis, genetic counseling, pedigree, animal trafficking and poaching: Germplasm maintenance, taxonomy and Biodiversity.	

Assessment Method	
Internal/Online Assessment (40%)	1. Written test (20 Marks) 2 .Quiz / Group Discussion (10 Marks) 3. Assignments / Seminar (10 Marks)
External Assessment (60%)	Term End Theory examination (Written test 60 Marks)

References-

Principles of Gene Manipulations 1994 by Old and Primrose Blackwell Scientific Publications.

DNA Cloning: A Practical Approach by D.M. Glower and B.D. Hames, IRL Press, Oxford. 1995.

Molecular Biotechnology 2nd Edition by S.B. Primrose. Blackwell Scientific Publishers, Oxford. 1994.

Genetic Engineering and Introduction to Gene Analysis and Exploitation in Eukaryotes by S.M. Kingsman and A.J. Kingsman, Blackwell Scientific Publications, Oxford 1998.

PCR Technology - Principles and Applications for DNA Amplification by Henry A. Erlich (Ed.) Stockton Press. 1989.

Biotechnology: A Guide to Genetic Engineering by Peters.

Genetic Engineering – 2000 by Nicholl.

Recombinant DNA and Biotechnology: Guide for Teachers. 2nd Edition by Helen Kreuz. 2001.ASM Publications.

Molecular Biotechnology: Principles and Applications of Recombinant DNA. 2nd Edition. 1998 by Bernard R. Glick and Jack J. Pastemak, ASM Publications.

From genes to clones by Winnaker.

Manipulations and expression of recombinant DNA by Robertson.

Gene targeting – A practical approach by Joyner.

M.Sc. Semester-2	MMIC -203P	**Recombinant DNA Technology**	Compulsory
Credit- 02, Total Number of Teaching Hours- 60Hrs			

Course Outcome (CO)
After studying this course the student will be able to
CO1: Explain genomic DNA extraction techniques from various biological sources including bacteria, blood, and plants. **CO**2: Develop proficiency in molecular techniques such as agarose gel electrophoresis, restriction digestion, and RFLP analysis.

CO–PO-PSO Mapping Matrix

CO	**PO**													**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Average**	**1**	**2**	**3**	**Average**
1	3	3	3	–	–	–	–	3	–	2	–	–	**2.8**	3	2	2	**2.33**
2	3	2	3	–	–	–	–	3	–	–	–	–	**2.75**	3	3	2	**2.67**

(2-Medium Correlation; 3 – Strong Correlation)

Teaching Pedagogy
1. Constructivism 2. Social Constructivism 3. Behaviorism
Teaching Methods and Tools
1. Direct Teaching using Black board, 2. Experimentation, 3. Hands on training

Practical Syllabus	
Practicals	
1	Agarose gel electrophoresis
2	Solution based Genomic DNA extraction from bacteria.
3	Ultrapure genomic DNA extraction by mini preps spin column from bacteria.
4	Genomic DNA extraction from whole blood.
5	Genomic DNA from plant using (CTAB)
6	Restriction digestion
7	RFLP

Assessment Method	
Internal/Online Assessment (40%)	Internal Practical Examination (40 Marks)
External Assessment (60%)	Term End Practical examination (60 Marks)

M.Sc. Semester-2	**MMIC -204**	**Bioinformatics**	Compulsory
Credit- 03, Total Number of Teaching Hours- 45Hrs			

Course Outcome (CO)
After studying this course the student will be able to
CO1: Describe fundamentals of bioinformatics and explore various biological databases for retrieving genomic and proteomic information. **CO**2: Discuss sequence alignment methods and utilize computational tools for analyzing DNA, RNA, and protein sequences. **CO**3: Apply gene sequence data to construct phylogenetic trees and study evolutionary relationships for microbial identification. **CO**4: Use bioinformatics in fields like drug discovery, vaccine development, and personalized medicine, while identifying future directions.

CO–PO-PSO Mapping Matrix

CO	**PO**													**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Average**	**1**	**2**	**3**	**Average**
1	3	–	–	–	–	–	2	3	–	3	–	–	**2.75**	2	2	2	**2.00**
2	3	3	3	–	–	–	–	2	–	–	–	–	**2.75**	3	2	2	**2.33**
3	3	3	3	3	2	–	–	3	–	–	–	–	**2.8**	2	2	3	**2.33**
4	3	3	3	3	3	2	2	3	**-**	3	3	**-**	**2.8**	2	3	3	**2.67**

(2-Medium Correlation; 3 – Strong Correlation)

Teaching Pedagogy
1. Constructivism 2. Social Constructivism 3. Behaviorism
Teaching Methods and Tools
1. Direct Teaching using Black board, 2. Presentations, 3. Multimedia resources, 4. Diagrams and Layouts, 5. Group discussion and activity, 6. Experimentation, 7. Hands on training

Unit Wise Detailed Syllabus		
Units		**Number of Teaching Hours**
Unit -1 Biological Databases		11
1.1	Databases: Databases in Bioinformatics, various biological databases, Protein and Nucleotide sequence Data bases. Protein sequence, structure and Classification databases.	
1.2	Sequence analysis: Pairwise alignment, local and global alignment, Scoring matrices, multiple sequence alignment, tools for sequence alignment.	
Unit 2 Gene Prediction and Transcriptomics		11
2.1	Gene prediction: Gene prediction methods: Pattern Discrimination methods, Signal sites Predictions, Evaluation of Gene Prediction methods.	
2.2	Transcriptomics: Complete transcript cataloguing and gene discovery-sequencing based approach, Microarray based technologies and computation based technologies.	
	RNA secondary structure prediction	
Unit 3 Protein Structure Modelling and Computational Tools		11
3.1	Protein Computational Biology: Structure alignment and comparison, Secondary and tertiary structure prediction and evaluation, Prediction of specialized structures, Protein folding, modeling and Drug design.	
3.2	Tools in Bioinformatics: Protparam, Translate, Bioedit, findmod, Coils, Rasmol, Deep view.	
Unit-4 Genomics, Proteomics and Phylogenetic Analysis		12
4.1	Genomics: Genome Database, Gene Prediction, Comparative Genomics, and Functional Genomics.	
4.2	Proteomics: Types of proteomics, tools for proteomics-separation and isolation of proteins, databases and applications	
4.3	Phylogenetic analysis: Phylogenetic trees & different methods for phylogenetic inference	
4.4	Artificial Intelligence (AI) in Bioinformatics and its application	

Assessment Method	
Internal/Online Assessment (40%)	1. Written test (20 Marks) 2 .Quiz / Group Discussion (10 Marks) 3. Assignments / Seminar (10 Marks)
External Assessment (60%)	Term End Theory examination (Written test 60 Marks)

References-

Bioinformatics: Rastogi.

Introduction to Bioinformatics: Arthur M. Lesk.

Bioinformatics: Principles and applications, Ghosh and Mallick.

Bioinformatics: Genes, Proteins and Computer, C. A. Orengo.

Bioinformatics: A practical guide to the analysis of genes and proteins. 2nd Edition. John Wiley & Sons, New York. *Baxevanis, A. D. and Ouellette, B.F. F.* (2001)

GIS For Dummies (For Dummies (Computer/Tech)) by: Michael N. DeMers

GIS Basics by: Stephen Wise

GIS for Environmental Decision-Making (Innovations in Gis) by: Andrew A. Lovett, Katy Appleton

Textbook of Remote Sensing and Geographical Information Systems by: Reddy, M. Anji

Agrometeorology: Principles and Applications of Climate Studies in Agriculture by: Harpal S., Ph.D. Mavi, Graeme J. Tupper

Developing Bioinformatics Computer Skills by: Cynthia Gibas

Bioinformatics and Functional Genomics, 2nd Edition by: Jonathan Pevsner

M.Sc. Semester-2	**MMIC -204 P**	**Bioinformatics**	Compulsory
Credit- 02, Total Number of Teaching Hours- 60Hrs			

Course Outcome (CO)
After studying this course the student will be able to
CO1: Investigate key bioinformatics databases and tools for sequence and structural analysis of proteins and nucleic acids. **CO**2: Examine sequence alignment, primer designing, phylogenetic analysis, and active site/ORF prediction.

CO–PO-PSO Mapping Matrix

CO	**PO**													**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Average**	**1**	**2**	**3**	**Average**
1	3	–	–	–	–	–	3	3	–	2	–	–	**2.75**	3	2	2	**2.33**
2	3	3	3	–	–	–	–	2	–	–	–	–	**2.75**	3	3	2	**2.67**

(2-Medium Correlation; 3 – Strong Correlation)

Teaching Pedagogy
1. Constructivism 2. Social Constructivism 3. Behaviorism
Teaching Methods and Tools
1. Direct Teaching using Black board, 2. Experimentation, 3. Hands on training

Practical Syllabus	
Practicals	
1	A visit to Protein Data Bank, Ex Pasy, NCBI.
2	Study of Protein structures by Rasmol, Protein Explorer, Deep View.
3	Sequence alignment using FASTA and BLAST.
4	LOCAL and GLOBAL alignment Tools..
5	Protein structure alignment
6	PCR Primer designing
7	Phylogenetic Tree Construction.
8	Use of Ex PASy Tools.
9	Active Site and ORF Prediction.

Assessment Method	
Internal/Online Assessment (40%)	Internal Practical Examination (40 Marks)
External Assessment (60%)	Term End Practical examination (60 Marks)

Semester-3

M.Sc. Semester-3	**MMIC -301**	**Bioprocess Technology**	Compulsory
Credit- 03, Total Number of Teaching Hours- 45Hrs			

Course Outcome (CO)
After studying this course the student will be able to
CO1: Isolate, screen, and improve industrial microbes and state the basics of media formulation and scale-up processes. **CO**2: Design various fermenters and describe aseptic operation, monitoring, and control of critical process parameters. **CO**3: Explore sterilization techniques, inoculum development, aeration-agitation systems, and heat/mass transfer essential for optimal bioprocess performance. **CO**4: Examine methods for product recovery and purification and evaluate the economic factors influencing industrial fermentation processes.

CO–PO-PSO Mapping Matrix

CO	**PO**													**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Average**	**1**	**2**	**3**	**Average**
1	3	3	–	3	–	–	–	3	–	2	2	–	**2.6**	3	3	2	**2.67**
2	3	3	2	–	–	–	–	3	–	–	2	–	**2.6**	3	3	2	**2.67**
3	3	3	3	3	–	–	–	3	–	–	2	–	**2.8**	3	3	2	**2.67**
4	3	3	3	3	–	2	–	3	–	2	2	–	**2.6**	2	3	2	**2.33**

(2-Medium Correlation; 3 – Strong Correlation)

Teaching Pedagogy
1. Constructivism 2. Social Constructivism 3. Behaviorism
Teaching Methods and Tools
1. Direct Teaching using Black board, 2. Presentations, 3. Multimedia resources, 4. Diagrams and Layouts, 5. Group discussion and activity, 6. Experimentation, 7. Hands on training

Unit Wise Detailed Syllabus		
Units		**Number of Teaching Hours**
Unit -1 Elements of Bioprocess		11
1.1	Isolation, screening and preservation of industrially important microorganisms	
1.2	Strain improvement Techniques.:Mutation, Reombinant DNA techniques, Protoplast fusion	
1.3	Media formulation	
1.4	Fundamentals of scale up	
Unit 2 Fermenter Design and control		11
2.1	Fermenter design, types of fermenters	
2.2	The achievement and maintenance of aseptic conditions	
2.3	Monitoring and control of process variables (ion-specific sensors, enzyme and microbial electrodes, manual and automatic controls)	
Unit 3 Upstream processing		11
3.1	Sterilization of media, air and reactor	
3.2	Development of inoculum for industrial fermentations	
3.3	Aeration-agitation system, mass transfer of oxygen-factors affecting KLa	
3.4	Heat transfer	
Unit-4 Downstream processing and Fermentation economics		12
4.1	Methods of cell separation- filtration and centrifugation, Cell disruption, liquid-liquid extraction, chromatography, membrane processes	
4.2	Fermentation economics: Expenses for industrial organisms, strain improvement, media sterilization, heating, cooling, aeration, agitation etc., cost of plant and equipment, batch process cycle time, continuous culture, recovery and effluent treatments, cost recovery due to waste usages and recycling	

Assessment Method	
Internal/Online Assessment (40%)	1. Written test (20 Marks) 2 .Quiz / Group Discussion (10 Marks) 3. Assignments / Seminar (10 Marks)
External Assessment (60%)	Term End Theory examination (Written test 60 Marks)

References-

1. Principles of Fermentation Technology:Stanbury, Whittaker & Hall
2. Process Biotechnology Fundamentals: S. N. Mukhopadhyay
3. Fermentation Microbiology and Biotechnology :EL-Mansi & C.F.A.Bryce
4. Industrial Microbiology by L E Casida

M.Sc. Semester-3	**MMIC -301P**	**Bioprocess Technology**	Compulsory
Credit- 02, Total Number of Teaching Hours- 60Hrs			

Course Outcome (CO)
After studying this course the student will be able to
CO1: Measure oxygen transfer, point out rheological analysis, and predict scale-up studies. **CO**2: Screen out, optimize, produce and recover microbial products like enzymes, antibiotics, and exopolysaccharides.

CO–PO-PSO Mapping Matrix

CO	**PO**													**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Average**	**1**	**2**	**3**	**Average**
1	3	3	3	3	–	–	–	3	–	2	2	–	**2.7**	3	2	2	**2.33**
2	3	3	3	3	2	2	–	3	2	3	3	2	**2.6**	3	3	2	**2.67**

(2-Medium Correlation; 3 – Strong Correlation)

Teaching Pedagogy
1. Constructivism 2. Social Constructivism 3. Behaviorism
Teaching Methods and Tools
1. Direct Teaching using Black board, 2. Experimentation, 3. Hands on training

Practical Syllabus	
Practicals	
1	Determination of oxygen transfer rate (OTR-Sulfite method) and its scale-up
2	Primary Screening of Antibiotic Producer, Organic Acid Producer, Enzyme Producer
3	Optimization of conditions for production of Amylase by Submerged fermentation
4	Rheological study of fermented culture broth by Oswald viscometer
5	Recovery of Exopolysaccharides using acetone solvent
6	Bio assay of antibiotics

Assessment Method	
Internal/Online Assessment (40%)	Internal Practical Examination (40 Marks)
External Assessment (60%)	Term End Practical examination (60 Marks)

M.Sc. Semester-3	**MMIC -302**	**Environmental Biotechnology**	Compulsory
Credit- 03, Total Number of Teaching Hours- 45Hrs			

Course Outcome (CO)
After studying this course the student will be able to
CO1: Describe principles, processes, and technologies involved in primary, secondary, and tertiary biological wastewater treatment. **CO**2: Explain anaerobic wastewater treatment methods, including toxicity testing and microbiological processes influencing anaerobic digestion. **CO**3: Describe microbial degradation of pollutants, advanced bioremediation techniques, and the role of GMOs and biofilters in environmental cleanup. **CO**4: Demonstrate microbial applications in bioleaching, oil recovery, and biodesulfurization for eco friendly resource management and pollution reduction.

CO–PO-PSO Mapping Matrix

CO	**PO**													**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Average**	**1**	**2**	**3**	**Average**
1	3	–	3	–	3	–	–	–	–	2	–	2	**2.6**	2	3	2	**2.33**
2	3	3	3	3	3	–	–	–	–	–	–	2	**2.8**	2	3	2	**2.33**
3	3	3	3	3	3	3	–	2	–	3	2	2	**2.7**	3	3	3	**3.00**
4	3	3	3	3	3	3	3	2		3	2	2	**2.7**	3	3	2	**2.67**

(2-Medium Correlation; 3 – Strong Correlation)

Teaching Pedagogy
1. Constructivism 2. Social Constructivism 3. Behaviorism
Teaching Methods and Tools
1. Direct Teaching using Black board, 2. Presentations, 3. Multimedia resources, 4. Diagrams and Layouts, 5. Group discussion and activity, 6. Experimentation, 7. Hands on training

Unit Wise Detailed Syllabus		
Units		**Number of Teaching Hours**
Unit -1 Principles of Waste Treatment		11
1.1	Principles and aims of biological wastewater treatment processes: Primary, secondary and tertiary treatment of waste water.	
1.2	Suspended growth technologies: Activated sludge, oxidation ditches, waste stabilization ponds.	
1.3	Fixed film technologies: Trickling filters, rotating biological contactors, fluidized bed and submerged aerated filters.	
Unit 2 Techniques of Waste Treatment		11
2.1	Toxicity testing in waste water treatment plants using microorganisms.	
2.2	Anaerobic digestion: microbiological and biochemical fundamentals, factors influencing anaerobic digestion.	
2.3	Anaerobic waste water treatment systems: RBC, UASB, anaerobic filters. Merits and demerits of anaerobic treatment of waste.	
Unit 3 Biodegradation and Biodeterioration		11
3.1	Pollution problems and biodegradation of simple polycyclic aromatic hydrocarbons, azo dyes, and pesticides.	
3.2	Bioremediation: In situ and ex situ bioremediation technologies. Intrinsic bioremediation, Biostimulation and Bioaugmentation. Phytoremediation.	
3.3	Use of GMO in bioremediation. Biological treatment of waste gas (polluted air): biofilters, bioscrubbers, membrane bioreactors	
Unit-4 Biogeotechnology		12
4.1	Bioleaching of metals: Mechanisms of bioleaching, factors affecting bioleaching and biomining processes.	
4.2	Biobeneficiation, Microbially enhanced oil recovery.	
4.3	Biodesulfurization of coal: Removal of organic and inorganic sulphur from coal.	

Assessment Method	
Internal/Online Assessment (40%)	1. Written test (20 Marks) 2 .Quiz / Group Discussion (10 Marks) 3. Assignments / Seminar (10 Marks)
External Assessment (60%)	Term End Theory examination (Written test 60 Marks)

References-

Biotechnology-Rehm and Reid.
Waste water microbiology by G. Bitton
Biodegradation and bioremediation by M.Alexander
Waste water treatment for pollution control, 2nd edition. Arceivala
Environmental Biotechnology by H. Jordening and JosefWinter .
Comprehensive Biotechnology Vol-4, MurrayMoo Young.

M.Sc. Semester-3	**MMIC -302 P**	**Environmental Biotechnology**	Compulsory
Credit- 02, Total Number of Teaching Hours- 60Hrs			

Course Outcome (CO)
After studying this course the student will be able to
CO1: Analyse and characterize wastewater and potable water using physical, chemical, biochemical, and microbiological parameters. **CO**2: Isolate probiotic cultures, and evaluate microbial profiles in fermented foods.

CO–PO-PSO Mapping Matrix

CO	**PO**													**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Average**	**1**	**2**	**3**	**Average**
1	3	–	3	–	3	–	–	–	–	2	–	2	**2.6**	3	2	2	**2.33**
2	3	3	3	3	3	3	–	3	–	2	2	2	**2.7**	3	3	2	**2.67**

(2-Medium Correlation; 3 – Strong Correlation)

Teaching Pedagogy
1. Constructivism 2. Social Constructivism 3. Behaviorism
Teaching Methods and Tools
1. Direct Teaching using Black board, 2. Experimentation, 3. Hands on training

Practical Syllabus	
Practicals	
1	Bioremediation of inorganic pollutants and phytoremediation - biosorption
2	Characterization of waste water: Physical: odour, colour, turbidity, temperature, salinity, Volatile Solids (VS), Dissolved Solids (DS), Suspended Solids (SS) and Total Solids (TS) Chemical: acidity, alkalinity, chloride, phosphate, sulphate, copper and hardness
3	Water Analysis: Biochemical characterization of waste water: BOD and COD Bacteriological characterization of potable water: MTT and MFT
4	Isolation of probiotic culture from various sources: Evaluation and efficacy of probiotic culture
5	Production of fermented food and characterization of acidity, alkalinity and its microbial profile

Assessment Method	
Internal/Online Assessment (40%)	Internal Practical Examination (40 Marks)
External Assessment (60%)	Term End Practical examination (60 Marks)

M.Sc. Semester-3	**MMIC -303**	**Microbial Products and Technology**	Compulsory
Credit- 03, Total Number of Teaching Hours- 45Hrs			

Course Outcome (CO)
After studying this course the student will be able to
CO1: Describe microbial production of food products from grains and milk, state the role of microbes as food, and examine food safety standards like HACCP. **CO**2: Demonstrate microbial applications in agriculture through the production of biofertilizers and biopesticides, and describe composting and soil health enhancement. **CO**3: Discuss microbial production processes of primary (acids, amino acids, vitamins, enzymes) and secondary metabolites (antibiotics) used in industry. **CO**4: Explain microbial technologies for producing specialty compounds such as ergot alkaloids, alcoholic beverages, biopolymers, and solvents.

CO–PO-PSO Mapping Matrix

CO	**PO**													**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Average**	**1**	**2**	**3**	**Average**
1	3	3	3	3	3	3	–	3	–	2	2	2	**2.7**	2	3	3	**2.67**
2	3	3	3	3	3	–	–	–	–	2	2	2	**2.6**	2	3	2	**2.33**
3	3	3	3	3	3	3	–	3	3	2	2	2	**2.7**	3	3	2	**2.67**
4	3	3	3	3	3	3	–	3	3	2	2	2	**2.7**	3	3	2	**2.67**

(2-Medium Correlation; 3 – Strong Correlation)

Teaching Pedagogy
1. Constructivism 2. Social Constructivism 3. Behaviorism
Teaching Methods and Tools
1. Direct Teaching using Black board, 2. Presentations, 3. Multimedia resources, 4. Diagrams and Layouts, 5. Group discussion and activity, 6. Experimentation, 7. Hands on training

Unit Wise Detailed Syllabus		
Units		**Number of Teaching Hours**
Unit -1 Food Products		13
1.1	Food products from Grains- Bread	
1.2	Food products from Milk- Cheese, Butter	
1.3	Microbial cells as food- Single Cell Protein, Single Cell Oil	
1.4	Food safety and quality requirements- HACCP	
Unit 2 Agricultural Products		12
2.1	Biofertilizers- Production and application of rhizobium, azotobacter and azospirillum inoculants, Phosphate solubilizers, Phosphate mobilizers and absorbers- Mycorrhiza and VAM, composting	
2.2	Biocontrol agents- Bacterial and viral biopesticides	
Unit 3 Industrial products- Primary and Secondary metabolites		10
3.1	Organic acids- Citric acid	
3.2	Amino acids- L-Lysin,	
3.3	Vitamins- B12	
3.4	Enzymes- Protease	
3.5	Antibiotics- Streptomycin	
Unit-4 Other Industrial Products		10
4.1	Ergot alkaloids	
4.2	Alcoholic beverages- Beer, Wine	
4.3	Polymers- Xanthan, Dextran	
4.4	Solvents- Acetone-butanol	

Assessment Method	
Internal/Online Assessment (40%)	1. Written test (20 Marks) 2 .Quiz / Group Discussion (10 Marks) 3. Assignments / Seminar (10 Marks)
External Assessment (60%)	Term End Theory examination (Written test 60 Marks)

References-

"Food Science" – B. Srilakshmi, *Publisher:* New Age International, *Edition:* 6th Edition, 2016

"Breadmaking: Improving Quality" – Stanley P. Cauvain, *Publisher:* Woodhead Publishing, *Edition:* 2nd Edition, 2012

"Microbial Biotechnology" – Glazer & Nikaido, *Publisher:* Cambridge University Press, *Edition:* 2nd Edition, 2007

"HACCP: A Practical Approach" – Sara Mortimore & Carol Wallace, *Publisher:* Springer / Springer US, *Edition:* 3rd Edition, 2013

US FDA – HACCP Guidelineshttps://www.fda.gov/food/hazard-analysis-critical-control-point-haccp
US FDA – HACCP Guidelineshttps://www.fda.gov/food/hazard-analysis-critical-control-point-haccp
FAO – Food and Agriculture Organization- https://www.fao.org/food-safety
OpenWHO – Food Safety Training- https://openwho.org/
Comprehensive Biotechnology: The Principles, Applications and Regulations of Biotechnology in Industry, Agriculture and Medicine, Vol. 1 to 4, Editor in chief- Murray, Moo-young, Pergamon Press, Oxford (1985)
Industrial Microbiology- Prescott, SC and Dunn, CG, Agrobios Publication, Jodhpur (2011)
Biotechnology- Rehm HJ and Reed, G, VCH Publication (1991)
Biofertilizers in Agriculture and Forestry- Subba Rao, NS (2019)
Biological Nitrogen Fixation- Subba Rao, NS, Venkataraman, GS and Kannaiyan S (1993)
Bacillus thuringiensis as a Biocontrol agent- Kadu, BB
Biotechnology of Industrial Antibiotics- Vandamme, EJ

M.Sc. Semester-3	**MMIC -303P**	**Microbial Products and Technology**	Compulsory
Credit- 02, Total Number of Teaching Hours- 60Hrs			

Course Outcome (CO)
After studying this course the student will be able to
CO1: Analyse microbial products like SCP, alcohol, citric acid, and exopolysaccharides. **CO**2: Predict the microbiological quality of milk and dairy products using standard laboratory techniques.

CO–PO-PSO Mapping Matrix

CO	**PO**													**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Average**	**1**	**2**	**3**	**Average**
1	3	3	3	3	3	–	–	3	–	2	2	2	**2.6**	3	3	2	**2.67**
2	3	3	3	3	3	3	–	3	3	2	2	2	**2.7**	3	3	2	**2.67**

(2-Medium Correlation; 3 – Strong Correlation)

Teaching Pedagogy
1. Constructivism 2. Social Constructivism 3. Behaviorism
Teaching Methods and Tools
1. Direct Teaching using Black board, 2. Experimentation, 3. Hands on training

Practical Syllabus	
Practicals	
1	Fermentative production and estimation of Single cell protein
2	Fermentative production and estimation of alcohol
3	Fermentative production and estimation of citric acid
4	Fermentative production and estimation of Exopolyssaccharides.
5	Determination of microbiological quality of milk by MBRT
6	Determination of microbiological quality of milk by MBRT
7	Laboratory fermentation and estimation of dairy product.

Assessment Method	
Internal/Online Assessment (40%)	Internal Practical Examination (40 Marks)
External Assessment (60%)	Term End Practical examination (60 Marks)

M.Sc. Semester-3	**MMIC -304**	**Biomethanation**	Compulsory
Credit- 03, Total Number of Teaching Hours- 45Hrs			

Course Outcome (CO)
After studying this course the student will be able to
CO1: Describe the historical evolution of biomethanation research and discuss the classification, taxonomy, and diversity of methanogenic archaea. **CO**2: State the physiological adaptations, ecological interactions, and environmental roles of methanogens, including methods used for their detection and application. **CO**3: List the biochemical pathways and key enzymes involved in methanogenesis from various substrates such as CO_2, methanol, and acetate. **CO**4: Outline the biosynthesis of unique coenzymes in methanogens and discuss their anabolic metabolism, including precursor and central metabolic pathways.

CO–PO-PSO Mapping Matrix

CO	**PO**													**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Average**	**1**	**2**	**3**	**Average**
1	3	–	–	–	–	–	3	–	–	2	–	–	**2.6**	2	2	3	**2.33**
2	3	3	3	3	3	–	–	–	–	–	–	–	**3**	3	3	2	**2.67**
3	3	3	3	3	3	3	–	2	–	2	–	–	**2.7**	3	2	2	**2.33**
4	3	3	3	3	3	3	–	2	–	2	2	–	**2.6**	3	2	2	**2.33**

(2-Medium Correlation; 3 – Strong Correlation)

Teaching Pedagogy
1. Constructivism 2. Social Constructivism 3. Behaviorism
Teaching Methods and Tools
1. Direct Teaching using Black board, 2. Presentations, 3. Multimedia resources, 4. Diagrams and Layouts, 5. Group discussion and activity, 6. Experimentation, 7. Hands on training

Unit Wise Detailed Syllabus		
Units		**Number of Teaching Hours**
Unit -1 Historical overview		10
	Historical overview, Modern Era, 1950, 1960, Microbial Basis, Methyl Cobalamine Era, Serine Era, Resolution of Methanobacillus omilanskii	
	Diversity of Methanogens, Classification of Methanogens, Taxa of methanogens, Methanobacteriales, Methanococcales, Methanomicrobiales, Methaosarcinales, Methanopyrales	
Unit 2 Physiology of Methaogens: Substrate range of Methanogens		15
	Physiological Adaptations (Salinity, temperature, pH, Oxygen, Genetic and Metabolic Regulations, Motility and Gas vesicles reserve materials)	
	Microbial Interactions: Competition for methanogenic substrates: General considerations, Competition for hydrogen, Competition for acetate, Competition for other methanogenic Substrates, Facultative Interspecies H_2 formate transfer, Obligate Interspecies H_2 formate transfer, Interspecies acetate transfer.	
	Methods to study Methanogens in Natural Habitats: Cultural Methods, Microscopic, immunological, Molecular Biology, Activity measurement, Stable isotopes.	
	Methanogenic Habitats: Anaerobic Digesters, Fresh water sediments and soils, marine habitats, Animal GIT, Geothermal habitats, Other habitats	
	Biotechnological Uses of Mixed Methanogenic Cultures: Novel Substrates and Anaerobic bioreactor Configurations, Thermophilic Anaerobic Digestion, Anaerobic dehalogination.	
Unit 3 Biochemistry of Methanogenesis		10
	Reactions and Enzymes involved in Methanogenesis From CO_2 and H_2: Hydrogenotropic methanogenesis and Bioenergetics, Transition metals required for growth on H_2 and CO_2, Activation of molecular H_2, F420 reducing and Non reducing hydrogenases, H_2 forming methylene tetrahydromethanopterin dehydrogenase, CO_2 reduction to MFR, Mo and Tungstun containing dehydrogenases, Formyl Gr transfer to H_4MPT, Conversion to N^5, N^{10}- Methenyl- H_4MPT, reduction to N^5, N^{10}- Methylene- H_4MPT, reduction to N^5 Methyl- H_4MPT, Methyl transfer to COM, MCR, HDR	
	Conversion of Methanol and Methylamine to Methane and CO_2: Metylotropic methanogenic bacteria, substrates utilized by Metylotropic methanogenic bacteria, Route of methanol reduction, reduction of CoM, Route of methanol oxidation, Methyl Gr oxidation to CO_2, Reduction of HDS, Proton translocation and electron transport, Methanogenesis from Methyl amines and Methyl sulphides, Metabolic regulation.	
	Fermentation of Acetate: Ecology of Acetotrops, Growth and Physiology (Metahnosarcina and Methanothrix), Activation of acetate, C-C and C-s	

	bond cleavage, CODH enzyme complex, Methyl transfer and reductive demethylation of CH_3-COM, electron transport and bioenergetics.	
Unit-4 Biosynthesis of Co-enzymes		10
	Methanofuran, Tertahydromethanopterin, Anabolic pathways: Central Anabolic pathways (Acetyl CoA, Pyruvate, Incomplete TCA cycle), Precursor Biosynthesis	

Assessment Method	
Internal/Online Assessment (40%)	1. Written test (20 Marks) 2 .Quiz / Group Discussion (10 Marks) 3. Assignments / Seminar (10 Marks)
External Assessment (60%)	Term End Theory examination (Written test 60 Marks)

References-

Methanogenesis: Ecology, Physiology, Biochemistry & Genetics. James G. Ferry

Comprehensive Biotechnology: The Principles, Applications and Regulations of Biotechnology in Industry, Agriculture and Medicine, Vol. 1 to 4, Editor in chief- Murray, Moo-young, Pergamon Press, Oxford

Biodegradation and bioremediation by M.Alexander

M.Sc. Semester-3	**MMIC -304P**	**Biomethanation**	Compulsory
Credit- 02, Total Number of Teaching Hours- 60Hrs			

Course Outcome (CO)
After studying this course the student will be able to
CO1: Interpret proximate analysis of biomass and waste materials relevant to anaerobic digestion processes. **CO**2: Quantify key components such as moisture, organic matter, sugars, lipids, starch, cellulose, hemicellulose, and lignin.

CO–PO-PSO Mapping Matrix

CO	**PO**													**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Average**	**1**	**2**	**3**	**Average**
1	3	–	–	–	3	–	3	–	–	2	–	2	**2.6**	3	2	2	**2.33**
2	3	3	3	3	3	3	–	3	–	2	2	2	**2.7**	3	3	2	**2.67**

(2-Medium Correlation; 3 – Strong Correlation)

Teaching Pedagogy
1. Constructivism 2. Social Constructivism 3. Behaviorism
Teaching Methods and Tools
1. Direct Teaching using Black board, 2. Experimentation, 3. Hands on training

Practical Syllabus	
Practicals	
	Proximate analysis of Biomass or Waste for Anaerobic Digestion
1	Moisture
2	Total organic Matter
3	Soluble sugars
4	Coloring matter
5	Lipid content
6	Starch
7	Cellulose
8	Hemicellulose
9	Lignin

Assessment Method	
Internal/Online Assessment (40%)	Internal Practical Examination (40 Marks)
External Assessment (60%)	Term End Practical examination (60 Marks)

Semester-4

M.Sc. Semester-4	**MMIC -401**	**Dissertation**	Compulsory
Credit- 20, Total Number of Teaching Hours- 600Hrs			

Course Outcome (CO)
After studying this course the student will be able to
CO1: Develop and demonstrate the ability to independently plan, execute, and document a research project using microbiological and interdisciplinary approaches. **CO2:** Apply experimental design, data analysis, and interpretation in real-time laboratory/field settings. **CO3:** To communicate scientific findings effectively through written reports, presentations, and discussions. **CO4:** To cultivate scientific integrity, project management skills, and research ethics.

CO–PO-PSO Mapping Matrix

CO	**PO**													**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Average**	**1**	**2**	**3**	**Average**
1	3	3	3	3	3	3	3	3	3	2	2	2	**2.75**	3	2	3	**2.67**
2	3	3	3	3	3	3	3	3	3	2	2	2	**2.75**	3	2	2	**2.33**
3	3	3	3	3	3	3	3	3	3	2	2	2	**2.75**	2	2	3	**2.33**
4	3	3	3	3	3	3	3	3	3	2	2	2	**2.75**	2	2	3	**2.33**

(2-Medium Correlation; 3 – Strong Correlation)