Curriculum Framework

Master of Science in Microbiology

As per NEP 2020 and Learning Outcomes-based National Curriculum Framework
(Aligned with NCrF and NHEQF)

Effective From Academic Year 2025-2026

Founded by Mahatma Gandhi in 1920

Gujarat Vidyapith
Ahmedabad

Curriculum Framework

Master of Science
(Microbiology)

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GUJARAT VIDYAPITH: AHMEDABAD

Curriculum Framework of Master of Science (Microbiology)

Published by:

Dr. Himanshu Patel

Registrar

Gujarat Vidyapith

Near Income Tax Office, Ashram Road, Ahmedabad - 380009.

From the Desk of Vice Chancellor…

Dear All,

Any curriculum, at any level, must be firmly grounded in the objectives and goals that an educator or an educational institution aspires to achieve for its students. A course that trains students to solve mathematical equations must be very different from one that teaches them how to play a musical instrument, practice yoga, or conduct social research. Each subject requires its own methods, activities, and learning goals, which is why curriculum design is so important.

Therefore, curriculum is of utmost importance, as it determines how teachers and students will spend their time—in laboratories, in clinical practice, in creative endeavors, or in interactive lectures. It also reflects what a class, a department, a school, or an institution values; what it defines as its mission; and what it expects its graduates to accomplish. In this sense, the curriculum is the map that guides the essentials of learning from the classroom level to the institutional level.

The true success of any curriculum must be judged by its ability to achieve its intended objectives. It is a test of how well an institution—or an individual teacher—understands and articulates those objectives, and how effectively a pathway is created for students to attain success as defined by them. Curriculum is, in fact, a continuous chain of activities designed to translate broad educational goals into concrete practices, learning materials, and observable changes in behavior. A lesson plan, for instance, is curriculum at the classroom level, answering the critical questions: *What do I want my students to know? How can I engage them meaningfully? How will I measure what they have learned?*

For a society to achieve its educational aspirations, the curriculum must be both functional and relevant to its needs. Through careful management of curriculum, effective use of resources, and policies that bring systemic improvements, education can move society toward a more promising future. Indeed, curriculum is the very foundation of any academic institution—without it, the institution would lose its purpose and direction.

At Gujarat Vidyapith, established by Mahatma Gandhi in 1920 with its rich cultural and educational heritage, we remain committed to these ideals and we work with well-defined objectives to prepare our students for a brighter academic and social future.

It gives me immense pride and joy to announce the unveiling of the latest curriculum of Gujarat Vidyapith. This curriculum has been carefully designed in alignment with the objectives and guiding principles of the National Education Policy (NEP) 2020. I take this opportunity to place on record my deep appreciation for the efforts of the teaching faculty of Gujarat Vidyapith, the Members of the Board of Studies, and the Members of the Academic Council. Their dedication and vision have given shape to this comprehensive neo-curriculum, which will guide our students and our institution toward continued excellence.

With best wishes,

Dr. Harshad Patel
Vice Chancellor
Gujarat Vidyapith

Curriculum Framework

Master of Science (Microbiology)

Effective From Academic Year 2025-2026

Department of Microbiology

Faculty of Science

Gujarat Vidyapith

Board of Studies

Chairperson:

Dr. Nikhil S. Bhatt
Professor & Dean, Faculty of Science, Gujarat Vidyapith, Ahmedabad.

External Experts:

1) **Dr. Shailesh R. Dave**
   Professor & Director, Xavier's Research Foundation, Ahmedabad.

2) **Dr. Rakesh Patel**
   Retired Faculty, R.G. Shah Science college, Microbiology Department, Ahmedabad.

Members from the Department:

1) **Dr. Mayur C. Shah**
   Professor & Head, Department of Microbiology, Faculty of Science, Gujarat Vidyapith, Ahmedabad.

2) **Dr. Srinivas Duggirala**
   Professor, Department of Microbiology, Faculty of Science, Gujarat Vidyapith, Ahmedabad.

3) **Dr. Niraj T. Sheth**
   Professor, Department of Microbiology, Faculty of Science, Gujarat Vidyapith, Ahmedabad.

4) **Dr. Prateek G. Shilpkar**
   Professor, Department of Microbiology, Faculty of Science, Gujarat Vidyapith, Ahmedabad.

5) **Mrs. Preeti K. Shukla**
   Associate Professor, Department of Microbiology, Faculty of Science, Gujarat Vidyapith, Ahmedabad.

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7) **Mr. Arvind B. Dungrechiya**
   Assistant Professor, Department of Microbiology, Faculty of Science, Gujarat Vidyapith, Ahmedabad.

PROGRAMME STRUCTURE							
Course Code	Course Name	Hours			Credit	Evaluations	
		Theory	Practical	Total		CCE	TEE
SEMESTER-1							
256010338001	Microbial Diversity	45	0	45	3	40	60
256010238002	Microbial Diversity Practical	0	60	60	2	40	60
256010338003	Microbial Physiology	45	0	45	3	40	60
256010238004	Microbial Physiology Practical	0	60	60	2	40	60
256010338005	Bioinstrumentation	45	0	45	3	40	60
256010238006	Bioinstrumentation Practical	0	60	60	2	40	60
256010338007	Immunology	45	0	45	3	40	60
256010238008	Immunology Practical	0	60	60	2	40	60
Total		**180**	**240**	**420**	**20**	**320**	**480**
SEMESTER-2							
256010338009	Enzymology	45	0	45	3	40	60
256010238010	Enzymology Practical	0	60	60	2	40	60
256010338011	Molecular biology and Bacterial Genetics	45	0	45	3	40	60
256010238012	Molecular biology and Bacterial Genetics Practical	0	60	60	2	40	60
256010338013	Recombinant DNA Technology	45	0	45	3	40	60
256010238014	Recombinant DNA Technology Practical	0	60	60	2	40	60
256010338015	Bioinformatics	45	0	45	3	40	60
256010238016	Bioinformatics Practical	0	60	60	2	40	60
Total		**180**	**240**	**420**	**20**	**320**	**480**
SEMESTER-3							
256510338017	Bioprocess Technology	45	0	45	3	40	60
256510238018	Bioprocess Technology Practical	0	60	60	2	40	60
256510338019	Environmental Biotechnology	45	0	45	3	40	60
256510238020	Environmental Biotechnology Practical	0	60	60	2	40	60
256510338021	Microbial Products and Technology	45	0	45	3	40	60
256510238022	Microbial Products and Technology Practical	0	60	60	2	40	60
256510338023	Biomethanation	45	0	45	3	40	60
256510238024	Biomethanation Practical	0	60	60	2	40	60
Total		**180**	**240**	**420**	**20**	**320**	**480**
SEMESTER-4							
256512038025	Dissertation	00	600	600	20	40	60
Total		**0**	**600**	**600**	**20**	**40**	**60**
GRAND TOTAL		**540**	**1320**	**1860**	**80**	**1000**	**1500**

***CCE- Continuous Comprehensive Evaluation; **TEE- Term End Evaluation**

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

Programme Outcomes (POs)

This program prepares postgraduates to achieve the following POs within two years of education.

PO-1	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.
PO-2	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.
PO-3	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.
PO-4	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**.
PO-5	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.
PO-6	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.
PO-7	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**.
PO-8	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.
PO-9	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.
PO-10	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.
PO-11	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.
PO-12	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)

After successful completion of "Two Year Degree Program" in Microbiology, a student will be able to:

PSO Number	Programme Specific Outcomes (PSOs)	Justification
PSO-1 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.
PSO-2 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.
PSO-3 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 Levels (OBE & NEP 2020 Aligned)						
COs Attainment Levels	**Level**	**Description**	**Attainment Criteria**			
	Level 3	High	≥ 60% students scored ≥ Benchmark			
	Level 2	Moderate	50–59% students scored ≥ Benchmark			
	Level 1	Low	40–49% students scored ≥ Benchmark			
	Level 0	Not Attained	< 40% students scored ≥ Benchmark			
Target Attainment (Benchmark)	**COs**		**CO-1**	**CO-2**	**CO-3**	**CO-4**
	Target Level (%)		**55**	**55**	**55**	**55**

Program – M.Sc. (Microbiology) Semester- 1		
Course Code 256010338001	**Name of Course** Microbial Diversity	**Major**
Credit: 03	**Teaching Scheme: Theory (45)**	**Teaching Hours: 45**

Course Outcomes (COs)

After studying this course, the student will be able to:

CO-1: Relate major biological events with microbial evolution and state basics of microbial taxonomy and classification.
CO-2: State the diversity of microbes and their key metabolic processes.
CO-3: Describe extremophiles and their adaptations to harsh environments.
CO-4: Examine conservation methods and biotechnological uses of microbial diversity.

Detailed Syllabus

Unit-1. Microbial Evolution and Taxonomy (11h)

1.1. Origin of earth and life **(2h)**
1.2. Microbial evolution and biogeochemical cycles **(1h)**
1.3. Impact of oxygen, Endosymbiotic evolution, Origin of ozone layer, Evolutionary chronometers **(2h)**
1.4. Sequence of Major events during biological evolution **(2h)**
1.5. Taxonomy of Eubacteria and Archaea- Nomenclature, classification, Identification **(1h)**
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 **(3h)**

Unit-2. Basics of Microbial Diversity (11h)

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 **(3h)**
2.2. Microbial metabolism of Hydrogen **(2h)**
2.3. Aerobic metabolism of Glucose **(2h)**
2.4. Aerobic metabolism of Methane and Methanol **(2h)**
2.5. Microbial metabolism of carbon dioxide **(2h)**

Unit-3. Extremophiles (11h)

3.1. Extremes of environmental conditions allowing bacterial growth and survival **(2h)**
3.2. Extremophilic microbes- acidophiles, alkaliphiles, psychrophiles, halophiles, thermophiles, Taxonomy and physiology of Extremely Halophilic Archaea **(5h)**
3.3. Microbial diversity of rumen **(2h)**
3.4. Microbial diversity of desert ecosystem **(2h)**

Unit-4. Conservation strategies and Exploitation of Microbial Diversity (12h)

4.1. The challenges of studying microbial diversity **(1h)**
4.2. Microbial diversity loss- causes and restoration **(1h)**
4.3. National Biodiversity Strategy and Action Plan **(1h)**
4.4. Biotechnology of artificial cells including application to artificial organs **(2h)**
4.5. Biotechnology applied to Raw Mineral Processing, Microbially Enhanced Oil Recovery **(2h)**
4.6. Microbial diversity and biodegradation of xenobiotics **(2h)**
4.7. Exploitation of fungal and cyanobacterial diversity **(1h)**
4.8. Societal issues of biotechnology **(2h)**

Mapping Matrix of POs, PSOs, and COs																
COs	**POs**												**PSOs**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Avg**	**1**	**2**	**3**	**Avg**
CO-1	3	2	–	–	–	–	–	–	–	2	–	2	**2.25**	2	2	3	**2.33**
CO-2	3	3	2	–	2	–	–	–	–	–	–	2	**2.4**	3	3	2	**2.67**
CO-3	3	2	–	3	3	–	–	–	–	–	–	3	**2.8**	2	2	1	**1.67**
CO-4	3	3	–	2	3	–	2	–	2	3	2	3	**2.5**	3	3	2	**2.67**
Avg	3	2.5	2	2.5	2.66	--	2	--	2	2.5	2	2.5		2.5	2.5	2	

3 = Strong Contribution, 2 = Moderate Contribution, 1 = Slight Contribution, --- = No Significant Contribution

Teaching Pedagogy	
CO-1 (Unit: 1)	• Constructivism, Social Constructivism, Behaviorism
CO-2 (Unit: 2)	• Constructivism, Social Constructivism, Behaviorism
CO-3 (Unit: 3)	• Constructivism, Social Constructivism, Behaviorism
CO-4 (Unit: 4)	• Constructivism, Social Constructivism, Behaviorism

Assessment Method

			Exam Component		
Continuous Comprehensive Evaluation 40 Marks	**COs**	**Marks**	**Written Test**	**Assignment/Seminar**	**Quiz/Discussion**
	CO-1	10	10	--	--
	CO-2	10	10	--	--
	CO-3	10	0	5	5
	CO-4	10	0	5	5
Term-End Evaluation 60 Marks	**COs**	**Marks**	**Exam Component**		
	CO-1	15	Term End Examination		
	CO-2	15			
	CO-3	15			
	CO-4	15			

References

1. Dutuyma, D. J. (2017). *Evolution* (4th ed.). Sinauer Associates; Oxford University Press.
2. Brown, J. W. (2014). *Principles of microbial diversity*. ASM Press.
3. Dubey, R. C. (2019). *Microbial taxonomy* (latest ed.). S. Chand Publishing.
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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 Libraryhttps://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

Program – M.Sc. (Microbiology) Semester- 1		
Course Code 256010238002	**Name of Course** Microbial Diversity Practical	**Major**
Credit: 02	**Teaching Scheme: Practical (60)**	**Teaching Hours: 60**

Course Outcomes (COs)

After studying this course, the student will be able to:

CO-1: Distinguish microorganisms based on their physiological and metabolic traits.

CO-2: Compare microbial diversity across fungi and various natural habitats.

Detailed Syllabus

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.

Mapping Matrix of POs, PSOs, and COs

COs	POs													PSOs			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Avg**	**1**	**2**	**3**	**Avg**
CO-1	3	3	3	2	2	–	–	3	2	–	–	2	**2.5**	3	2	2	**2.33**
CO-2	3	3	3	2	–	2	3	2	2	3	2	3	**2.54**	2	3	2	**2.33**
Avg	3	3	3	2	2	2	3	2.5	2	3	2	2.5		2.5	2.5	2	

3 = Strong Contribution, 2 = Moderate Contribution, 1 = Slight Contribution, --- = No Significant Contribution

Teaching Pedagogy

CO-1 (Unit: 1)	• Constructivism, Social Constructivism, Behaviorism
CO-2 (Unit: 2)	• Constructivism, Social Constructivism, Behaviorism

Assessment Method

Continuous Comprehensive Evaluation 40 Marks	**COs**	**Marks**	**Exam Component**
			Continuous Evaluation
	CO-1	20	
	CO-2	20	
Term-End Evaluation 60 Marks	**COs**	**Marks**	**Exam Component**
	CO-1	30	Term End Examination
	CO-2	30	

Program – M.Sc. (Microbiology) Semester- 1		
Course Code 256010338003	**Name of Course** Microbial Physiology	**Major**
Credit: 03	**Teaching Scheme: Theory (45)**	**Teaching Hours: 45**

Course Outcomes (COs)

After studying this course, the student will be able to:

CO-1: Describe the principles of microbial growth kinetics, factors affecting growth, measurement techniques, and methods to control microbial proliferation.

CO-2: Describe membrane structure and transport mechanisms, and examine microbial adaptations, gene regulation, and cell-to-cell communication.

CO-3: 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.

Detailed Syllabus

Unit-1. Microbial Growth (11h)

1.1 Bacterial growth and its kinetics: Definition, trophophase and idiophase, Diauxic growth, Maximum growth rate, Specific growth rate, Yield co-efficient **(3h)**

1.2 Continuous growth and its kinetics: Continuous culture, Dilution rate, Residual substrate concentration **(2h)**

1.3 Factors affecting growth: Temperature, pH, Oxygen, Salt concentration, Pressure, Water activity, Radiation **(2h)**

1.4 Growth measurement: Direct methods and indirect methods **(2h)**

1.5 Control of microbial growth: Physical agents and chemical agents **(2h)**

Unit-2. Membrane Transport, Physiological Adaptations and Intercellular Signalling (11h)

2.1 Cytoplasmic Membrane and Transport- Membrane Structure, The Functions of cytoplasmic membrane, **(3h)**

2.2 Nutrient Transport. **(2h)**

2.3 Physiological Adaptation and Intercellular signaling- Overview of Regulation of gene expression, Bioluminescence, Signal Transduction and its Molecular mechanisms **(3h)**

2.4 Mechanism of drug resistance, Quorum Sensing, Cellular Differentiation, Microbial Stress Responses **(3h)**

Unit-3. Physiological and Metabolism Diversity of Fungi (12h)

3.1 Introduction to fungal physiology **(2h)**

3.2 Morphology of yeasts and fungi- Filamentous fungi, Yeasts **(2h)**

3.3 Ultrastructure and function of fungal cells- The fungal cell surface, Subcellular architecture and organelle function. **(2h)**

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. **(2h)**

3.5 Fungal metabolism- Carbon catabolism, Nitrogen metabolism. **(2h)**

3.6 Fungal growth and reproduction- Physical requirements for growth, Cellular reproduction, Population growth, Fungal cell death. **(2h)**

Unit-4. Diversity of Heterotrophic and Autotrophic Metabolism (11h)

4.1 Metabolic Strategies for Generating Cellular Energy. **(3h)**

4.2 Respiration- Oxydative Phosphorylation, Aerobic Chemoorganotrophic Process, Anaerobic Respiration. **(4h)**

4.3 Autotrophy (The Calvin Cycle, Other Autotrophic pathways, Nitrogen Metabolism). **(4h)**

Mapping Matrix of POs, PSOs, and COs

COs	POs													PSOs			
	1	2	3	4	5	6	7	8	9	10	11	12	Avg	1	2	3	Avg
CO-1	3	3	2	–	2	–	–	–	–	2	–	–	**2.4**	3	2	2	**2.33**
CO-2	3	2	3	–	–	–	–	3	–	–	–	2	**2.6**	3	2	3	**2.67**
CO-3	3	2	–	2	2	–	–	–	–	–	–	–	**2.25**	2	3	2	**2.33**
CO-4	3	3	2	–	3	–	2	3	–	3	2	2	**2.55**	3	3	2	**2.67**
Avg	3	2.5	2.33	2	2.33	--	2	3	--	2.5	2	2	2.45	2.75	2.5	2.25	2.5

3 = Strong Contribution, 2 = Moderate Contribution, 1 = Slight Contribution, --- = No Significant Contribution

Teaching Pedagogy

CO-1 (Unit: 1)	• Constructivism, Social Constructivism, Behaviorism
CO-2 (Unit: 2)	• Constructivism, Social Constructivism, Behaviorism
CO-3 (Unit: 3)	• Constructivism, Social Constructivism, Behaviorism
CO-4 (Unit: 4)	• Constructivism, Social Constructivism, Behaviorism

Assessment Method

			Exam Component		
Continuous Comprehensive Evaluation 40 Marks	**COs**	**Marks**	**Written Test**	**Assignment/Seminar**	**Quiz/Discussion**
	CO-1	10	10	--	--
	CO-2	10	10	--	--
	CO-3	10	0	5	5
	CO-4	10	0	5	5
Term-End Evaluation 60 Marks	**COs**	**Marks**	**Exam Component**		
	CO-1	15	Term End Examination		
	CO-2	15			
	CO-3	15			
	CO-4	15			

References

1. Walker, G. M., & White, N. A. (2017). Introduction to fungal physiology. In K. Kavanagh (Ed.), *Fungi: Biology and Applications* (pp. xx–xx). John Wiley & Sons. - (You'll need to insert the chapter page range in place of "xx–xx.")
2. Moat, A. G., Foster, J. W., & Spector, M. P. (2002). *Microbial Physiology* (4th ed.). Wiley-Liss.
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Program – M.Sc. (Microbiology) Semester- 1		
Course Code 256010238004	**Name of Course** Microbial Physiology Practical	**Major**
Credit: 02	**Teaching Scheme: Practical (60)**	**Teaching Hours: 60**

Course Outcomes (COs)

After studying this course, the student will be able to:

CO-1: Use practical skills for measuring microbial growth, death rates, and biomass using standard physiological methods.

CO-2: Examine how environmental and nutritional factors influence microbial growth through hands-on experimentation.

Detailed Syllabus

1. Growth Kinetics
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.

Mapping Matrix of POs, PSOs, and COs

COs	POs													PSOs			
	1	2	3	4	5	6	7	8	9	10	11	12	Avg	1	2	3	Avg
CO-1	3	3	3	–	2	–	2	–	–	2	–	–	2.5	3	2	2	2.33
CO-2	3	2	3	–	–	2	2	3	2	3	2	3	2.77	3	3	2	2.67
Avg	3	2.5	3	--	2	2	2	3	2	2.5	2	3		3	2.5	2	3

3 = Strong Contribution, 2 = Moderate Contribution, 1 = Slight Contribution, --- = No Significant Contribution

Teaching Pedagogy

CO-1 (Unit: 1)	• Constructivism, Social Constructivism, Behaviorism
CO-2 (Unit: 2)	• Constructivism, Social Constructivism, Behaviorism

Assessment Method

Continuous Comprehensive Evaluation 40 Marks	**COs**	**Marks**	**Exam Component**
			Continuous Evaluation
	CO-1	20	
	CO-2	20	
Term-End Evaluation 60 Marks	**COs**	**Marks**	**Exam Component**
	CO-1	30	Term End Examination
	CO-2	30	

Program – M.Sc. (Microbiology)
Semester- 1

Course Code	Name of Course	Major
256010338005	Bioinstrumentation	
Credit: 03	**Teaching Scheme: Theory (45)**	**Teaching Hours: 45**

Course Outcomes (COs)

After studying this course, the student will be able to:

CO-1: 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.

Detailed Syllabus

Unit-1. Principle, Instrumentation and Techniques (11h)

1. Principle and application of scanning and transmission electron microscopy, scanning tunneling microscopy, confocal microscopy.
2. PCR and Sequencing Techniques.

Unit-2. Specialized Spectroscopy: (Principle, Instrumentation and Applications) (12h)

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) (11h)

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) (11h)

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.

Mapping Matrix of POs, PSOs, and COs

COs	POs													PSOs			
	1	2	3	4	5	6	7	8	9	10	11	12	Avg	1	2	3	Avg
CO-1	3	3	3	--	--	2	2	--	--	--	--	--	**2.6**	3	2	2	**2.33**
CO-2	3	3	3	--	--	--	2	3	--	--	--	--	**2.8**	3	2	2	**2.33**
CO-3	3	2	3	--	--	--	--	2	--	--	--	--	**2.5**	3	3	2	**2.67**
CO-4	3	3	3	--	--	--	2	3	2	3	--	--	**2.7**	3	2	2	**2.33**
Avg	3	2.75	3	--	--	2	2	2.66	2	3	--	--	2.65	3	2.25	2	2.42

3 = Strong Contribution, 2 = Moderate Contribution, 1 = Slight Contribution, --- = No Significant Contribution

Teaching Pedagogy	
CO-1 (Unit: 1)	• Constructivism, Social Constructivism, Behaviorism
CO-2 (Unit: 2)	• Constructivism, Social Constructivism, Behaviorism
CO-3 (Unit: 3)	• Constructivism, Social Constructivism, Behaviorism
CO-4 (Unit: 4)	• Constructivism, Social Constructivism, Behaviorism

Assessment Method

			Exam Component		
Continuous Comprehensive Evaluation 40 Marks	**COs**	**Marks**	**Written Test**	**Assignment/Seminar**	**Quiz/Discussion**
	CO-1	10	10	--	--
	CO-2	10	10	--	--
	CO-3	10	0	5	5
	CO-4	10	0	5	5
Term-End Evaluation 60 Marks	**COs**	**Marks**	**Exam Component**		
	CO-1	15	Term End Examination		
	CO-2	15			
	CO-3	15			
	CO-4	15			

References

1. Sharma, B. K. (n.d.). *Instrumental Methods of Chemical Analysis*. [Publisher].
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3. Plummer, D. T. (n.d.). *An Introduction to Practical Biochemistry*. [Publisher].
4. Chatwal, G. R., & Anand, S. (n.d.). *Instrumentation: Spectroscopy*. [Publisher].
5. Boyer, R. (n.d.). *Modern Experimental Biology*. [Publisher].
6. Berg, J. M., Tymoczko, J. L., & Stryer, L. (2006). *Biochemistry* (6th ed.). W. H. Freeman.
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11. Nölting, B. (2006). *Methods in Modern Biophysics* (2nd ed.). Springer.
12. Pattabhi, V., & Gautham, N. (2002). *Biophysics*. Kluwer Academic / Narosa.
13. Wilson, K., & Walker, J. (2005). *Principles and Techniques of Biochemistry and Molecular Biology* (6th ed.). Cambridge University Press.
14. Eggins, B. (n.d.). *Biosensors: An Introduction*. Wiley.

Program – M.Sc. (Microbiology) Semester- 1		
Course Code 256010238006	**Name of Course** Bioinstrumentation Practical	**Major**
Credit: 02	**Teaching Scheme: Practical (60)**	**Teaching Hours: 60**

Course Outcomes (COs)

After studying this course, the student will be able to:

CO-1: 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.

Detailed Syllabus

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

Mapping Matrix of POs, PSOs, and COs

COs	POs													PSOs			
	1	2	3	4	5	6	7	8	9	10	11	12	Avg	1	2	3	Avg
CO-1	3	3	3	-	-	2	2	-	-	-	-	-	**2.6**	3	2	2	**2.33**
CO-2	3	2	3	-	-	-	2	3	2	3	-	-	**2.57**	3	3	2	**2.67**
Avg	3	2.5	3	--	--	2	2	3	2	3	--	--		3	2.5	2	

3 = Strong Contribution, 2 = Moderate Contribution, 1 = Slight Contribution, --- = No Significant Contribution

Teaching Pedagogy

CO-1 (Unit: 1)	• Constructivism, Social Constructivism, Behaviorism
CO-2 (Unit: 2)	• Constructivism, Social Constructivism, Behaviorism

Assessment Method

Continuous Comprehensive Evaluation 40 Marks	**COs**	**Marks**	**Exam Component**
	CO-1	20	**Continuous Evaluation**
	CO-2	20	
Term-End Evaluation 60 Marks	**COs**	**Marks**	**Exam Component**
	CO-1	30	Term End Examination
	CO-2	30	

Program – M.Sc. (Microbiology) Semester- 1		
Course Code 256010338007	**Name of Course** Immunology	**Major**
Credit: 03	**Teaching Scheme: Theory (45)**	**Teaching Hours: 45**

Course Outcomes (COs)

After studying this course, the student will be able to:

CO-1: 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.

Detailed Syllabus

Unit-1. Immune System Overview (10h)

1.1.A. General principles of immunology: Structure, composition and function of cells and organs involved in immune system. **(2.5h)**

1.1 B. Immune response (humoral and cell mediated) innate immunity, acquired immunity. **(2.5h)**

1.2.A. Antigens – antibodies: Antigens-structure and properties; types-iso and allo; haptens adjuvants, antigen specificity. **(2.5h)**

1.2.B. Membrane receptors for antigens; immunoglobulins; structure-heterogeneity-types and subtypes-properties; theories of antibody production. **(2.5h)**

Unit-2. Immune Interactions (10h)

2.1.A. Antigen and antibody interactions: In vitro methods-agglutination, precipitation, complement fixation, immunofluorescence, ELISA, radio immunoassay; **(3h)**

2.1.B. In vivo methods; phagocytosis, opsonization, neutralization. **(2h)**

2.2 Complement system; complement components. complement activation - pathways, regulation of complement system, **(3h)**

2.2.B. Biological consequences of complement activation, complement deficiencies. **(2h)**

Unit-3. Immunogenetics (15h)

3.1.A. 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; **(5h)**

3.1.B. HLA and tissue transplantation- tissue typing methods for organ and tissue transplantations in humans; graft versus host reaction and rejection. **(5h)**

3.2.A. Tumor immunology: Tumor immunology - tumor antigens, Host immune response to tumors, antibody dependent cell cytotoxicity (ADCC), **(2.5h)**

3.2.B. Tumor escape mechanisms Immuno diagnosis and therapy. **(2.5h)**

Unit-4. Applied Immunology (10h)

4.1.A. Immunopathology: Classification of immunopathological disorders. General account of immune deficiency disorders. Primary and secondary, phagocytic cell disorder. Gammopathies. Complement deficiencies. **(2h)**

4.1.B. Hypersensitivity reactions: type I, II, III and IV the respective diseases, immunological methods of their diagnosis. Autoimmunity mechanism and diseases. **(4h)**

4.2.A. Immuno biotechnology: Isolation of spleen cells, Myeloma cell lines used as fusion partner, fusion method, detection and application of monoclonal antibodies, **(2h)**

4.2.B. Types of vaccines, whole - organism vaccines, recombinant vector vaccines, DNA vaccines, synthetic peptide vaccines, subunit vaccines, immunization procedures, adverse reactions to vaccines. **(2h)**

Mapping Matrix of POs, PSOs, and COs

COs	POs													PSOs			
	1	2	3	4	5	6	7	8	9	10	11	12	Avg	1	2	3	Avg
CO-1	3	3	–	–	–	2	2	–	–	–	–	–	**2.5**	2	3	2	**2.33**
CO-2	3	3	3	–	–	–	3	3	–	–	–	–	**3**	2	3	2	**2.33**
CO-3	3	3	–	3	–	–	3	–	3	–	–	–	**3**	2	3	3	**2.67**
CO-4	3	3	3	–	–	3	–	2	2	3	–	3	**2.75**	3	3	3	**3.00**
Avg	3	3	3	3	--	2.5	2.66	2.5	2.5	3	--	3	2.81	2.2	3	2.5	2.58

3 = Strong Contribution, 2 = Moderate Contribution, 1 = Slight Contribution, --- = No Significant Contribution

Teaching Pedagogy

CO-1 (Unit: 1)	• Constructivism, Social Constructivism, Behaviorism
CO-2 (Unit: 2)	• Constructivism, Social Constructivism, Behaviorism
CO-3 (Unit: 3)	• Constructivism, Social Constructivism, Behaviorism
CO-4 (Unit: 4)	• Constructivism, Social Constructivism, Behaviorism

Assessment Method

			Exam Component		
Continuous Comprehensive Evaluation 40 Marks	**COs**	**Marks**	**Written Test**	**Assignment/Seminar**	**Quiz/Discussion**
	CO-1	10	10	--	--
	CO-2	10	10	--	--
	CO-3	10	0	5	5
	CO-4	10	0	5	5
Term-End Evaluation 60 Marks	**COs**	**Marks**	**Exam Component**		
	CO-1	15	Term End Examination		
	CO-2	15			
	CO-3	15			
	CO-4	15			

References

1. Riott, I. M. (1998). *Essentials of Immunology*. ELBS / Blackwell Scientific Publishers.
2. Kuby, J. (1994). *Immunology* (2nd ed.). W. H. Freeman.
3. Elgert, C. D. (1996). *Understanding the Immune System*. Wiley-Liss.
4. Paul, W. (n.d.). *Fundamentals of Immunology*. [Publisher].
5. Abbas, A. (Ed.). (n.d.). *Cellular and Molecular Immunology* (3rd ed.). [Publisher].
6. Travers, P. (n.d.). *Immunobiology: The Immune System in Health and Disease* (3rd ed.). [Publisher].
7. Benjamin, D. (n.d.). *Immunology: A Short Course* (2nd ed.). [Publisher].
8. Rose, N. R., Hamilton, R. G., & Detrick, B. (Eds.). (2002). *Manual of Clinical Laboratory and Immunology* (6th ed.). ASM Publications.
9. Murray, P. R. (1998). *Pocket Guide to Clinical Microbiology* (2nd ed.). ASM Publications.

Program – M.Sc. (Microbiology) Semester- 1		
Course Code 256010238008	**Name of Course** Immunology Practical	**Major**
Credit: 02	**Teaching Scheme: Practical (60)**	**Teaching Hours: 60**

Course Outcomes (COs)

After studying this course, the student will be able to:

CO-1: 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.

Detailed Syllabus

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

Mapping Matrix of POs, PSOs, and COs

COs	POs													PSOs			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Avg**	**1**	**2**	**3**	**Avg**
CO-1	3	3	3	–	–	2	2	–	–	–	–	–	**2.6**	3	2	2	**2.33**
CO-2	3	2	3	–	–	–	2	3	2	3	–	3	**2.625**	3	3	2	**2.67**
Avg	3	2.5	3	--	--	2	2	3	2	3	--	3		3	2.5	2	

3 = Strong Contribution, 2 = Moderate Contribution, 1 = Slight Contribution, --- = No Significant Contribution

Teaching Pedagogy

CO-1 (Unit: 1)	• Constructivism, Social Constructivism, Behaviorism
CO-2 (Unit: 2)	• Constructivism, Social Constructivism, Behaviorism

Assessment Method

			Exam Component
Continuous Comprehensive Evaluation 40 Marks	**COs**	**Marks**	**Continuous Evaluation**
	CO-1	10	
	CO-2	10	
Term-End Evaluation 60 Marks	**COs**	**Marks**	**Exam Component**
	CO-1	15	Term End Examination
	CO-2	15	

Program – M.Sc. (Microbiology) Semester- 2		
Course Code 256010338009	**Name of Course** Enzymology	**Major**
Credit: 03	**Teaching Scheme: Theory (45)**	**Teaching Hours: 45**

Course Outcomes (COs)

After studying this course, the student will be able to:

CO-1: 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.

Detailed Syllabus

Unit-1. Structure and Functions of Enzymes (11h)

1.1 Introduction to Enzymes (History, naming and classification of Enzymes). **(5 h)**

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 **(6 h)**

Unit-2. Enzyme Kinetics (11h)

2.1 Kinetics of Single-substrate-enzyme catalysed reactions- **(4 h)**

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- **(4 h)**

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- **(3 h)**

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 (11h)

3.1 Enzyme Inhibition- **(4 h)**

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: **(3 h)**

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: **(4 h)**

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 (12h)

4.1 Immobilization Techniques for Enzymes: **(6 h)**

Carrier- Definition, Durability and adverse effects

Immobilization procedures- adsorption, covalent coupling, cross linking, entrapment, encapsulation

4.2 Immobilization Techniques for Cell : **(6 h)**

Immobilization procedures- Adsorption, Covalent Bonding, Cell to cell crosslinking, Microencapsulation,

Mapping Matrix of POs, PSOs, and COs

COs	POs													PSOs			
	1	2	3	4	5	6	7	8	9	10	11	12	Avg	1	2	3	Avg
CO-1	3	2	–	–	–	–	–	–	–	2	–	2	**2.25**	2	2	2	**2.00**
CO-2	3	3	2	–	–	–	–	3	–	–	–	–	**2.75**	2	3	2	**2.33**
CO-3	3	3	3	–	–	–	–	3	–	–	–	–	**3**	2	2	2	**2.00**
CO-4	3	3	3	3	--	3	2	2	2	3	2	3	**2.7**	3	3	2	**2.67**
Avg	3	2.75	2.66	3	--	3	2	2	2	2.5	2	2.5	2.675	2.25	2.5	2	2.25

3 = Strong Contribution, 2 = Moderate Contribution, 1 = Slight Contribution, --- = No Significant Contribution

Teaching Pedagogy	
CO-1 (Unit: 1)	• Constructivism, Social Constructivism, Behaviorism
CO-2 (Unit: 2)	• Constructivism, Social Constructivism, Behaviorism
CO-3 (Unit: 3)	• Constructivism, Social Constructivism, Behaviorism
CO-4 (Unit: 4)	• Constructivism, Social Constructivism, Behaviorism

Assessment Method

			Exam Component		
Continuous Comprehensive Evaluation 40 Marks	**COs**	**Marks**	**Written Test**	**Assignment/Seminar**	**Quiz/Discussion**
	CO-1	10	10	--	--
	CO-2	10	10	--	--
	CO-3	10	0	5	5
	CO-4	10	0	5	5
Term-End Evaluation 60 Marks	**COs**	**Marks**	**Exam Component**		
	CO-1	15	Term End Examination		
	CO-2	15			
	CO-3	15			
	CO-4	15			

References

1. Berg, J. M., Tymoczko, J. L., & Stryer, L. (2015). *Biochemistry* (8th ed.). W. H. Freeman.
2. Nelson, D. L., & Cox, M. M. (2021). *Lehninger Principles of Biochemistry* (8th ed.). W. H. Freeman / Macmillan.
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4. Rosevear, K., Kennedy, J., & Cabral, M. S. (1987). *Immobilized Enzymes and Cells*. Adam Hilger.
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6. Trevan, M. D. (1980). *Immobilized Enzymes*. John Wiley & Sons.
7. Expasy / IUBMB. (n.d.). *Enzyme Nomenclature Database*. https://enzyme.expasy.org/
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Program – M.Sc. (Microbiology) Semester- 2		
Course Code 256010238010	**Name of Course** Enzymology Practical	**Major**
Credit: 02	**Teaching Scheme: Practical (60)**	**Teaching Hours: 60**

Course Outcomes (COs)

After studying this course, the student will be able to:

CO-1: 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.

Detailed Syllabus

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

Mapping Matrix of POs, PSOs, and COs

COs	POs													PSOs			
	1	2	3	4	5	6	7	8	9	10	11	12	Avg	1	2	3	Avg
CO-1	3	3	3	–	–	–	–	3	–	3	–	–	**3**	3	2	2	**2.33**
CO-2	3	2	3	–	–	–	–	3	–	–	–	–	**2.75**	3	3	2	**2.67**
Avg	3	2.5	3	--	--	--	--	3	--	3	--	--		3	2.5	2	

3 = Strong Contribution, 2 = Moderate Contribution, 1 = Slight Contribution, --- = No Significant Contribution

Teaching Pedagogy

CO-1 (Unit: 1)	• Constructivism, Social Constructivism, Behaviorism
CO-2 (Unit: 2)	• Constructivism, Social Constructivism, Behaviorism

Assessment Method

Continuous Comprehensive Evaluation 40 Marks	**COs**	**Marks**	**Exam Component**
	CO-1	20	**Continuous Evaluation**
	CO-2	20	
Term-End Evaluation 60 Marks	**COs**	**Marks**	**Exam Component**
	CO-1	30	Term End Examination
	CO-2	30	

Program – M.Sc. (Microbiology) Semester- 2		
Course Code 256010338011	**Name of Course** Molecular Biology and Bacterial Genetics	**Major**
Credit: 03	**Teaching Scheme: Theory (45)**	**Teaching Hours: 45**

Course Outcomes (COs)

After studying this course, the student will be able to:

CO-1: 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.

Detailed Syllabus

Unit-1. Bacterial Genome Organization and Gene Expression Mechanisms (12h)

1.1 Structure and organization of bacterial genome and Replication **(5.5h)**

1.1.1 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 **(2h)**

1.1.2 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 **(2h)**

1.1.3 Bacterial DNA replication **(1.5h)**

1.2 Transcription and translation of bacterial genes **(6.5h)**

1.2.1. The structure and function of RNA- types of RNA, RNA precursors, RNA structure, RNA processing and modification **(1h)**

1.2.2. Transcription- Molecular mechanism; Bacterial RNA polymerase, Transcription Initiation, Polymerization reaction, Transcription Termination **(2h)**

1.2.3. Translation- Protein structure, Ribosome structure, the Genetic code, Translation initiation, elongation and termination, Polycistronic mRNA**(2h)**

1.2.4. Post translational modification and Protein folding- Mechanism of post translational modification of protein, Protein folding mechanism- Chaperones, Protein disulfide isomerases, Membrane proteins **(1.5h)**

Unit-2. Mechanisms of Mutation, DNA Repair and Genetic Recombination in Bacteria (11h)

2.1 Mutations and DNA repair **(8h)**

2.1.1. 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. **(2h)**

2.1.2. 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. **(3h)**

2.1.3. 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. **(3h)**

2.2 Recombination models **(3h)**

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. Molecular Mechanisms of Horizontal Gene Transfer in Bacteria (11h)

3.1 Conjugation **(4h)**

3.1.1. Mechanism of DNA transfer during Conjugation in Gram –ve bacteria- Transfer tra genes, the oriT sequence, function of plasmid primases in transfer, Mobilizable plasmids **(1.5h)**

3.1.2. Chromosome transfer by plasmids- Formation of Hfr strains, transfer of chromosomal DNA by integrated Plasmids, chromosome mobilization and Prime factors **(1.5h)**

3.1.3. Transfer systems of Gram +ve bacteria- Plasmid attracting Pheromones **(1h)**

3.2 Transformation **(4h)**

3.2.1. Natural Transformation **(0.5h)**

3.2.2. Competence **(0.5h)**

3.2.3. Uptake of DNA during Natural Transformation **(1h)**

3.2.4 Mechanism of DNA uptake during Transformation **(1h)**

3.2.5. Role of Natural Transformation **(0.5h)**

3.2.6 Artificially induced competence- Calcium ion induction and Electroporation **(0.5h)**

3.3 Transduction **(3h)**

3.3.1 Phage λ and lysogeny **(1h)**

3.3.2 Generalized and specialized Transduction and its consequences **(2h)**

Unit-4. Extra-chromosomal Genetics and Gene Regulation in bacteria (11h)

4.1 Extra chromosomal inheritance: **(4h)**

4.1.1 Nomenclature and classification of Plasmids, Plasmid structure, phenotypic traits encoded by Plasmids. **(1.5h)**

4.1.2. 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. **(2.5h)**

4.2 Transpositon **(4h)**

4.2.1. Structure of Transposons **(1h)**

4.2.2. Types of bacterial Transposons- IS elements, Composite transposons, Non-composite transposons **(1h)**

4.2.3 Molecular models for transposition- Replicative transposition, Cut and paste transposition, Relationship between replicative and cut and paste transposition and their target regulation **(2h)**

4.3 Control **(3h)**

4.3.1 Lac operon- Positive control, Negative control, Catabolite repression and role of CAP **(1.5h)**

4.3.2. Tryptophan operon- Attenuation control **(1.5h)**

Mapping Matrix of POs, PSOs, and COs

COs	POs													PSOs			
	1	2	3	4	5	6	7	8	9	10	11	12	Avg	1	2	3	Avg
CO-1	3	3	–	–	–	–	3	2	–	2	–	–	**2.6**	2	3	2	**2.33**
CO-2	3	3	2	–	–	–	–	2	–	–	–	–	**2.5**	2	3	2	**2.33**
CO-3	3	3	3	3	–	–	–	–	–	–	–	–	**3**	2	3	3	**2.67**
CO-4	3	3	2	3	–	3	–	2	–	3	3	3	**2.77**	3	3	2	**2.67**
Avg	3	3	2.33	3	--	3	3	2	--	2.5	3	3	2.71	2.2	3	2.2	2.5

3 = Strong Contribution, 2 = Moderate Contribution, 1 = Slight Contribution, --- = No Significant Contribution

Teaching Pedagogy	
CO-1 (Unit: 1)	• Constructivism, Social Constructivism, Behaviorism
CO-2 (Unit: 2)	• Constructivism, Social Constructivism, Behaviorism
CO-3 (Unit: 3)	• Constructivism, Social Constructivism, Behaviorism
CO-4 (Unit: 4)	• Constructivism, Social Constructivism, Behaviorism

Assessment Method

			Exam Component		
Continuous Comprehensive Evaluation 40 Marks	**COs**	**Marks**	**Written Test**	**Assignment/Seminar**	**Quiz/Discussion**
	CO-1	10	10	--	--
	CO-2	10	10	--	--
	CO-3	10	0	5	5
	CO-4	10	0	5	5
Term-End Evaluation 60 Marks	**COs**	**Marks**	**Exam Component**		
	CO-1	15	Term End Examination		
	CO-2	15			
	CO-3	15			
	CO-4	15			

References

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2. De Robertis, E. D. P., & De Robertis, E. M. F. (2006). *Cell and Molecular Biology* (8th ed.). Lippincott Williams & Wilkins.
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7. Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments* (6th ed.). John Wiley & Sons.
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Program – M.Sc. (Microbiology) Semester- 2		
Course Code 256010238012	**Name of Course** Molecular Biology and Bacterial Genetics Practical	**Major**
Credit: 02	**Teaching Scheme: Practical (60)**	**Teaching Hours: 60**

Course Outcomes (COs)

After studying this course, the student will be able to:

CO-1: 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.

Detailed Syllabus

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.

Mapping Matrix of POs, PSOs, and COs

COs	POs													PSOs			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Avg**	**1**	**2**	**3**	**Avg**
CO-1	3	3	3	–	–	–	–	3	–	2	–	–	**2.8**	3	2	2	**2.33**
CO-2	3	2	3	–	–	–	–	3	–	–	–	–	**2.75**	3	3	2	**2.67**
Avg	3	2.5	3	--	--	--	--	3	--	2	--	--		3	2.5	2	

3 = Strong Contribution, 2 = Moderate Contribution, 1 = Slight Contribution, --- = No Significant Contribution

Teaching Pedagogy

CO-1 (Unit: 1)	• Constructivism, Social Constructivism, Behaviorism
CO-2 (Unit: 2)	• Constructivism, Social Constructivism, Behaviorism

Assessment Method

Continuous Comprehensive Evaluation 40 Marks			**Exam Component**
	COs	**Marks**	**Continuous Evaluation**
	CO-1	20	
	CO-2	20	
Term-End Evaluation 60 Marks	**COs**	**Marks**	**Exam Component**
	CO-1	30	Term End Examination
	CO-2	30	

Program – M.Sc. (Microbiology) Semester- 2		
Course Code 256010338013	**Name of Course** Recombinant DNA Technology	**Major**
Credit: 03	**Teaching Scheme: Theory (45)**	**Teaching Hours: 45**

Course Outcomes (COs)

After studying this course, the student will be able to:

CO-1: 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

Detailed Syllabus

Unit-1. Tools of Genetic Engineering (11h)

1.1.A. 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. **(4h)**

1.1.B. DNA ligase, DNA polymerase, **(3h)**

1.2.A, Polynucleotide kinase, phosphatase, reverse transcriptase its activity and mode of action. **(2h)**

1.2.B. Restriction digestion, ligation and transformation **(2h)**

Unit-2. Vectors and Cloning Systems (11h)

2.1.A. Vectors: Properties, incompatibility, isolation and purification techniques, plasmid vectors and their properties, **(3h)**

2.1.B. PBR 322 – its construction and derivatives. **(2h)**

2.2.A. Bacteriophage lambda as a vector: Essential features, organization of genome, general structure, rationale for vector construction, improved vectors, **(3h)**

2.2.B. gt series, EMBL vectors, invitro packaging, cosmids, phasmids, filamentous phage vectors. **(3h)**

Unit-3. Gene Mapping and Expression Strategies (11h)

3.1.A. Specialized cloning strategies: Expression vectors, genomic DNA libraries, chromosome walking and jumping, cDNA libraries, short gun cloning, directed cloning, **(3h)**

3.1.B. Recombinant DNA technology with reference to cloning and production interferon and insulin. Miscellaneous applications of Genetically engineered microorganisms (GEMS) / genetically modified organisms (GMO's). **(3h)**

3.2.A. Molecular mapping of genome: PCR methods and Applications DNA sequencing methods, Dideoxy and Chemical method. Sequence assembly. Automated sequencing. **(3h)**

3.2.B. Genetic and physical maps, physical mapping and map –based cloning, fluorescence in situ hybridization for genome analysis, Chromosome microdissection and microcloning, **(2h)**

Unit-4. Applications and Molecular Diagnostics using rDNA Techniques (12h)

4.1 Molecular markers in genome analysis: RFLP, RAPD and AFLP analysis, molecular markers linked to disease resistance genes **(6h)**

4.2 Application of RFLP in forensic, disease prognosis, genetic counseling, pedigree, animal trafficking and poaching: Germplasm maintenance, taxonomy and Biodiversity. **(6h)**

Mapping Matrix of POs, PSOs, and COs																	
COs	**POs**													**PSOs**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Avg**	**1**	**2**	**3**	**Avg**
CO-1	3	3	3	–	–	–	–	3	–	2	–	–	**2.8**	3	2	2	**2.33**
CO-2	3	3	3	–	–	–	–	3	–	–	3	–	**3**	3	3	2	**2.67**
CO-3	3	3	3	3	3	3	–	3	2	3	2	2	**2.7**	2	3	3	**2.67**
CO-4	3	3	3	3	3	3	2	2	3	3	3	3	**8.5**	2	3	3	**2.67**
Avg	3	3	3	3	3	3	2	2.75	2.5	2.66	2.66	2.5	4.25	2.5	2.75	2.5	2.58

3 = Strong Contribution, 2 = Moderate Contribution, 1 = Slight Contribution, --- = No Significant Contribution

Teaching Pedagogy	
CO-1 (Unit: 1)	• Constructivism, Social Constructivism, Behaviorism
CO-2 (Unit: 2)	• Constructivism, Social Constructivism, Behaviorism
CO-3 (Unit: 3)	• Constructivism, Social Constructivism, Behaviorism
CO-4 (Unit: 4)	• Constructivism, Social Constructivism, Behaviorism

Assessment Method					
Continuous Comprehensive Evaluation 40 Marks	**COs**	**Marks**	**Exam Component**		
			Written Test	**Assignment/Seminar**	**Quiz/Discussion**
	CO-1	10	10	--	--
	CO-2	10	10	--	--
	CO-3	10	0	5	5
	CO-4	10	0	5	5
Term-End Evaluation 60 Marks	**COs**	**Marks**	**Exam Component**		
	CO-1	15	Term End Examination		
	CO-2	15			
	CO-3	15			
	CO-4	15			

References

1. Old, R. W., & Primrose, S. B. (1994). *Principles of Gene Manipulations*. Blackwell Scientific.
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Program – M.Sc. (Microbiology) Semester- 2		
Course Code 256010238014	**Name of Course** Recombinant DNA Technology Practical	**Major**
Credit: 02	**Teaching Scheme: Practical (60)**	**Teaching Hours: 60**

Course Outcomes (COs)

After studying this course, the student will be able to:

CO-1: 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

Detailed Syllabus

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

Mapping Matrix of POs, PSOs, and COs

COs	POs													PSOs			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Avg**	**1**	**2**	**3**	**Avg**
CO-1	3	3	3	–	–	–	–	3	–	2	–	–	**2.8**	3	2	2	**2.33**
CO-2	3	2	3	–	–	–	–	3	–	–	–	–	**2.75**	3	3	2	**2.67**
Avg	3	2.5	3	--	--	--	--	3	--	2	--	--		3	2.5	2	

3 = Strong Contribution, 2 = Moderate Contribution, 1 = Slight Contribution, --- = No Significant Contribution

Teaching Pedagogy

CO-1 (Unit: 1)	• Constructivism, Social Constructivism, Behaviorism
CO-2 (Unit: 2)	• Constructivism, Social Constructivism, Behaviorism

Assessment Method

Continuous Comprehensive Evaluation 40 Marks	**COs**	**Marks**	**Exam Component**
	CO-1	20	**Continuous Evaluation**
	CO-2	20	
Term-End Evaluation 60 Marks	**COs**	**Marks**	**Exam Component**
	CO-1	30	Term End Examination
	CO-2	30	

Program – M.Sc. (Microbiology) Semester- 2		
Course Code 256010338015	**Name of Course** Bioinformatics	**Major**
Credit: 03	**Teaching Scheme: Theory (45)**	**Teaching Hours: 45**

Course Outcomes (COs)

After studying this course, the student will be able to:

CO-1: 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

Detailed Syllabus

Unit-1. Biological Databases (11h)

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 (11h)

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.

Unit-3. Protein Structure Modelling and Computational Tools (12h)

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 (11h)

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

Mapping Matrix of POs, PSOs, and COs

COs	POs													PSOs			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Avg**	**1**	**2**	**3**	**Avg**
CO-1	3	–	–	–	–	–	2	3	–	3	–	–	**2.75**	2	2	2	**2.00**
CO-2	3	3	3	–	–	–	–	2	–	–	–	–	**2.75**	3	2	2	**2.33**
CO-3	3	3	3	3	2	–	–	3	–	–	–	–	**2.8**	2	2	3	**2.33**
CO-4	3	3	3	3	3	2	2	3	--	3	3	--	**2.8**	2	3	3	**2.67**

Avg	3.0	3	3	3	2.5	2	2	2.7	--	3	3	--	2.78	2.25	2.25	2.50	2.33

3 = Strong Contribution, 2 = Moderate Contribution, 1 = Slight Contribution, --- = No Significant Contribution

Teaching Pedagogy	
CO-1 (Unit: 1)	• Constructivism, Social Constructivism, Behaviorism
CO-2 (Unit: 2)	• Constructivism, Social Constructivism, Behaviorism
CO-3 (Unit: 3)	• Constructivism, Social Constructivism, Behaviorism
CO-4 (Unit: 4)	• Constructivism, Social Constructivism, Behaviorism

Assessment Method

			Exam Component		
Continuous Comprehensive Evaluation 40 Marks	**COs**	**Marks**	**Written Test**	**Assignment/Seminar**	**Quiz/Discussion**
	CO-1	10	10	--	--
	CO-2	10	10	--	--
	CO-3	10	0	5	5
	CO-4	10	0	5	5
Term-End Evaluation 60 Marks	**COs**	**Marks**	**Exam Component**		
	CO-1	15	Term End Examination		
	CO-2	15			
	CO-3	15			
	CO-4	15			

References

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10. Mavi, H. S., & Tupper, G. J. (n.d.). *Agrometeorology: Principles and Applications of Climate Studies in Agriculture*. [Publisher].
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Program – M.Sc. (Microbiology) Semester- 2		
Course Code 256010238016	**Name of Course** Bioinformatics Practical	**Major**
Credit: 02	**Teaching Scheme: Practical (60)**	**Teaching Hours: 60**

Course Outcomes (COs)

After studying this course, the student will be able to:

CO-1: 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.

Detailed Syllabus

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.

Mapping Matrix of POs, PSOs, and COs

COs	POs													PSOs			
	1	2	3	4	5	6	7	8	9	10	11	12	Avg	1	2	3	Avg
CO-1	3	–	–	–	–	–	3	3	–	2	–	–	**2.75**	3	2	2	**2.33**
CO-2	3	3	3	–	–	–	–	2	–	–	–	–	**2.75**	3	3	2	**2.67**
Avg	3	3	3	--	--	--	3	2.5	--	2	--	--		3	2.5	2	

3 = Strong Contribution, 2 = Moderate Contribution, 1 = Slight Contribution, --- = No Significant Contribution

Teaching Pedagogy

CO-1 (Unit: 1)	• Constructivism, Social Constructivism, Behaviorism
CO-2 (Unit: 2)	• Constructivism, Social Constructivism, Behaviorism

Assessment Method

Continuous Comprehensive Evaluation 40 Marks	**COs**	**Marks**	**Exam Component**
	CO-1	20	Continuous Evaluation
	CO-2	20	
Term-End Evaluation 60 Marks	**COs**	**Marks**	**Exam Component**
	CO-1	30	Term End Examination
	CO-2	30	

Program – M.Sc. (Microbiology)
Semester- 3

Course Code	Name of Course	Major
256510338017	Bioprocess Technology	
Credit: 03	**Teaching Scheme: Theory (45)**	**Teaching Hours: 45**

Course Outcomes (COs)

After studying this course, the student will be able to:

CO-1: 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.

Detailed Syllabus

Unit-1. Elements of Bioprocess (11h)

1.1 Isolation, screening and preservation of industrially important microorganisms. **(2h)**

1.2 Strain improvement Techniques.:Mutation, Reombinant DNA techniques, Protoplast fusion. **(3h)**

1.3 Media formulation **(3h)**

1.4 Fundamentals of scale up **(3h)**

Unit-2. Fermenter Design and control (11h)

2.1 Fermenter design, types of fermenters **(3h)**

2.2 The achievement and maintenance of aseptic conditions **(3h)**

2.3 Monitoring and control of process variables (ion-specific sensors, enzyme and microbial electrodes, manual and automatic controls) **(5h)**

Unit-3. Upstream processing (11h)

3.1 Sterilization of media, air and reactor **(3h)**

3.2 Development of inoculum for industrial fermentations **(2h)**

3.3 Aeration-agitation system, mass transfer of oxygen-factors affecting KLa **(3h)**

3.4 Heat transfer **(3h)**

Unit-4. Downstream processing and Fermentation economics (12h)

4.1 Methods of cell separation- filtration and centrifugation, Cell disruption, liquid-liquid extraction, chromatography, membrane processes. **(6h)**

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. **(6h)**

Mapping Matrix of POs, PSOs, and COs

COs	POs													PSOs			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Avg**	**1**	**2**	**3**	**Avg**
CO-1	3	3	–	3	–	–	–	3	–	2	2	–	**2.6**	3	3	2	**2.67**
CO-2	3	3	2	–	–	–	–	3	–	–	2	–	**2.6**	3	3	2	**2.67**

CO-3	3	3	3	3	–	–	–	3	–	–	2	–	**2.8**	3	3	2	**2.67**
CO-4	3	3	3	3	–	2	–	3	–	2	2	–	**2.6**	2	3	2	**2.33**
Avg	3	3	2.66	3	--	2	--	3	--	2	2	--	2.65	2.75	3.00	2.00	2.59

3 = Strong Contribution, 2 = Moderate Contribution, 1 = Slight Contribution, --- = No Significant Contribution

Teaching Pedagogy	
CO-1 (Unit: 1)	• Constructivism, Social Constructivism, Behaviorism
CO-2 (Unit: 2)	• Constructivism, Social Constructivism, Behaviorism
CO-3 (Unit: 3)	• Constructivism, Social Constructivism, Behaviorism
CO-4 (Unit: 4)	• Constructivism, Social Constructivism, Behaviorism

Assessment Method

			Exam Component		
Continuous Comprehensive Evaluation 40 Marks	**COs**	**Marks**	**Written Test**	**Assignment/Seminar**	**Quiz/Discussion**
	CO-1	10	10	--	--
	CO-2	10	10	--	--
	CO-3	10	0	5	5
	CO-4	10	0	5	5
Term-End Evaluation 60 Marks	**COs**	**Marks**	**Exam Component**		
	CO-1	15	Term End Examination		
	CO-2	15			
	CO-3	15			
	CO-4	15			

References

1. Stanbury, P. F., Whittaker, A., & Hall, S. J. (n.d.). *Principles of Fermentation Technology*. [Publisher].
2. Mukhopadhyay, S. N. (n.d.). *Process Biotechnology Fundamentals*. [Publisher].
3. El-Mansi, M., & Bryce, C. F. A. (n.d.). *Fermentation Microbiology and Biotechnology*. [Publisher].
4. Casida, L. E. (n.d.). *Industrial Microbiology*. [Publisher].

Program – M.Sc. (Microbiology) Semester- 3		
Course Code 256510238018	**Name of Course** Bioprocess Technology Practical	**Major**
Credit: 02	**Teaching Scheme: Practical (60)**	**Teaching Hours: 60**

Course Outcomes (COs)

After studying this course, the student will be able to:

CO-1: 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.

Detailed Syllabus

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

Mapping Matrix of POs, PSOs, and COs

COs	POs													PSOs			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Avg**	**1**	**2**	**3**	**Avg**
CO-1	3	3	3	3	–	–	–	3	–	2	2	–	**2.7**	3	2	2	**2.33**
CO-2	3	3	3	3	2	2	–	3	2	3	3	2	**2.6**	3	3	2	**2.67**
Avg	3	3	3	3	2	2	--	3	2	2.5	2.5	2		3	2.5	2	

3 = Strong Contribution, 2 = Moderate Contribution, 1 = Slight Contribution, --- = No Significant Contribution

Teaching Pedagogy

CO-1 (Unit: 1)	• Constructivism, Social Constructivism, Behaviorism
CO-2 (Unit: 2)	• Constructivism, Social Constructivism, Behaviorism

Assessment Method

Continuous Comprehensive Evaluation 40 Marks	**COs**	**Marks**	**Exam Component**
	CO-1	20	Continuous Evaluation
	CO-2	20	
Term-End Evaluation 60 Marks	**COs**	**Marks**	**Exam Component**
	CO-1	30	Term End Examination
	CO-2	30	

Program – M.Sc. (Microbiology) Semester- 3		
Course Code 256510338019	**Name of Course** Environmental Biotechnology	**Major**
Credit: 03	**Teaching Scheme: Theory (45)**	**Teaching Hours: 45**

Course Outcomes (COs)

After studying this course, the student will be able to:

CO-1: 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.

Detailed Syllabus

Unit-1. Principles of Waste Treatment (12h)

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 (11h)

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 (11h)

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 (11h)

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.

Mapping Matrix of POs, PSOs, and COs																	
COs	**POs**													**PSOs**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Avg**	**1**	**2**	**3**	**Avg**
CO-1	3	–	3	–	3	–	–	–	–	2	–	2	**2.6**	2	3	2	**2.33**
CO-2	3	3	3	3	3	–	–	–	–	–	–	2	**2.8**	2	3	2	**2.33**
CO-3	3	3	3	3	3	3	–	2	–	3	2	2	**2.7**	3	3	3	**3.00**
CO-4	3	3	3	3	3	3	3	2		3	2	2	**2.7**	3	3	2	**2.67**
Avg	3	3	3	3	3	3	3	2	-	2.66	2	2	2.70	2.50	3.00	2.25	2.58

3 = Strong Contribution, 2 = Moderate Contribution, 1 = Slight Contribution, --- = No Significant Contribution

Teaching Pedagogy	
CO-1 (Unit: 1)	• Constructivism, Social Constructivism, Behaviorism
CO-2 (Unit: 2)	• Constructivism, Social Constructivism, Behaviorism
CO-3 (Unit: 3)	• Constructivism, Social Constructivism, Behaviorism
CO-4 (Unit: 4)	• Constructivism, Social Constructivism, Behaviorism

Assessment Method

			Exam Component		
Continuous Comprehensive Evaluation 40 Marks	**COs**	**Marks**	**Written Test**	**Assignment/Seminar**	**Quiz/Discussion**
	CO-1	10	10	--	--
	CO-2	10	10	--	--
	CO-3	10	0	5	5
	CO-4	10	0	5	5
Term-End Evaluation 60 Marks	**COs**	**Marks**	**Exam Component**		
	CO-1	15	Term End Examination		
	CO-2	15			
	CO-3	15			
	CO-4	15			

References

1. Rehm, H. J., & Reid, G. (n.d.). *Biotechnology*. [Publisher].
2. Bitton, G. (n.d.). *Waste Water Microbiology*. [Publisher].
3. Alexander, M. (n.d.). *Biodegradation and Bioremediation*. [Publisher].
4. Arceivala, S. J. (n.d.). *Waste Water Treatment for Pollution Control* (2nd ed.). [Publisher].
5. Jordening, H., & Winter, J. (n.d.). *Environmental Biotechnology*. [Publisher].
6. Moo-Young, M. (Ed.). (n.d.). *Comprehensive Biotechnology* (Vol. 1–4). Pergamon Press.

Program – M.Sc. (Microbiology) Semester- 3		
Course Code 256510238020	**Name of Course** Environmental Biotechnology Practical	**Major**
Credit: 02	**Teaching Scheme: Practical (60)**	**Teaching Hours: 60**

Course Outcomes (COs)

After studying this course, the student will be able to:

CO-1: 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.

Detailed Syllabus

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

Mapping Matrix of POs, PSOs, and COs

COs	POs													PSOs			
	1	2	3	4	5	6	7	8	9	10	11	12	Avg	1	2	3	Avg
CO-1	3	–	3	–	3	–	–	–	–	2	–	2	**2.6**	3	2	2	**2.33**
CO-2	3	3	3	3	3	3	–	3	–	2	2	2	**2.7**	3	3	2	**2.67**
Avg	3	3	3	3	3	3	0	3	0	2	2	2		3	2.5	2	

3 = Strong Contribution, 2 = Moderate Contribution, 1 = Slight Contribution, --- = No Significant Contribution

Teaching Pedagogy

CO-1 (Unit: 1)	• Constructivism, Social Constructivism, Behaviorism
CO-2 (Unit: 2)	• Constructivism, Social Constructivism, Behaviorism

Assessment Method

Continuous Comprehensive Evaluation 40 Marks	**COs**	**Marks**	**Exam Component**
	CO-1	20	Continuous Evaluation
	CO-2	20	
Term-End Evaluation 60 Marks	**COs**	**Marks**	**Exam Component**
	CO-1	30	Term End Examination
	CO-2	30	

Program – M.Sc. (Microbiology)
Semester- 3

Course Code	Name of Course	Major
256510338021	Microbial Products and Technology	
Credit: 03	**Teaching Scheme: Theory (45)**	**Teaching Hours: 45**

Course Outcomes (COs)

After studying this course, the student will be able to:

CO-1: 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.

Detailed Syllabus

Unit-1. Food Products (12 h)

1.1 Food products from Grains- Bread **(3 h)**

1.2 Food products from Milk- Cheese, Butter **(3 h)**

1.3 Microbial cells as food- Single Cell Protein, Single Cell Oil **(3 h)**

1.4 Food safety and quality requirements- HACCP **(3 h)**

Unit-2. Agricultural Products (12 h)

2.1 Biofertilizers- Production and application of rhizobium, azotobacter and azospirillum inoculants, Phosphate solubilizers, Phosphate mobilizers and absorbers- Mycorrhiza and VAM, composting **(9 h)**

2.2 Biocontrol agents- Bacterial and viral biopesticides. **(3 h)**

Unit-3. Industrial products- Primary and Secondary metabolites (11 h)

3.1 Organic acids- Citric acid **(3 h)**

3.2 Amino acids- L-Lysin **(1 h)**

3.3 Vitamins- B12 **(2 h)**

3.4 Enzymes- Protease **(3 h)**

3.5 Antibiotics- Streptomycin **(2 h)**

Unit-4. Other Industrial Products (10 h)

4.1 Ergot alkaloids **(3 h)**

4.2 Alcoholic beverages- Beer, Wine **(3 h)**

4.3 Polymers- Xanthan, Dextran **(3 h)**

4.4 Solvents- Acetone-butanol **(1 h)**

Mapping Matrix of POs, PSOs, and COs

	POs													PSOs			
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Avg**	**1**	**2**	**3**	**Avg**
CO-1	3	3	3	3	3	3	–	3	–	2	2	2	**2.7**	2	3	3	**2.67**
CO-2	3	3	3	3	3	–	–	–	–	2	2	2	**2.6**	2	3	2	**2.33**
CO-3	3	3	3	3	3	3	–	3	3	2	2	2	**2.7**	3	3	2	**2.67**
CO-4	3	3	3	3	3	3	–	3	3	2	2	2	**2.7**	3	3	2	**2.67**
Avg	3	3	3	3	3	3	-	3	3	2	2	2	2.68	2.50	3.00	2.25	2.59

3 = Strong Contribution, 2 = Moderate Contribution, 1 = Slight Contribution, --- = No Significant Contribution

Teaching Pedagogy	
CO-1 (Unit: 1)	• Constructivism, Social Constructivism, Behaviorism
CO-2 (Unit: 2)	• Constructivism, Social Constructivism, Behaviorism
CO-3 (Unit: 3)	• Constructivism, Social Constructivism, Behaviorism
CO-4 (Unit: 4)	• Constructivism, Social Constructivism, Behaviorism

Assessment Method

			Exam Component		
Continuous Comprehensive Evaluation 40 Marks	**COs**	**Marks**	**Written Test**	**Assignment/Seminar**	**Quiz/Discussion**
	CO-1	10	10	--	--
	CO-2	10	10	--	--
	CO-3	10	0	5	5
	CO-4	10	0	5	5
Term-End Evaluation 60 Marks	**COs**	**Marks**	**Exam Component**		
	CO-1	15	Term End Examination		
	CO-2	15			
	CO-3	15			
	CO-4	15			

References

1. Srilakshmi, B. (2016). *Food Science* (6th ed.). New Age International.
2. Cauvain, S. P. (2012). *Breadmaking: Improving Quality* (2nd ed.). Woodhead Publishing.
3. Glazer, A. N., & Nikaido, H. (2007). *Microbial Biotechnology* (2nd ed.). Cambridge University Press.
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11. Subba Rao, NS (2019) Biofertilizers in Agriculture and Forestry
12. Subba Rao, NS, Venkataraman, GS and Kannaiyan S (1993) Biological Nitrogen Fixation-
13. Kadu, BB *Bacillus thuringiensis* as a Biocontrol agent
14. Vandamme, EJ Biotechnology of Industrial Antibiotics

Program – M.Sc. (Microbiology) Semester- 3		
Course Code 256510238022	**Name of Course** Microbial Products and Technology Practical	**Major**
Credit: 02	**Teaching Scheme: Practical (60)**	**Teaching Hours: 60**

Course Outcomes (COs)

After studying this course, the student will be able to:

CO-1: 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.

Detailed Syllabus

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.

Mapping Matrix of POs, PSOs, and COs

	POs													PSOs			
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Avg**	**1**	**2**	**3**	**Avg**
CO-1	3	3	3	3	3	–	–	3	–	2	2	2	**2.6**	3	3	2	**2.67**
CO-2	3	3	3	3	3	3	–	3	3	2	2	2	**2.7**	3	3	2	**2.67**
Avg	3	3	3	3	3	3	-	3	3	2	2	2		3	3	2	

3 = Strong Contribution, 2 = Moderate Contribution, 1 = Slight Contribution, --- = No Significant Contribution

Teaching Pedagogy

CO-1 (Unit: 1)	• Constructivism, Social Constructivism, Behaviorism
CO-2 (Unit: 2)	• Constructivism, Social Constructivism, Behaviorism

Assessment Method

Continuous Comprehensive Evaluation 40 Marks	**COs**	**Marks**	**Exam Component**
	CO-1	20	Continuous Evaluation
	CO-2	20	
Term-End Evaluation 60 Marks	**COs**	**Marks**	**Exam Component**
	CO-1	30	Term End Examination
	CO-2	30	

Program – M.Sc. (Microbiology) Semester- 3		
Course Code 256510338023	**Name of Course** Biomethanation	**Major**
Credit: 03	**Teaching Scheme: Theory (45)**	**Teaching Hours: 45**

Course Outcomes (COs)

After studying this course, the student will be able to:

CO-1: 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.

Detailed Syllabus

Unit-1. Historical overview (10h)

1.1 Historical overview, Modern Era, 1950, 1960, Microbial Basis, Methyl Cobalamine Era, Serine Era, Resolution of Methanobacillus omilanskii. **(5h)**

1.2 Diversity of Methanogens, Classification of Methanogens, Taxa of methanogens, Methanobacteriales, Methanococcales, Methanomicrobiales, Methaosarcinales, Methanopyrales. **(5h)**

Unit-2. Physiology of Methaogens: Substrate range of Methanogens (15h)

2.1 Physiological Adaptations (Salinity, temperature, pH, Oxygen, Genetic and Metabolic Regulations, Motility and Gas vesicles reserve materials) **(2h)**

2.2 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. **(3h)**

2.3 Methods to study Methanogens in Natural Habitats: Cultural Methods, Microscopic, immunological, Molecular Biology, Activity measurement, Stable isotopes. **(3h)**

2.4 Methanogenic Habitats: Anaerobic Digesters, Fresh water sediments and soils, marine habitats, Animal GIT, Geothermal habitats, Other habitats **(3h)**

2.5 Biotechnological Uses of Mixed Methanogenic Cultures: Novel Substrates and Anaerobic bioreactor Configurations, Thermophilic Anaerobic Digestion, Anaerobic dehalogination. **(3h)**

Unit-3. Biochemistry of Methanogenesis(10h)

3.1 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 **(4h)**

3.2 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. **(3h)**

3.3 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. **(3h)**

Unit-4. Biosynthesis of Co-enzymes (10h)

4.1 Biosynthesis of Methanofuran, **(3h)**

4.2 Biosynthesis of Tertahydromethanopterin, **(3h)**

4.3 Anabolic pathways: Central Anabolic pathways (Acetyl CoA, Pyruvate, Incomplete TCA cycle), Precursor Biosynthesis **(4h)**

Mapping Matrix of POs, PSOs, and COs

COs	POs													PSOs			
	1	2	3	4	5	6	7	8	9	10	11	12	Avg	1	2	3	Avg
CO-1	3	–	–	–	–	–	3	–	–	2	–	–	**2.6**	2	2	3	**2.33**
CO-2	3	3	3	3	3	–	–	–	–	–	–	–	**3**	3	3	2	**2.67**
CO-3	3	3	3	3	3	3	–	2	–	2	–	–	**2.7**	3	2	2	**2.33**
CO-4	3	3	3	3	3	3	–	2	–	2	2	–	**2.6**	3	2	2	**2.33**
Avg	3	3	3	3	3	2	3	2	-	2	2	-	2.73	2.75	2.25	2.25	2.42

3 = Strong Contribution, 2 = Moderate Contribution, 1 = Slight Contribution, --- = No Significant Contribution

Teaching Pedagogy

CO-1 (Unit: 1)	• Constructivism, Social Constructivism, Behaviorism
CO-2 (Unit: 2)	• Constructivism, Social Constructivism, Behaviorism
CO-3 (Unit: 3)	• Constructivism, Social Constructivism, Behaviorism
CO-4 (Unit: 4)	• Constructivism, Social Constructivism, Behaviorism

Assessment Method

			Exam Component		
Continuous Comprehensive Evaluation 40 Marks	**COs**	**Marks**	**Written Test**	**Assignment/Seminar**	**Quiz/Discussion**
	CO-1	10	10	--	--
	CO-2	10	10	--	--
	CO-3	10	0	5	5
	CO-4	10	0	5	5
Term-End Evaluation 60 Marks	**COs**	**Marks**	**Exam Component**		
	CO-1	15	Term End Examination		
	CO-2	15			
	CO-3	15			
	CO-4	15			

References

1. Ferry, J. G. (n.d.). *Methanogenesis: Ecology, Physiology, Biochemistry & Genetics*. [Publisher].
2. Alexander, M. (n.d.). *Biodegradation and Bioremediation*. [Publisher].
3. Murray, Moo-young (n.d.) Comprehensive Biotechnology: The Principles, Applications and Regulations of Biotechnology in Industry, Agriculture and Medicine, Vol. 1 to 4, Pergamon Press, Oxford

Program – M.Sc. (Microbiology) Semester- 3		
Course Code 256510238024	**Name of Course** Biomethanation Practical	**Major**
Credit: 02	**Teaching Scheme: Practical (60)**	**Teaching Hours: 60**

Course Outcomes (COs)

After studying this course, the student will be able to:

CO-1: 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

Detailed Syllabus

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

Mapping Matrix of POs, PSOs, and COs

COs	POs													PSOs			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Avg**	**1**	**2**	**3**	**Avg**
CO-1	3	–	–	–	3	–	3	–	–	2	–	2	**2.6**	3	2	2	**2.33**
CO-2	3	3	3	3	3	3	–	3	–	2	2	2	**2.7**	3	3	2	**2.67**
Avg	3	3	3	3	3	3	3	3	--	2	2	2		3	2.5	2	

3 = Strong Contribution, 2 = Moderate Contribution, 1 = Slight Contribution, --- = No Significant Contribution

Teaching Pedagogy

CO-1 (Unit: 1)	• Constructivism, Social Constructivism, Behaviorism
CO-2 (Unit: 2)	• Constructivism, Social Constructivism, Behaviorism

Assessment Method

Continuous Comprehensive Evaluation 40 Marks	**COs**	**Marks**	**Exam Component**
	CO-1	20	Continuous Evaluation
	CO-2	20	
Term-End Evaluation 60 Marks	**COs**	**Marks**	**Exam Component**
	CO-1	30	Term End Examination
	CO-2	30	

Program – M.Sc. (Microbiology) Semester- 4		
Course Code 256510238025	**Name of Course** Dissertation	**Major**
Credit: 20	**Teaching Scheme: Practical (600)**	**Teaching Hours: 600**

Course Outcomes (COs)

After studying this course, the student will be able to:

CO-1: Develop and demonstrate the ability to independently plan, execute, and document a research project using microbiological and interdisciplinary approaches

CO-2: Apply experimental design, data analysis, and interpretation in real-time laboratory/field settings

CO-3: To communicate scientific findings effectively through written reports, presentations, and discussions.

CO-4: To cultivate scientific integrity, project management skills, and research ethics

Mapping Matrix of POs, PSOs, and COs

COs	POs													PSOs			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Avg**	**1**	**2**	**3**	**Avg**
CO-1	3	3	3	3	3	3	3	3	3	2	2	2	**2.75**	3	2	3	**2.67**
CO-2	3	3	3	3	3	3	3	3	3	2	2	2	**2.75**	3	2	2	**2.33**
CO-3	3	3	3	3	3	3	3	3	3	2	2	2	**2.75**	2	2	3	**2.33**
CO-4	3	3	3	3	3	3	3	3	3	2	2	2	**2.75**	2	2	3	**2.33**
Avg	3	3	3	3	3	3	3	3	3	2	2	2	2.75	2.50	2.00	2.75	2.42

3 = Strong Contribution, 2 = Moderate Contribution, 1 = Slight Contribution, --- = No Significant Contribution

Teaching Pedagogy

CO-1 (Unit: 1)	• Constructivism, Social Constructivism, Behaviorism
CO-2 (Unit: 2)	• Constructivism, Social Constructivism, Behaviorism

Assessment Method

Continuous Comprehensive Evaluation 40 Marks			Exam Component
	COs	Marks	Term End Evaluation
	CO-1	10	
	CO-2	10	
	CO-3	10	
	CO-4	10	
Term-End Evaluation 60 Marks	COs	Marks	Exam Component
	CO-1	15	Term End Examination
	CO-2	15	
	CO-3	15	
	CO-4	15	

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