தமிழ்நாடு மத்தியப் பல்கலைக்கழகம்

CENTRAL UNIVERSITY OF TAMIL NADU

तमिलनाडु केन्द्रीय विश्वविद्यालय

ESTABLISHED BY AN ACT OF PARLIAMENT IN 2009

Department of Microbiology

(DST-FIST Sponsored)

School of Life Sciences

Central University of Tamil Nadu

(Accredited by NAAC with A+ Grade)

(DST-PURSE Supported)

(NIRF-2024 Rankings: 99th in the University Category)

Thiruvarur, Tamil Nadu - 610005

B.Sc. Honours & B.Sc. Honours with Research

Curriculum & Syllabus (NEP 2020)

2026-27 Onwards

A. Vision

Vision Statement of the Department

To develop enlightened citizenship of a knowledge society for peace and prosperity of individuals, nation, and the world, through promotion of innovation, creative endeavors, and scholarly inquiry, and to be a global destination of higher education and research.

B. Mission

Mission Statements of the Department

M1	To serve as a beacon of change, through multi-disciplinary learning, for the creation of a knowledge community, by building a strong character and nurturing a value-based, transparent work ethic, promoting creative and critical thinking for holistic development and self-sustenance for the people of India.
M2	The University seeks to achieve this objective by cultivating an environment of excellence in teaching, research, and innovation in pure and applied areas of learning
M3	To enhance awareness of current research across various fields of microbiology and to bring student's knowledge to the latest state-of-the-art in their area of interest.

C. Program Educational Objective (PEO)

After five years of successful completion of the program, the student will be able to

PEO1	Understand the basic concepts of all the dimensions in Microbiology
PEO2	Get an advanced outlook on the recent findings in all fields of Microbiology
PEO3	Develop critical and experimental thinking
PEO4	Become an insightful individual with an in depth understanding of various research directions and methods
PEO5	Demonstrate precision in practical and experimental procedures

D. Graduate Attributes for B.Sc. Honours Microbiology Program

1. Disciplinary Knowledge: Content and pedagogical knowledge synchronised with the curriculum frameworks and policies
2. Communication Skills: Possess clarity in conveying the ideas
3. Critical Thinking: Capacity to apply analytical thought in the teaching and learning process
4. Problem Solving: Participate in the educational problem solving and applying the knowledge in the day-to-day professional endeavours.
5. Cooperation: Appreciate collaboration and cooperation among stakeholders of education.
6. ICT Skills: Selecting and integrating appropriate ICT skills for professional development.
7. Ethics: Doing what is right to society
8. Self-Directed Learning: Developing autonomy and self-regulation in teaching-learning and professional development.
9. Reasoning: Ability to interpret and draw the conclusion from qualitative/quantitative data with open-mindedness

10. Creativity: Ability to produce new idea. 11. Societal and Environmental Concern: Performing an act or solving a problem with respect to societal and environmental concern Lifelong Learning: Understands the need for learning and practices it throughout life

E. PEO to Mission Statement Mapping

	PEO1	PEO2	PEO3	PEO4	PEO5
M1	3	3	3	3	3
M2	3	3	3	3	3
M3	3	3	3	3	2

(If the correlation between mission statement and program specific outcome is high 3 is assigned, for moderate 2, for low 1, and for 0 are assigned)

F. Program Outcomes (PO)

On the successful completion of the program, the student will be able to

(Program outcomes are common for all courses in a particular program)

PO1	Understand basic and advanced microbiological concepts
PO2	In depth knowledge into other fields of biological sciences
PO3	Imbibe critical scientific thinking
PO4	Design and develop experimental protocols
PO5	Demonstrate efficacy in skilled experiments
PO6	Preparedness to engage in both academic and industrial sectors

G. PO to PEO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
PEO1	3	3	3	3	3	3
PEO2	3	3	3	2	2	3
PEO3	3	3	3	3	3	3
PEO4	3	3	3	2	2	3
PEO5	3	2	3	3	3	2

(If the correlation between mission statement and program specific outcome is high 3 is assigned, for moderate 2, for low 1, and for 0 are assigned)

FIRST YEAR

SEMESTER – I

No	Course Code	Course Title	Type	Credit	Hours / Week		Marks	
					L	T	Int	Ext
1	MIB5011	Introduction to Microbiology*	CC	3	3		40	60
2	MIB5012	Introduction to Microbiology Practical *	CCP	2	4		100	
3	EPH5011	Basic of Statistics in Public Health **	Minor	3	3		40	60
4	EPH5012	Basic of Statistics in Public Health Practical**	Minor	2	4		100	
5	MIBOE01	Open Elective (Microbes in Human Health)	OE	3	3		40	60
6		English	AECC	3	3		40	60
7		Cyber Security	SEC	2	2		40	60
8	ENSVAC	Environmental Science #	VAC	3	3		40	60
			Total	**21**	**25**			

SEMESTER – II

No	Course Code	Course Title	Type	Credit	Hours / Week		Marks	
					L	T	Int	Ext
1	MIB5021	Biology-I*	CC	3	3		40	60
2	MIB5022	Biology practical *	CCP	2	4		100	
3		General Chemistry$	Minor	3	3		40	60
4		General Chemistry Practical$	Minor	2	4		100	
5	MIBOE02	Open Elective (Applied Microbiology)	OE	3	3		40	60
6		Tamil / Hindi/French	AECC	3	3		40	60
7		Disaster Risk Reduction	SEC	2	2		40	60
8		Constitutional Values	VAC	3	3		40	60
9		Extension Activity	EXT	1*	--		--	--
			Total	**21**	**25**			
			Cumulative Total	**42**				
For students exiting after one year (Certificate in Science) * Enrollment in 1st year								
10		Soft skills	VOC	4	4		100	
			Total	**46**				

*Credit not included

Courses with * are minor courses for Department of EPH offered by Department of Microbiology

Courses with ** are minor courses for Department of Microbiology offered by Department of EPH

Courses with $ are minor courses offered by Department of Chemistry

Vocational course by offered by Department of EPH for both Microbiology and EPH department

SECOND YEAR

SEMESTER – III

No	Course Code	Course Title	Type	Credit	Hours / Week		Marks	
					L	T	Int	Ext
1	MIB5031	Biochemistry*	CC	3	3		40	60
2	MIB5032	Biochemistry Practical*	CCP	2	4		100	
3		Biology II **	Minor	3	3		40	60
4		General Organic Chemistry$	Minor	3	3		40	60
5	MIBOE01	Open Elective (Microbes In Human Health)	OE	3	3		40	60
6		Tamil / Hindi/French	AECC	3	3		40	60
7	HORSE01	Mushroom Cultivation^	SEC	2	2		40	60
8		Yoga	VAC	2	2		40	60
			Total	**21**	**23**			
			Cumulative Total	**63**				

SEMESTER – IV

No	Course Code	Course Title	Type	Credit	Hours /Week		Marks	
					L	T	Int	Ext
1	MIB5041	Microbial Physiology and Metabolism	CC	4	4		40	60
3	MIB5042	Medical Biotechnology	CC	4	4		40	60
4	MIB5043	Bio-instrumentation Practical	CCP	2	4		100	
5	MIB5044	Bacteriology and Mycology	CC	4	3		40	60
6	MIB5045	Bacteriology and Mycology Practical	CCP	2	4		100	
7		English	AECC	3	3		40	60
8	EPHSE01	Fundamentals in R programming~	SEC	3	3		40	60
			Total	**22**	**25**			
			Cumulative Total	85				
For students exiting after two years (Diploma in Science)								
Vocational Course		Lab training	VOC		4		4	
			Total	89				

L: Lecture; T: Tutorial

Courses with * is offered by Department of Microbiology for both Microbiology and EPH

Course with ** is a minor course offered by Department of EPH for Microbiology and EPH

Courses with $ is a minor course by Department of Chemistry for Department of Microbiology

^ is a SEC offered by Department of Horticulture for Department of Microbiology

~ is a SEC offered by Department of EPH for both the Microbiology and EPH departments.

THIRD YEAR

SEMESTER – V

No	Course Code	Course Title	Type	Credit	Hours / Week		Marks	
					L	T	Int	Ext
1	EPH5051	Biomedical applications for Bioinformatics $^{\Phi}$	CC	4	4		40	60
2	EPH5052	Biomedical applications for Bioinformatics Practical $^{\Phi}$	CCP	2	4		100	
3	MIB5053	Marine and Environmental Microbiology	CC	4	4		40	60
4	MIB5054	Immunobiology	CC	4	4		40	60
5	MIB5055	Molecular Cell Biology	CC	4	2		40	60
6	MIB5056	Molecular Cell Biology Practical	CCP	2	4			
7	MIBON01	MOOCs	DSE	3	3		40	60
			Total	**23**	**25**			
			Cumulative Total	**108**				

SEMESTER – VI

No	Course Code	Course Title	Type	Credit	Hours / Week		Marks	
					L	T	Int	Ext
1	MIB5061	Bioanalytical techniques	CC	4	4		40	60
2	MIB5062	Medical Microbiology	CC	4	4		40	60
3	MIB5063	Medical Microbiology Practical	CCP	2	4		100	
4	MIB5064	Microbial Genetics	CC	3	3		40	60
5	MIB5065	Microbial Genetics Practical	CCP	2	4		100	
6	MIBEC01	Advanced cell systems	DSE	3	3		40	60
7	MIBEC02	Virology	DSE	3	3		40	60
8	MIB5066	Internship	INT	2				
			Total	**23**	**27**			
			Cumulative Total	**131**				

L: Lecture; T: Tutorial

Courses with $^{\Phi}$ are core courses offered by the Dept. of EPH for both Microbiology & EPH

Students can exit after three years with a B.Sc. Microbiology Degree (with 131 credits)

Students willing to continue for the fourth year will receive either a B.Sc. Honours/ Honours with Research Degree based on their total CGPA as follows:

For B.Sc. Honours with Research degree, the student shall score more than 7.5 CGPA

FOURTH YEAR

SEMESTER-VII

No	Course Code	Course Title	Type	Credit	Hours / Week		Marks	
					L	T	Int	Ext
1	MIB5071	Recombinant DNA Technology	CC	4	3	1	40	60
2	MIB5072	Recombinant DNA Technology Practical	CCP	2	4		100	
3	MIB5073	Agromicrobiology	CC	4	4		40	60
4	MIB5074	Microbiology in Food & Industry	CC	4	4		40	60
5	MIB5075	Microbiology in Food & Industry Practical	CCP	2	4		100	
6	MIBEC03	*Antimicrobial Resistance and One health	DSE	3	3		40	60
7	MIBEC04	*Algal Bioresources and Biotechnology	DSE					
*Choose one of the two elective courses								
8	MIBON02	MOOC-2	DSE	3	3		40	60
			Total	**22**	**25**	**1**		
			Cumulative Total	**153**				

SEMESTER – VIII

No	Course Code	Course Title	Type	Credit	Hours / Week		Marks	
					L	T	Int	Ext
For B.Sc. Honours Degree								
1	MIB5081	Research Project	PROJH	8	16		40	60
2	MIB5083	Research Methodology and Publication Ethics	CC	4	4		40	60
3	MIB5084	Multiomics	CC	4	3	1	40	60
4	MIB5085	Bioethics, Biosafety and Intellectual Property Rights	CC	4	3	1	40	60
			Total	**20**	**26**	**2**		
			OVERALL	**173**				
For B.Sc. Honours with a Research Degree								
1	MIB5082	Dissertation	PROJR	12	24		40	60
2	MIB5083	Research Methodology and Publication Ethics	CC	4	4		40	60
3	MIB5084	Multiomics	CC	4	3	1	40	60
			Total	**20**	**31**	**1**		
			OVERALL	**173**				

COURSE-WISE CREDIT DISTRIBUTION

1. Four-Year B.Sc. Honours with Research in Microbiology

SEM	CC	DSE	Minor	OE	AECC	SEC	VAC	EXT	INT	PROJ	TOTAL
I	5	-	5	3	3	2	3	-	-	-	**21**
II	5	-	5	3	3	2	3	1*	-	-	**21**
III	5	-	6	3	3	2	2	-	-	-	**21**
IV	16	-	-	-	3	3	-	-	-	-	**22**
V	20	3	-	-	-	-	-	-	-	-	**23**
VI	15	6	-	-	-		-	-	2	-	**23**
VII	16	6	-	-	-		-	-	-	-	**22**
VIII	8	-	-	-	-		-	-	-	12	**20**
TOTAL	**90**	**15**	**16**	**9**	**12**	**9**	**8**	**1***	**2**	**12**	**173**

2. Four-Year B.Sc. Honours in Microbiology

SEM	CC	DSE	Minor	OE	AECC	SEC	VAC	EXT	INT	PROJ	TOTAL
I	5	-	5	3	3	2	3	-	-	-	**21**
II	5	-	5	3	3	2	3	1*	-	-	**21**
III	5	-	6	3	3	2	2	-	-	-	**21**
IV	16	-	-	-	3	3	-	-	-	-	**22**
V	20	3	-	-	-	-	-	-	-	-	**23**
VI	15	6	-	-	-		-	-	2	-	**23**
VII	16	6	-	-	-		-	-	-	-	**22**
VIII	12	-	-	-	-	-	-	-	-	8	**18**
TOTAL	**94**	**15**	**16**	**9**	**12**	**9**	**8**	**1***	**2**	**8**	**173**

3. Three-Year B.Sc. Microbiology

SEM	CC	DSE	Minor	OE	AECC	SEC	VAC	EXT	INT	TOTAL
I	5	-	5	3	3	2	3	-	-	**21**
II	5	-	5	3	3	2	3	1*	-	**21**
III	5	-	6	3	3	2	2	-	-	**21**
IV	16	-	-	-	3	3	-	-	-	**22**
V	20	3	-	-	-	-	-	-	-	**23**
VI	15	6	-	-	-		-	-	2	**23**
TOTAL	**61**	**9**	**16**	**9**	**12**	**9**	**8**	**1***	**2**	**131**

4. Two-Year Diploma in Microbiology

SEM	CC	Minor	OE	AECC	SEC	VAC	EXT	VOC	TOTAL
I	5	5	3	3	2	3	-	-	**21**
II	5	5	3	3	2	3	1*	-	**21**
III	5	6	3	3	2	2	-	-	**21**
IV	16	-	-	3	3	-	-	4	**26**
TOTAL	**31**	**16**	**9**	**12**	**9**	**8**	**1***	**4**	**89**

5. One-Year Certificate in Microbiology

SEM	CC	Minor	OE	AECC	SEC	VAC	EXT	VOC	TOTAL
I	5	5	3	3	2	3	-	-	**21**
II	5	5	3	3	2	3	1*	4	**21**
TOTAL	**10**	**10**	**6**	**6**	**4**	**6**	**1***	**4**	**46**

*Credit not included

Syllabus for BSc. Honors/Research in Microbiology

SEMESTER-I					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIB5011	**Introduction to Microbiology**	**3**	**-**	**-**	**3**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO1	To know the scope, history and contributions of important microbiologists	Understand
CO2	To study the microbial taxonomy and manual of systemic bacteriology	Apply
CO3	To understand the principles of microscopic and staining techniques	Understand
CO4	To study the structure and classification of prokaryotes and eukaryotes	Analyze
CO5	To study the basic microbiology techniques and principles of sterilization, Isolation, preservation and preparation of growth medium.	Apply

b. Syllabus

Units	Content	Hrs.
I	**History and Scope of Microbiology** Scope of microbiology; ancient microbiology - Refutation of a biogenesis: Discovery of penicillin: Discovery of vaccination; One-gene one-enzyme hypothesis; Contribution of scientists – Leeuwenhoeck, Edward Jenner, Alexander Fleming, Joseph Lister, Robert Koch, Louis Pasteur, Hargobind Khorrana; Modern Microbiology; Landmark achievements in 20th century.	9
II	**Microbial Diversity** Definition and systematics; Nomenclatural rules and identification; Evolutionary relationship among the living organisms; Haeckel's three kingdom classification; Whittaker's five kingdom approach; Woese domain system; General characteristics of various group of microorganisms viz., Bacteria, Archaea, fungi, yeast, algae, virus and protozoa.	9
III	**Microbial Taxonomy** Major characteristics used in taxonomy: Morphological, physiological and metabolic, genetic and molecular taxonomy; Second edition of Bergey's manual of systematic bacteriology – characteristic features of each volume with important phyla of each.	9

IV	**Microscopy** General principles of light microscopy - magnification, resolving power and numerical aperture; Principle and application of light, dark-field, phase contrast, differential interference contrast (DIC), fluorescence, scanning and transmission electron microscopy; scanning tunnelling microscopy; atomic force microscopy; confocal microscopy; bacterial staining.	9
V	**Basic Microbiological Techniques** Different types of growth media (natural synthetic, complex, enriched, selective etc). Sterilization and disinfection techniques; principles and methods of sterilization - physical methods – heat, filters and radiation; chemical methods. Isolation and Preservation of microbial cultures.	9
	Tasks and Assignments: Each student is required to submit the following: ✓ A write-up on the underlying principle for various microscopes ✓ Seminar on Microscopy ✓ A mini project on learning basic microbiological techniques ✓ Internal exams **References** 1. Brock Biology of Microorganisms, 15th edition by Madigan, Bender, Buckley, Sattley and Stahl, Published by Pearson (2020) 2. Prescott's Microbiology, 11th edition by Willey, Sandman and Wood, Published by McGraw Hill (2019) 3. Extremophiles:MicrobialLifeinExtreme EnvironmentsbyHorikoshi and Grant, Published by Wiley (1998) 4. Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2014). Brock Biology of Microorganisms. 14th edition. Pearson International Edition.	

c. Mapping of Program Outcomes with Course Outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	3	3	2
CO2	3	3	3	3	3
CO3	3	2	2	3	3
CO4	3	3	3	3	3
CO5	2	2	2	2	2

d. Evaluation Scheme

	CO1	**CO2**	**CO3**	**CO4**	**CO5**	**Total**
Internal	8	8	8	8	8	40

External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	**CO2**	**CO3**	**CO4**	**CO5**
Assignments	2	2	-	-	2
Seminar	1	1	2	2	-
Test	4	4	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Part–A (Objective-10x1=10marks)	2	2	2	2	2
Part–B (Short Answer- 5x3=15marks)	3	3	3	3	3
Part–C (Essay-5x7=35marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No.	**Criteria**	**100%**	**75%**	**50%**	**25%**	**0%**	**Relation to COs**
1	**Content 50%**	Ideas are detailed, well developed, supported with specific evidenc e& facts and examples	Ideas are detailed, Developedand supportedwith evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported.	Content is not sound	Not attended	CO1, CO2, CO4

2	**Organiza-tion** **50%**	Includes title, introduction, statement of them a in idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO4

h. Rubric for Seminar

Sl. No.	**Criteria**	**100%**	**75%**	**50%**	**25%**	**0%**	**Relation to Cos**
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO5
2	**Presentation 50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO5

i. Model Question Paper

Sl. No.	**Model Questions**	**Specification**	**Level**
	Part–A: Objective Type **Multiple choice 10x 1 =10**		
1	*Pseudomonas aeruginosa* is a common pathogen that infects the airways of patients with cystic fibrosis. It does not grow in the absence of oxygen. The bacterium is probably which of the following? A. An aerotolerant anaerobe B. An obligate aerobe C. An obligate anaerobe D. A facultative anaerobe	Recognize	Remember

2	The Reactive Oxygen Species (ROS) produced by some bacteria are degraded by which of the following enzymes? A. Peroxidase B. Lyase C. Catalase D. Superoxide dismutase, Catalase and Peroxidase	Recall	Remember
3	In Robertson's cooked medium, the blackening of meat occurs because of the A. Iron Fillings B. Protein decomposition C. Carbohydrate decomposition D. Haematin in meat	Recognize	Remember
4	Which of the following culturing methods is usually used for checking the motility of microbes? A. Stab culture B. Streak culture C. Single cell culture D. Spread culture	Recognize	Remember
5	Which of the following statements is false. A. Obligate anaerobes have only partially functional Super Oxide Dismutase B. Microaerophiles produce lethal amounts of toxic forms of Oxygen when exposed to normal atmospheric oxygen C. Facultative anaerobes show best growth where more oxygen is present D.Oxygen has no effect on the growth of aerotolerant anaerobes	Recognize	Remember
6	Which of the following microscopy techniques relies on the specimen interfering with the wavelength of light to produce a high contrast image without the need for dyes or any damage to the sample? A. Conventional bright field light microscopy B. Phase contrast microscopy C. Electron microscopy D. Fluorescence microscopy	Recognize	Remember
7	When the power of ocular lensis 10X and objective lens is 20x the magnification is: A. 30 times B. 20 times C. 200 times D. 2000 times	Recall	Remember
8	Who developed acid-fast staining? A. Robert Koch B. Edward Jenner **C.** Paul Ehrlich **D.** John Tyndall	Recall	Remember

9	Who awarded Nobel prize for genetic code in the field of physiology and medicine? A. Sergei N. Winograsky B. Alexander Fleming C. Hargobind Khorrana **D.** Edward Jenner	Identify	Remember
10	Which is the highest rank in the taxonomy? A. Phylum B. Order C. Genus D. Domain	Identify	Remember
	PART–B Short Answer **The answer should not exceed 200words (Marks: 5x3=15)**		
11	Describe the refutation of biogenesis?	Cite Examples	Explain
12	Elaborate the Louis Pasteur contribution?	Explain	Describe
13	Draw the major classification of extremophiles?	Cite Examples	Understand
14	What are Kosh's Postulates?	Illustrate	Describe
15	What are Stromatolites?	Explain	Understand
	PART–C Essay Answer **The answer should not exceed 400words 5x7=35**		
16	a) How are extremophiles classified based on their temperature requirements? or b) Explain in detail the adaptation mechanism for Psychrophiles and thermophiles?	Explain	Understand
17	a) What is Radio resistor? Why they are important to study? or b) Illustrate with two examples of Radio resistor microorganisms And describe in detail their adaptation strategies.	Explain Discuss	Understand
18	a) Explain the various Moist Heat sterilization methods or b) Compare the various filtration sterilization methods	Cite Examples	Understand
19	a) Explain in brief Louis Pasteur major contributions in the field of microbiology. or b) Describe in brief refutation of biogenesis.	Illustrate	Apply

20	a) What are the major characteristics used in taxonomy? Or b) List out and describe different kinds of media used for culturing the microbes in the laboratory.	Describe	Analyze

SEMESTER-I					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIB5012	**Introduction to Microbiology**	**-**	**-**	2	**2**

j. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO1	Demonstration on handling microscopes	Analyze
CO2	Evaluate growth and measurement of microorganisms	Apply
CO3	To analyze the microorganisms under microscope	Analyze
CO4	To learn purification and preservation of microorganisms	Skill
CO5	Demonstration on isolation and characterization of microorganisms	analyze

k. Syllabus

Units	**Content**	**Hrs.**
I	1. Microbiology Good Laboratory Practices and Biosafety 2. Microscope - parts, uses and handling 3. Principles and operations of Laboratory equipments – autoclave, hot air oven, incubator, laminar air flow, filtration, colony counter, centrifuge, pH meter, colorimeter, Spectrophotometer 4. Micrometry – measurement of microorganisms 5. Preparation of growth media – for bacteria, fungi, actinomycetes and algae	15
II	6. Isolation of microorganisms – serial dilution and plating techniques 7. Purification and preservation of microorganisms 8. Turbidometric assessment of growth of microorganisms viz., bacteria, microalgae 9. Staining techniques – simple and differential staining 10. Morphological and biochemical characterization of bacteria for identification	15

	Tasks and Assignments: Each student is required to submit the following: 5. To carry out the experiments mentioned above 6. Hand on staining techniques 7. Isolation and characterization of microorganisms 8. Internal exams 9. Maintaining record notebooks 10. Group discussion **References** 1. James Cappuccino and Chad Welsh, Microbiology: A Laboratory Manual, Pearson Publisher, 2019. 2. Ted R. Johnson and Christine L. Case, Laboratory experiments in Microbiology, 3rd Ed., The Benjamin/Cummings PublishingCompany Inc., 1992. 3. Mette Ibba, Katherine Elasky, Basic and Practical Microbiology lab Manual, Cognella, Incorporated Publisher, 2018. 4. Harold J. Benson, Microbiology Applications: Laboratory Manual in General Microbiology, McGraw-Hill Publisher, 2002.	

Semester I & III					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIBOE01	**Microbes in Health and Well- being**	3	-	-	3

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO 1	To acquire knowledge and gain understanding of basic concepts in microbiology and understand the origins of microbiology.	Remember
CO 2	To understand the significance of microbes in environment and to understand the role of microbes in human well being	Understand
CO 3	To gain an overview of plethora of diseases caused by pathogenic microbes in humans	Apply
CO 4	To understand the epidemiological aspects of microbial diseases in humans	Analyze
CO 5	To gain knowledge in applications of microbes as nutraceuticals	Skill

b. Syllabus

Units	**Content**	**Hrs.**
I	**Origins of Microbiology:** Historical development of Microbiology – Theory of spontaneous generation, Biogenesis and Abiogenesis, Contribution of Indian scientists in the field of Microbiology, Fossil evidences of microorganisms, Origin of life, primitive cells and evolution of microorganisms, Overview of Prokaryotic and Eukaryotic cells.	7

II	**Microbes in Environment and Human microbiome:** Terrestrial environment (microflora), aquatic environment (microflora of fresh and marine habitats), atmosphere (aeromicroflora and dispersal of microbes), Extreme Habitats: extremophiles, Microbes in space, Microbes and climate change, Microbes in bioremediation, Microbiota of skin, throat, gastrointestinal tract, urogenital tract. Significance of microbiome. Normal and abnormal microflora of the human body: importance of normal microflora, normal microflora of skin, throat, gastrointestinal tract, urogenital tract, Probiotics, Prebiotics.	7
III	**Human diseases caused by Microbial Pathogens:** Malaria, Kala-azar – causes, symptoms, diagnosis and treatments, Brief description of the following types of mycoses and one representative disease in detail: Cutaneous mycoses-Tinea pedis (Athlete's foot), Systemic mycoses-Histoplasmosis, Opportunistic mycoses – Candidiasis, Polio, Herpes, Hepatitis, Rabies, Dengue, AIDS, Influenza (swine flu and bird flu), Ebola, Chikungunya, Japanese Encephalitis, Rota virus, Zika virus - causes, symptoms, diagnosis and treatments, Diseases caused by Streptococcus pyogenes, Haemophilus influenzae, Mycobacterium tuberculosis, Escherichia coli, Salmonella typhi, Vibrio cholerae, Helicobacter pylori.	7
IV	**Control and Epidemiology of Microbial diseases in Humans:** Public health hygiene and communicable diseases. Survey and surveillance of microbial infections, Air borne microbial diseases, water borne microbial diseases, Food borne microbial infections, Epidemiology of microbial infections, their detection and control, Antimicrobial resistance genes and their epidemiology, Combating infectious diseases	7
V	**Microbial neutraceuticals:** Potential of microbes as a source of nutraceuticals/dietary supplements/functional foods/food supplements and its health benefits in relation to various health problems, microorganisms in the treatment and prevention of anaemia, obesity, diarrhoea, irritable bowel syndrome, inflammatory bowel disorders and colitis, atopic dermatitis, cancer, gluten therapy-resistant coeliac syndrome, Crohn's disease, diabetes, and allergies	7
	Tasks and Assignments: • Internal exams • A quiz on Prebiotics and probiotics • An assignment on Antimicrobial Resistance genes • Discussion on Human Microbiome **References:** • Lund, B.M., Baird- Parker, A.C and Gould, G.W. (editors). (2000). The Microbiological Safety and Quality of Foods. Vol. 1-2. Springer, USA. 9. • Tortora, G.J., Funke, B.R., and Case, C.L. (2016). Microbiology: An Introduction. 12th edition. Pearson Education, USA. • Atlas, R.M. and Bartha, R. (2000). Microbial Ecology: Fundamentals and Applications. 4th edition. Benjamin Cummings, USA	

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**3**	**2**	**3**	**3**
CO2	**2**	**1**	**3**	**2**	**3**
CO3	**2**	**2**	**2**	**1**	**2**

CO4	**3**	**1**	**3**	**2**	**2**
CO5	**3**	**3**	**2**	**3**	**3**

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	2	2	-	-	2
Seminar	-	-	2	2	-
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Essay- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content 50%**	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organiza -tion 50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Knowledge and Understanding 50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4
2	**Presentation 50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

i. Model Question Paper

Sl. No.	Model Questions	Specification	Level
	Part – A: Objective Type **Multiple Choice Marks: 10 x 1 = 10**		
1	Small Pox vaccination was developed by a. Alexander Flemming b. Edward Jenner c. Loius Pasteur d. Robert Koch	Recall	Remember
2	_____boiled the beef broth for an hour and sealed in a flask. No microbes observed during incubation. A. Lazzaro Spallanzani; B. Louis Pasteur; C. Anton von Leeuwenhock; D. Robert koch	Recall	Remember
3	_____ gave the concept of Germ theory of disease, which means germs are responsible for the disease not the not the inert matter. A. Lazzaro Spallanzani; B. Louis Pasteur; C. Anton von Leeuwenhock; D. Robert koch	Recognize	Remember
4	_____ developed vaccine against rabbis from the brains and spinal cord of rabbit. A. Lazzaro Spallanzani; B. Louis Pasteur; C. Anton von Leeuwenhock; D. Robert koch	Recognize	Remember
5	The lowest temperature that kills all microorganisms in a liquid suspension in 10 minutes is known as the _____A. thermal death point; B. D value; C. F value; D. Z value	Recognize	Remember
6	The time required to kill 90% of the microorganisms in a sample at a specific temperature is the _____A. thermal death point; B. D value; C. F value; D. Z value	Recognize	Remember
7	The time in minutes at a specific temperature needed to kill a population of cells is the _____A. thermal death point; B. D value; C. F value; D. Z value	Recall	Remember
8	_____ is used to prevent infection by killing or inhabiting pathogen growth on animal tissue. A. Antiseptic; B. Germicide; C. Bacteriostatic; D. fungicidal	Recall	Remember
9	Microorganisms belonging to the same _____ would be expected to have the most characteristics in common with each other. A. genus; B. species; C. family; D. order	Identify	Remember
	_____ is the arrangement of organisms into groups or		

10	taxa. A. phylogeny; B. systematic; C. taxonomy; D. classification	Identify	Remember
	PART – B Short Answer **The answer should not exceed 200 words Marks :5 x 3 =15**		
11	Write a short notes on Eukaryotic cells	Explain and cite	Remember
12	Write about importance of microbes in bioremediation	Explain	Understand
13	Write about Kala Azar and its symptoms	Describe	Analyze
14	Explain the differences between Air and water borne microbial diseases	Differentiate	Analyze
15	Describe about Irritable Bowel Syndrome	Describe	Remember
	PART – C Essay Answer **The answer should not exceed 400 words Marks: 5 x 7= 35**		
16	a) Write the scope for microbiology and Explain the refutation of a biogenesis. (or) b) Write the contribution of scientists – Edward Jenner, Francesco redi, Joseph Lister and Paul ehrlich.	Explain and cite	Remember
17	a) Explain in detail about the human gut microbiome. (or) b) Write about extremophiles and their adaptations	Explain	Understand
18	a) Write about diseases caused by Streptococcus pyogenes, Haemophilus influenzae, Mycobacterium tuberculosis (or) b) Write about opportunistic mycoses – Candidiasis, Polio, Herpes	Describe	Analyze
19	a) Write an essay on Combating infectious diseases (or) b) Write about Public health hygiene and communicable diseases	Differentiate	Analyze
20	a) Write about potential of microbes as a source of nutraceuticals (or) b) Write about the role of microorganisms in the treatment and prevention of anemia and obesity.	Describe	Remember

SEMESTER - II					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIB5021	Biology-I	3	-	-	3

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO 1	Analyze the origins of life and the mechanisms of biological evolution, including Hardy-Weinberg equilibrium and macroevolution.	Remember
CO 2	Examine the thallus organization, cell structure, and diverse life cycles of major algal groups.	Understand
CO 3	Evaluate the classification, nutrition, and reproductive strategies of fungi.	Apply
CO 4	Analyze the land adaptations and reproductive mechanisms of Bryophytes, Pteridophytes, and Gymnosperms	Analyze
CO 5	Apply the principles of ICN and molecular systematics to identify plant families and utilize modern taxonomic tools like E-floras.	Skill

b. Syllabus

Units	**Content**	**Hrs.**
I	**Origin of Life and Evolution:** Early earth and the origin of life; Theories of origin of life; Major events in the history of life; Mechanism of macroevolution; Phylogeny and the tree of life; Evidences for evolution, Biological evolution, Mechanism of evolution, Hardy-Weinberg principle, Classification of the living organisms -five kingdom classification concepts	12
II	**Introduction to Algae** General characteristics, occurrence, range of thallus organization, cell structure and life cycle of Algae (Cyanophyta, Chlorophyta, Charophyta, Xanthophyta, Phaeophyta, Rhodophyta). Economic importance of algae.	12
III	**Introduction to true Fungi** Definition, General characteristics; Affinities with plants and animals; Thallus organization; Cell wall composition; Nutrition; Classification. Zygomycetes: General characteristics; Ecology; Thallus organisation; Life cycle with reference to Rhizopus. Ascomycota General characteristics (asexual and sexual fruiting bodies); Ecology; Life cycle, Heterokaryosis and parasexuality; life cycle and classification with reference to Aspergillus, Neurospora, Peziza, Symbiotic associations: Lichens. Economic importance of fungi.	12
IV	**Introduction to Archegoniatae** General characteristics; Adaptations to land habit; Classification; Range of thallus organization. Classification (up to family) Reproduction of Bryophytes (Riccia, Marchantia and Funaria species), Pteridophytes (Psilotum, Selaginella, Equisetum species), and	12

	Gymnosperms (Cycus, Pinus, Gnetum). Economic importance of archegoniatae..	
V	**Taxonomy and Anatomy of Angiosperms** Taxonomic Hierarchy & Nomenclature: Principles of ICBN/ICN; ranks, hierarchy, and the concept of "Type" (holotype, isotype); Tools in Taxonomy: Herbarium techniques, E-floras, and the role of Molecular Systematics in plant identification. Morphological features and economical importance of Fabaceae, Solanaceae and Lamiaceae, Structure and function of Meristematic (apical, intercalary, lateral) and Permanent tissues (Simple and Complex); Internal organization of roots, stems, and leaves in typical Dicotyledons and Monocotyledons; Detailed study of vascular cambium and cork cambium; formation of annual rings, heartwood, and sapwood. Brief study of anatomy in Hydrophytes and Xerophytes.	12
	Tasks and Assignments: Each student is required to submit the following: • Assignment on ICN principles to identify local flora (Fabaceae, Solanaceae, Lamiaceae) and submit labeled diagrams comparing the internal anatomy of Monocots and Dicots. • Midterm Internal exams **References:** 1. Campbell, N. A., & Reece, J. B. (2023). Biology. 12th/13th Edition. Pearson. 2. Barsanti, L., & Gualtieri, P. (2022). Algae: Anatomy, Biochemistry, and Biotechnology. 3rd Edition. CRC Press 3. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley & Sons (Asia) Singapore. 4th edition. 4. Webster, J., & Weber, R. (2020). Introduction to Fungi. 3rd/4th Edition. Cambridge University Press. 5. Singh, V., Pande, P. C., & Jain, D. K. (2022). A Textbook of Botany: Algae, Fungi, Bryophyta, Pteridophyta, Gymnosperms and Plant Pathology. Rastogi Publications. 6. Vashishta, P. C., Sinha, A. K., & Kumar, A. (2021). Botany for Degree Students: Bryophyta / Pteridophyta / Gymnosperms. S. Chand Publishing. 7. Pandey, B. P. (2022). Angiosperms: Taxonomy, Anatomy, Economic Botany and Embryology. S. Chand Publishing.	

c. Mapping of Program Outcomes with Course Outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	3	3	2
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	2	2	1	3	2
CO5	1	1	1	1	2

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments/Seminar	1	1	1	1	1
Test	6	6	6	6	6
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Essay- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content 50%**	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organiza -tion 50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

i. Model Question Paper

Sl. No.	Model Questions	Specification	Level
	Part – A: Objective Type **Multiple Choice** **Marks: 10 x 1 = 10**		
1	According to the Hardy-Weinberg principle, which of the following conditions must be met for a population's allele frequencies to remain constant over generations? a. Small population size and frequent mutations b. Random mating and absence of natural selection c. Significant gene flow and non-random mating d. High rates of genetic drift and directional selection	Recognize	Remember
2	In the Five Kingdom classification system proposed by Whittaker, which kingdom includes unicellular eukaryotic organisms like *Amoeba* and *Paramecium*? a. Monera b. Fungi c. Protista d. Animalia	Recognize	Remember
3	The life cycle of Polysiphonia is described as triphasic haplodiplobiontic. Which of the following sequences correctly represents the three distinct generations in this life cycle?	Recall	Remember

	a. Gametophyte (n) → Zygote (2n) → Tetrasporophyte (2n) b. Gametophyte (n) → Carposporophyte (2n) → Tetrasporophyte (2n) c.Haplobiotic (n) → Diplobiotic (2n) → Meiospore (n) d.Gametophyte (n) → Carposporophyte (n) → Tetrasporophyte (2n)		
4	Which group of Algae is characterized by the presence of phycoerythrin and a lack of flagellated stages? a. Chlorophyta b. Phaeophyta c. Rhodophyta d. Cyanophyta	Recognize	Remember
-5	In the life cycle of *Rhizopus*, which structure is formed as a result of the fusion of two compatible multinucleate gametangia? a. Ascocarp b. Zygospore c. Conidiophore d. Basidium	Recall	Remember
6	The phenomenon of "Parasexuality," which involves plasmogamy, karyogamy, and haploidization without a formal meiotic cycle, is a key genetic feature in which group? a. Cyanobacteria b. Bryophytes c. Ascomycota D. Chlorophyceae	Recognize	Remember
7	Which of the following is often called "the amphibians of the plant kingdom"? a. Pteridophytes b. Bryophytes c. Gymnosperms d. Angiosperms	Identify	Remember
8	Adiantum is popularly known as the "Walking Fern" because of which specific characteristic? a. Its spores have elaters that allow them to "walk" across the soil surface. b. It possesses a creeping rhizome that moves rapidly through the leaf litter. c. New plantlets develop at the leaf tips when they touch the moist soil, allowing the plant to "step" forward. d.It is a rare motile fern that can relocate its roots during flooding events.	Recall	Remember
9	According to ICN rules, a duplicate of the holotype collected by the same author at the same time is a/an:	Recognize	Remember

	a. Syntype b. Isotype c. Neotype d. Paratype		
10	The "Annual Rings" observed in the secondary xylem of temperate trees are formed by the activity of: a. Cork cambium b. Vascular cambium c. Apical meristem d. Phellogen	Recall	Remember
	PART – B Short Answer **The answer should not exceed 200 words Marks :5 x 3 = 15**		
11	Explain the Hardy-Weinberg Principle and provide the mathematical equation representing it.	Explain Discuss	Understand
12	Describe the range of thallus organization found in various algal groups.	Illustrate	Apply
13	Explain the symbiotic associations in Lichens and their economic importance.	Explain	Apply
14	Describe the unique xerophytic adaptations found in the anatomy of Pinus needles.	Explain Discuss	Understand
15	What are E-floras, and how do they assist in modern plant identification?	Differentiate	Understand
PART – C Essay Answer **The answer should not exceed 400 words Marks: 5 x 7= 35**			
16	a) Explain the mechanism of Natural Selection as proposed by Darwin. b) Describe the Five Kingdom Classification concept and its advantages over the two-kingdom system. (or) a) Elaborate on the mechanism of macroevolution and the construction of phylogenetic trees. b) Discuss the evidences for evolution from Comparative Anatomy (Homologous and Analogous organs)	Differentiate	Understand
17	a) Detailed the structure and development of Unilocular and Plurilocular sporangia in Brown Algae. How do they differ in terms of the spores they produce? b) What is Fucoxanthin, and how does it assist Brown Algae in adapting to their specific marine ecological niche? c) (or) a) Describe the ultrastructure of a Cyanophycean cell. How does it differ from a typical algal cell (like Chlorophyta)? b) Explain the structure and function of Heterocysts. Name one genus where they are commonly found.	Explain Discuss	Understand

18	a) Describe the thallus organization, nutrition, and life cycle of a) *Aspergillus niger* and b) *Agaricus bisporus*. (or) b) Discuss a) homo and heterothalism, b) parasexuality, and heterokaryosis in true fungi.	Explain	Understand
19	a) Detail the morphological features and reproductive mechanisms of i) *Selaginella bryopteris* and ii) *Bryum argenteum* (or) a) Describe the morphological features and the reproductive mechanisms of i) *Cycas sphaerica* and ii) *Ginkgo biloba*	Illustrate	Umderstand
20	a) Explain the principles of ICN and the role of Molecular Systematics in plant identification. b) Describe the morphological features and the reproductive mechanisms of *Salvia officinalis* (or) a) Detail the formation of secondary wood (heartwood and sapwood) and annual rings in Angiosperms. b) Explain the structure and functional differences between Xylem and Phloem. Why are they classified as "Complex Permanent Tissues"?	Explain Illustrate	Apply

SEMESTER II				
COURSE CODE	**COURSE TITLE**	**TYPE**	**CREDITS**	**HOURS / WEEK**
MIB5022	**Biology Practical**	**Core Course Practical**	**2**	**4 h**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

Course Outcome		**Level**
CO-1	Apply quantitative laboratory techniques to prepare molar solutions, buffers, and serial dilutions,	**Apply**
CO-2	Analyze the structural complexities and life cycles of diverse organisms ranging from lower cryptogams (algae, bryophytes) to higher gymnosperms and from Protozoa to Amphibia	**Analyse**
CO-3	Analyze the comparative anatomy of plant tissues and the morphological characters of floral families to identify diagnostic taxonomic features.	**Analyse**
CO-4	Understand the virus structure and replication cycles, and fungal and bacterial plant diseases	**Analyze**
CO-5	Apply cytological and specimen-handling techniques for mitotic observation and identify specialized chromosomal structures	**Apply**

b. Syllabus

Units	Content	Hrs.
I	1. Use of micropipettes, preparation of normal, molar and standard solutions, phosphate buffers, serial dilutions 2. Study of Vegetative & Reproductive Structures of Nostoc, Chlamydomonas, Oedogonium, Vaucheria, Fucus, Polysiphonia, Riccia, Anthoceros, Funaria; Psilotum, Selaginella, Pteris; Cycas, Pinus, Gnetum (Permanent slides only), 3. Tissues (Parenchyma, Collenchyma & Sclerenchyma); Macerated Xylary Elements, Phloem (Permanent Slides, Photographs) 4. Study of the characteristic features of any two flowers for each family (a) Malvaceae/ Fabaceae (any one family), (b) Compositae (c) Euphorbiaceae, (d) Poaceae/Liliaceae (any one family)	15
II	5. Study of Specimens from Protozoa to Annelida: Amoeba, Euglena, Plasmodium, Paramecium, Sycon, Hyalonema, & Euplectella, Obelia, Physalia, Aurelia, Tubipora, Metridium, Taenia solium, Male & female Ascaris lumbricoides, Aphrodite, Nereis, Pheretima, Hirudinaria 6. Study of Specimens from Protochordata to Amphibia : Balanoglossus, Herdmania, Branchiostoma, Petromyzon, Sphyrna, Protists, Torpedo, Labeo, Exocoetus, Anguilla, Ichthyophis/Ureotyphlus, Salamandra, Bufo, Hyla 7. Study of Permanent Slides: TS & LS of Sycon, Study of Life History Stages of Taenia, TS of Male & Female Ascari	15
III	8. Drosophila salivary glands to study Polytene Chromosomes 9. EMs/Models of Viruses: T-Phage & TMV, HIV, Dengue, Coronaviruses, Rabies, Ebola, Line Drawing/Photograph of Lytic & Lysogenic cycle 10. Cross-section of leaf spots to study fungal and bacterial plant diseases 11. Preparation of the onion root tip and Tradescantia's anther squash to visualise the stages of mitosis and meiosis in plant cells, respectively	15
	Task and Assignments: SOP 1. Calculate and document protocols for preparing molar solutions and phosphate buffers using micropipettes and serial dilutions. 2. Illustrate vegetative and reproductive structures of prescribed Algae, Bryophytes, Pteridophytes, and Gymnosperms from permanent slides. 3. Analyze plant tissues, dissected elements, and floral characteristics of Malvaceae, Compositae, and Poaceae families. 4. Identify diagnostic features of diverse zoological specimens from Protozoa to Amphibia and describe viral models like HIV and Coronaviruses. 5. Perform onion root tip mitosis and Tradescantia's anther meiosis preparations and examine cross-sections of fungal and	

	bacterial plant diseases. **References** 1. Jones, A., Reed, R., & Weyers, J. (2024). *Practical Skills in Biology*. 8th Edition. Pearson. 2. Alexopoulos CJ, Mims CW& Blackwell M. (1996) Introductory Mycology. Wiley &Sons, Singapore. 3. Singh, V., Pande, P. C., & Jain, D. K. (2023). Structure and Development of Plant Groups: Algae to Angiosperms (Practical Manual). 5th Edition. Rastogi Publications.\ 4. Bhatnagar SP&Moitra A. (1996) Gymnosperms. New Age International (P) Ltd Publishers, New Delhi. 5. Simpson, M. G. (2024). Plant Systematics. 4th Edition. Academic Press. 6. Miller, S. A., & Tupper, T. A. (2023). Zoology: Laboratory Manual. 11th Edition. McGraw Hill. 7. Kotpal RL (2019), Modern Text Book of Zoology (Invertebrate and Vertebrates), Rastogi Publications.	

Mapping of Program Outcomes with Course Outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	3	3	2
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	2	2	1	3	2
CO5	1	1	1	1	2

SEMESTER-II					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIB0E02	**Applied Microbiology**	**3**	**-**	**-**	**3**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO1	To know the scope, history and contributions of important microbiologists	Understand
CO2	To acquire knowledge and gain understanding of basic concepts in microbiology and understand the origins of microbiology.	Apply
CO3	To understand the importance biocontrol agents in plant disease control	Understand

CO4	To understand the concepts of fermented food production	Analyze
CO5	To understand the concept and importance of bioremediation and role of microbes in bioremediation.	Apply

b. Syllabus

Units	Content	Hrs.
I	**Introduction to Microbial World** History, development and scope of microbiology, evolution of microbial life; Theory of Spontaneous generation; Prokaryotes, archaebacteria and eukaryotes; Classification of microbes - numerical and molecular taxonomy; Bergey's manual for identification of various microbes; Diversity of the microbial world.	9
II	**Bioremediation** Bioremediation of toxic waste sites; Role of microbes; Microbial degradation of environmental pollutants-industrial solvents, pesticides, petroleum hydrocarbons, xenobiotics; bioremediation practices and technologies; Biofuel production from organic wastes; Bioleaching.	9
III	**Biofertilizers** General account of the microbes used as biofertilizers for various crop plants and their advantages over chemical fertilizers. Symbiotic N2 fixers, non-leguminous N fixers, Phosphate and silicate solubilizers, Mycorrhizal biofertilizers, Biofertilizers production, carrier materials, noval bioinoculants	9
IV	**Fermented Foods** Dairy starter cultures, fermented dairy products: yogurt, acidophilus milk, kumiss,kefir, dahi and cheese, other fermented foods: dosa, sauerkraut, soy sauce andtampeh, Probiotics: Health benefits, types of microorganisms used, probiotic foods available in market.	9
V	**Bioinsecticides** General account of microbes used as bioinsecticides and their advantages over synthetic pesticides, Bacillus thuringiensis, production, Field applications, Viruses – cultivation and field applications. Introduction to mycoinsecticides.	9

	Tasks and Assignments: Each student is required to submit the following: • A write-up on the underlying various by-products from microorganisms • Seminar on Biofertilizers • A mini project on learning basic Fermentation process • Internal exams **References** • Kannaiyan, S. (2003). Bioetchnology of Biofertilizers, CHIPS, Texas. • Mahendra K. Rai (2005). Hand book of Microbial Biofertilizers, The Haworth Press, Inc. New York. • Reddy, S.M. et. al. (2002). Bioinoculants for Sustainable Agriculture and Forestry, Scientific Publishers. • Subba Rao N.S (1995) Soil Microorganisms and Plant Growth, Oxford and IBH publishing co. Pvt. Ltd. NewDelhi. • Saleem F and Shakoori AR (2012) Development of Bioinsecticide, Lap Lambert Academic Publishing GmbH KG. • Aggarwal SK (2005) Advanced Environmental Biotechnology, APH publication.	

c. Mapping of Program Outcomes with Course Outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	3	3	2
CO2	3	3	3	3	3
CO3	3	2	2	3	3
CO4	3	3	3	3	3
CO5	2	2	2	2	2

d. Evaluation Scheme

	CO1	**CO2**	**CO3**	**CO4**	**CO5**	**Total**
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	**CO2**	**CO3**	**CO4**	**CO5**
Assignments	2	2	-	-	2
Seminar	1	1	2	2	-
Test	4	4	5	5	5

Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Part–A (Objective-10x1=10marks)	2	2	2	2	2
Part–B (Short Answer- 5x3=15marks)	3	3	3	3	3
Part–C (Essay-5x7=35marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No.	**Criteria**	**100%**	**75%**	**50%**	**25%**	**0%**	**Relation to COs**
1	**Content 50%**	Ideas are detailed, well developed, supported with specific evidenc e& facts and examples	Ideas are detailed, Developedand supportedwith evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported.	Content is not sound	Not attended	CO1, CO2, CO4
2	**Organiza -tion 50%**	Includes title, introduction, statement of them a in idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO4

h. Rubric for Seminar

Sl. No.	**Criteria**	**100%**	**75%**	**50%**	**25%**	**0%**	**Relati on to Cos**

1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO5
2	**Presentation 50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO5

i. Model Question Paper

Sl. No.	**Model Questions**	**Specification**	**Level**
Part–A: Objective Type **Multiple choice 10x 1 =10**			
1	1. Who coined the term Rhizosphere? A. Beijerinck B. Muntz C. Helriegel & Wilfarth D. Hiltner	Recognize	Remember
2	2. Who developed enrichment technique for isolating various group of bacteria? A. Beijerinck B. Winogradsky C. Hiltner D. Frank	Recall	Remember
3	3. Who is the father of Agricultural Microbiology? A. Beijerinck B. Winogradsky C. Frank D. Hiltner	Recognize	Remember
4	4. Which is the most dominant group of microorganism found in soil? A. Algae B. Bacteria C. Actinomycetes D. Fungi	Recognize	Remember

5	5. Microrganism most dominant in acid soils? A. Actinomycetes B. Bacteria C. Fungi D. Algae	Recognize	Remember
6	Which of the following microscopy techniques relies on the specimen interfering with the wavelength of light to produce a high contrast image without the need for dyes or any damage to the sample? A. Conventional bright field light microscopy B. Phase contrast microscopy C. Electron microscopy D. Fluorescence microscopy	Recognize	Remember
7	When the power of ocular lensis 10X and objective lens is 20x the magnification is: A. 30 times B. 20 times C. 200 times D. 2000 times	Recall	Remember
8	Who developed acid-fast staining? A. Robert Koch B. Edward Jenner **C.** Paul Ehrlich **D.** John Tyndall	Recall	Remember
9	Who awarded Nobel prize for genetic code in the field of physiology and medicine? A. Sergei N. Winograsky B. Alexander Fleming **C.** Hargobind Khorrana **D.** Edward Jenner	Identify	Remember
10	Which is the highest rank in the taxonomy? A. Phylum B. Order C. Genus D. Domain	Identify	Remember
PART–B Short Answer **The answer should not exceed 200words (Marks: 5x3=15)**			
11	Describe the role of microbes in degradation of environmental pollutants?	Cite Examples	Explain
12	Elaborate the advantages of using biofertilizers over chemical fertilizers?	Explain	Describe

13	Draw the major classification of biofertilizers?	Cite Examples	Understand
14	What is bioleaching?	Illustrate	Describe
15	What is BT?	Explain	Understand
PART–C Essay Answer **The answer should not exceed 400words 5x7=35**			
16	a) How are biofertilizers classified based on their requirements of crops? or b) Explain in mechanism involved bioremediation?	Explain	Understand
17	a) What are bioremediation? Why they are important to study? or b) Illustrate with two examples of fermented microorganisms And describe in detail their usage.	Explain Discuss	Understand
18	Explain the various fermented foods Explain in detail the mechanism of bioinsecticides	Cite Examples	Understand
19	a) Explain in brief Louis Pasteur major contributions in the field of microbiology. or b) Describe in brief refutation of biogenesis.	Illustrate	Apply
20	a) How viruses are cultivated for field application? Or b) List out and describe different kinds of media used for culturing the microbes in the laboratory.	Describe	Analyze

SEMESTER III					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIB5031	Biochemistry	3	-	-	3

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO 1	Understand the structure and functions of major biomolecules	Understand
CO 2	Learn enzyme function and basic principles of bioenergetics	Understand
CO 3	Understand key pathways of carbohydrate metabolism	Understand, Analyze
CO 4	Explore the lipid and amino acid metabolism in microorganisms	Understand, Apply
CO 5	Study the nucleic acid metabolism and basic molecular processes	Analyze, Apply

b. Syllabus

Units	**Content**	**Hrs.**
I	**Biomolecules and Their Biological Significance:** Structure, properties and functions of biomolecules: carbohydrates (mono-, di-, polysaccharides), lipids (fatty acids, triglycerides, phospholipids), proteins (amino acids, peptide bonds, levels of protein structure), nucleic acids (DNA, RNA). Biological importance of water, pH and buffers.	9
II	**Enzymes and Basic Bioenergetics:** Michaelis-Menten concept; Classification and mechanism of enzyme action; Factors affecting enzyme activity (pH, temperature, substrate concentration). Enzyme inhibition (competitive, non-competitive). Concept of energy in biological systems: ATP, high-energy compounds, basics of bioenergetics.	9
III	**Carbohydrate Metabolism:** Glycolysis (EMP pathway), fate of pyruvate (aerobic and anaerobic conditions), TCA cycle, Electron Transport Chain, Pentose phosphate pathway and its significance.	9
IV	**Lipid and Nitrogen Metabolism:** Lipid metabolism: β-oxidation of fatty acids, basic concept of lipid biosynthesis. Amino acid metabolism: transamination and deamination, urea cycle.	9
V	**Nucleic Acid Metabolism and Molecular Processes:** Biosynthesis of purines and pyrimidines, degradation of nucleotides. Introduction to central dogma: DNA replication, transcription and translation**.**	9
	Tasks and Assignments: • Internal exams • A quiz on fermented microbial products • An assignment on food spoilage detection • Presentation on microbial metabolites and their applications **References:** 1. Lehninger Principles of Biochemistry. New York: W.H. Freeman, 2021 2. Gerard J. Tortora, Berdell R. Funke, and Christine L. Case- Microbiology: An Introduction	

	3. Joanne M. Willey, Kathleen M. Sandman, and Dorothy H. Wood, Prescott's Microbiology, 12th Edition	

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**3**	**3**	**3**	**2**
CO2	**3**	**3**	**3**	**3**	**3**
CO3	**2**	**2**	**2**	**3**	**3**
CO4	**3**	**3**	**3**	**3**	**3**
CO5	**2**	**2**	**2**	**2**	**2**

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Test	7	7	7	7	7
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Essay- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments: No assignments in this course

h. Rubric for Seminar: No seminars in this course

i. Model Question Paper

Sl. No.	Model Questions	Specification	Level
	Part – A: Objective Type **Multiple Choice** **Marks: 10 x 1 = 10**		
1	According to the Michaelis-Menten concept, enzyme activity depends on:		Remember

	a) Light intensity b) **Substrate concentration** c) Oxygen availability d) Water potential	Recall	
2	Which of the following factors can affect enzyme activity? a) Temperature b) pH c) Substrate concentration d) **All of the above**	Recognize	Remember
3	In competitive inhibition, the inhibitor: a) **Binds to the active site** b) Destroys the enzyme c) Changes enzyme temperature d) Removes substrate	Recall	Remember
4	Which of the following polysaccharides contains β(1→4) glycosidic linkages? a) Glycogen b) Amylose c) **Cellulose** d) Dextran	Identify	Remember
5	The zwitterionic nature of amino acids is due to the presence of: a) Only amino groups b) Only carboxyl groups c) **Both positive and negative charges in the same molecule** d) Peptide bonds	Recognize	Remember
6	Which level of protein structure is mainly stabilized by hydrogen bonds between backbone atoms? a) Primary structure b) **Secondary structure** c) Tertiary structure d) Quaternary structure	Identify	Remember
7	The Henderson–Hasselbalch equation is primarily used to: a) Calculate ATP yield b) Determine enzyme kinetics c) **Estimate pH of buffer systems** d) Measure osmotic pressure	Recall	analyze
8	In non-competitive inhibition: a) Km increases and Vmax decreases b) Km decreases and Vmax increases c) **Vmax decreases without affecting Km** d) Both Km and Vmax remain unchanged	Identify	Remember
9	Which class of enzymes catalyzes oxidation-reduction reactions? a) Transferases b) Hydrolases c) **Oxidoreductases** d) Lyases	Recall	identify

10	The chemiosmotic theory of ATP synthesis was proposed by: a) Hans Krebs b) **Peter Mitchell** c) Linus Pauling d) Watson and Crick	Recall	Remember
	PART – B Short Answer **The answer should not exceed 200 words Marks:5 x 3 = 15**		
11	Explain the Michaelis–Menten concept of enzyme kinetics.	Explain	Remember
12	Differentiate between competitive and non-competitive enzyme inhibition.	Recall	Remember
13	Describe the process of β-oxidation of fatty acids.	Describe	Analyze
14	Describe the mechanism of DNA replication in prokaryotes.	explain	Analyze
15	Describe the levels of protein structure with suitable examples.	Describe	Remember
PART – C Essay Answer **The answer should not exceed 400 words Marks: 5 x 7= 35**			
16	Discuss the structure, properties, and biological significance of carbohydrates and lipids.	Explain	Understand
17	Describe the glycolytic pathway (EMP pathway) and explain the fate of pyruvate under aerobic and anaerobic conditions.	Describe	analyze
18	Explain β-oxidation of fatty acids and discuss its energetic significance.	analyze	differentiate
19	Describe the biosynthesis and degradation of purines and pyrimidines.	Explain	Discuss
20	Discuss the process of transcription and translation in prokaryotes.	Discuss	Describe

SEMESTER III					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIB5032	Biochemistry Practical			2	2

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO 1	Learn to prepare molar and normal solutions, buffer preparation, and measurement of pH.	skill
CO 2	Apply the principles of Beer–Lambert law to measure bacterial growth and perform glucose estimation	analyze
CO 3	Perform biochemical estimation of proteins and lipids	analyze
CO 4	Analyze microbial metabolic activities through detection of fermentation, starch hydrolysis, oxygen utilization.	skill

CO 5	To determine the water quality using presumptive test.	skill

b. Syllabus

Units	Content	Hrs.
	1. Preparation of Molar and Normal Solutions 2. Preparation of buffer solution and measurement of pH 3. Beer-Lambert Law and Measurement of Bacterial Growth curve 4. Estimation of Glucose by the DNS method 5. Estimation of Protein by the Biuret method 6. Estimation of lipid and Nile red fluorescence 7. Detection of Fermentation and gas production by microbes 8. Demonstration of Starch hydrolysis with amylase-producing bacteria 9. Demonstration of oxygen utilization using Thioglycolate medium 10. Determination of water quality using the Presumptive test	30
	Tasks and Assignments: Each student is required to submit the following: • A continuous assessment • A practical viva voce • Demonstration of determination of milk quality • Restriction mapping • Maintaining record notebooks • Group discussion **References:** 1. Laboratory Manual of Microbiology, Biochemistry and Molecular Biology-J. Saxena, M. Baunthiyal & I. Ravi 2. Harley and Prescott (1996), Laboratory Exercises in Microbiology, McGraw Hill Higher Education, 3rd Edition 3. "Practical Handbook of Microbiology" 4th Edition, Lorrence H Green 4. Ted R. Johnson and Christine L. Case, Laboratory experiments in Microbiology, 3rd Ed., The Benjamin/Cummings Publishing Company Inc., 1992.	

SEMESTER IV					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIB5041	Microbial Physiology and Metabolism	4	-	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO 1	Understand the nutritional requirements and classification of microorganisms	Understand
CO 2	Understand how microorganisms utilize diverse substrates and carry out basic metabolic processes.	Understand
CO 3	Gain knowledge on autotrophic metabolism, including photosynthesis and microbial roles in nitrogen and sulfur cycles.	Understand, Analyze
CO 4	Understand the principles of anaerobic respiration and its role in processes like denitrification and sulfate reduction.	Understand, Apply
CO 5	Study the basic mechanisms by which microorganisms regulate enzyme activity and metabolic pathways.	Analyze, Apply

b. Syllabus

Units	**Content**	**Hrs.**
I	**Microbial Nutrition:** Microbial nutrient requirements, macronutrients, micronutrients, growth factors, sources of nutrients. Nutritional classification of bacteria: phototrophs, chemotrophs, autotrophs, heterotrophs, photoautotrophs, photoheterotrophs, chemoautotrophs, chemoheterotrophs. Nutritional types of microorganisms: saprophytes, pathogens, auxotrophs. Growth curve (lag, log, stationary, death phase), Generation time, chemostat, batch culture.	12
II	**Microbial Metabolism:** Basic concepts of microbial metabolism; transport mechanism: Passive diffusion, facilitated diffusion, active transport, group translocation; Utilization of substrates other than glucose. Hydrolysis of polymers: starch hydrolysis, cellulose hydrolysis. Basic amino acid metabolism. Introduction to methanotrophs and utilization of single-carbon compounds.	12
III	**Photosynthesis and Inorganic Metabolism:** Characteristics of autotrophic microorganisms. Photosynthetic bacteria and cyanobacteria. Basic mechanism of photosynthesis and carbon dioxide fixation. Introduction to nitrogen cycle: nitrification (ammonia and nitrite oxidation). Introduction to sulfur cycle: sulfur-oxidizing bacteria.	12
IV	**Anaerobic Respiration:** Concept of anaerobic respiration & fermentation; Denitrification and its significance; Biochemistry of Sulfidogenesis, Sulfate reduction and sulfur-reducing bacteria; Introduction to metal reduction and its environmental importance.	12
V	**Metabolic Regulation:** Basic concepts of regulation of microbial metabolism; Stress Physiology: pH, temperature, osmotic stress adaptation; Regulation of enzyme activity: feedback inhibition and its significance. Allosteric enzymes and their role in controlling metabolic pathways. Induction and repression of enzymes (lac operon as an example). Overview	12

	of microbial metabolic pathway regulation in response to environmental changes.	
	Tasks and Assignments: • Internal exams • A quiz on fermented microbial products • An assignment on food spoilage detection • Presentation on microbial metabolites and their applications **References:** 1. Gerard J. Tortora, Berdell R. Funke, Christine L. Case. Microbiology-An Introduction.11th edition Pearson, 2013 2. 2. Alcomo, I.E. 2011. Fundamentals of Microbiology. 9th Edition, Jones and Bartlett Publishers, Sudbury. Massachusetts.	

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**3**	**3**	**3**	**2**
CO2	**3**	**3**	**3**	**3**	**3**
CO3	**2**	**2**	**2**	**3**	**3**
CO4	**3**	**3**	**3**	**3**	**3**
CO5	**2**	**2**	**2**	**2**	**2**

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Test	7	7	7	7	7
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Essay- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments: No assignments in this course

h. Rubric for Seminar: No seminars in this course

i. Model Question Paper

Sl. No.	Model Questions	Specification	Level
	Part – A: Objective Type **Multiple Choice Marks: 10 x 1 = 10**		
1	Out of the following, which is an example of active transport inside the cell? a) Passing calcium through channel proteins, from a high to low concentration. b) Oxygen entering the cells without the use of energy c) Sodium pumping out of the cell against its concentration gradient d) H2O crossing the plasma membrane	Recall	Remember
2	The organisms which can use reduced inorganic compounds as electron donors are known as _____ a) Chemotrophs b) Organotrophs c) Lithotrophs d) Phototrophs	Recognize	Remember
3	Group translocation differs from active transport because the transported substrate is: A. Oxidized during transport B. Reduced during transport C. Chemically modified during transport D. Transported without carrier proteins	Recall	Remember
4	The key enzyme involved in biological carbon dioxide fixation through the Calvin cycle is: A. Nitrogenase B. RuBisCO C. Hydrogenase D. ATP synthase	Identify	Remember
5	In sulfate-reducing bacteria, sulfate acts as the: A. Carbon source B. Electron donor C. Terminal electron acceptor D. Growth factor	Recognize	Remember
6	Metal-reducing bacteria are environmentally important because they contribute to: A. Antibiotic resistance B. Bioremediation of contaminated environments C. Photosynthetic oxygen evolution D. Viral replication	Identify	Remember
7	Allosteric enzymes regulate metabolic pathways by: A. Destroying substrates B. Changing conformation after effector binding C. Increasing mutation frequency D. Hydrolyzing ATP continuously	Recall	analyze

8	In the lac operon, lactose functions primarily as: A. Corepressor B. Structural gene C. Inducer molecule D. Feedback inhibitor	Identify	Remember
9	Active transport in bacteria is characterized by: A. Movement along the concentration gradient B. Requirement of metabolic energy C. Absence of membrane proteins D. Lack of substrate specificity	Recall	identify
10	Which process contributes significantly to the loss of soil nitrogen in agricultural fields? A. Nitrogen fixation B. Nitrification C. Denitrification D. Ammonification	Recall	Remember
	PART – B Short Answer **The answer should not exceed 200 words Marks:5 x 3 = 15**		
11	Define group translocation and cyclic phosphorylation	Explain	Remember
12	Write a short note on coupling in oxidative phosphorylation and Bacteriochlorophylls	Recall	Remember
13	Allosteric regulation of enzyme with one example	Describe	Analyze
14	Types of methylation on DNA and its importance	explain	Analyze
15	Draw the chemical structure of glucose and fructose	Describe	Remember
PART – C Essay Answer **The answer should not exceed 400 words Marks: 5 x 7= 35**			
16	a). Describe the function and structural components of Lac operon Or b). Explain microbial nutrient requirements and nutritional classification of bacteria.	Explain	Understand
17	a). Describe in detail, the process of carbon assimilation in methylotrophs. Or b). Explain microbial metabolism of carbohydrates, amino acids, and single-carbon compounds.	Describe	analyze
18	a). What is assimilatory sulfate reduction? How it contributes in biological sulfur cycle? Or b). Describe photosynthesis in bacteria and cyanobacteria with carbon dioxide fixation.	analyze	differentiate
19	a). What is key common intermediate in carbohydrate, lipid and protein metabolism, and explain with diagram? Or b). Discuss denitrification, sulfate reduction, and metal reduction with their environmental significance	Explain	Discuss

20	a). Which C1 metabolism is considered to be most energy efficient and why? Or b). Discuss stress physiology and regulation of enzymes with reference to the lac operon.	Discuss	Describe

SEMESTER -IV					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIB5042	Medical Biotechnology	4	0	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO 1	Understand and gain an in-depth knowledge of the biology of diseases	**Understand**
CO 2	Apply and to conduct research, develop diagnostics, and create biopharmaceuticals	**Apply**
CO 3	Apply their knowledge to solve medical problems through innovations like gene therapy and immunoassays techniques.	**Apply**
CO 4	Proficiency in using various tools for data analysis and the skill to conduct research, develop diagnostics and create biopharmaceuticals.	**Analyze**
CO 5	Gain knowledge in clinical research, licensing procedures in India.	**Analyze**

b. Syllabus

Units	**Content**	**Hrs.**
I	**The biology of diseases:** Infectious diseases, inflammatory diseases, the molecular basis of senescence, apoptosis and cell death, neurodegenerative diseases, cancer and chromosomal abnormalities, animal cell culture in disease biology, gene transfer methods, hybridoma technology, functional genomics and comparative genomics in understanding biology of diseases, animal models in biomedical research including cancer, diabetic, neurodegenerative disease models.	12
II	**Prognosis and Diagnostics:** Immunodiagnostics, genetic diagnosis, protein markers and identification of disease specific markers, gene expression profiling, automated workstations, genetic testing-neonatal screening.	12
III	**Therapeutics:** Monoclonal antibodies, therapeutic proteins for the treatment of various diseases, cytokines, hormones, basics of gene therapy, different approaches and applications of gene therapy, cancer vaccines, medical information database.	12

IV	**Treatment strategies and clinical approach** Rational drug design, important criteria in drug designing, High-throughput small molecule screening, gene knockdown methods in understanding disease mechanisms, various new developments in drug delivery methods.	12
V	**Ethics and regulations:** Ethics and regulations in clinical research, licensing procedures in India, intellectual property rights, patents in biotechnology, recent trends in medical biotechnology.	12
	Tasks and Assignments: 1. Internal exams 2. A quiz 3. An assignment 4. Presentation **References:** 1. Medical Biotechnology, Bernard R. Glick, T.L. Delovitch, Cheryl L. Pattern. ASM Press, 2014. 2. Biotechnology and Medical Sciences, Firdos Alam Khan, CRC Press, 2014. 3. Medical Biotechnology, Firdos Alam Khan, Academic Press, 2013. 4. An introduction to human diseases: Pathology and Pathophysiology correlations. Leonard V. Crowley, 2012. 5. Apoptosis: Physiology and Pathology, Johnc C Reed and Douglas R. Green, Cambridge University Press, 2011.	

c. Mapping of Program Outcomes with Course Outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**3**	**3**	**3**	**3**	**2**
CO2	**3**	**3**	**2**	**2**	**2**
CO3	**3**	**2**	**3**	**3**	**2**
CO4	**2**	**3**	**2**	**3**	**3**
CO5	**2**	**2**	**2**	**2**	**2**

d. Evaluation Scheme

	CO1	**CO2**	**CO3**	**CO4**	**CO5**	**Total**
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	**CO2**	**CO3**	**CO4**	**CO5**
Assignments	2	2	-	-	2
Seminar	-	-	2	2	-

Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Essay- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No.	**Criteria**	**100%**	**75%**	**50%**	**25%**	**0%**	**Relation to COs**
1	**Content 50%**	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organiza -tion 50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

h. Rubric for Seminar

Sl. No.	**Criteria**	**100%**	**75%**	**50%**	**25%**	**0%**	**Relation to COs**

1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

i. Model Question Paper

Sl. No.	Model Questions	Specification	Level
	Part – A: Objective Type **Multiple Choice Questions** **Marks: 10 x 1 = 10**		
1	Cytokines functions are a) Transient b) redundant c) pleotrophic d) all of the above	Find out	Remember
2	Herceptin is ----------. a) polyclonal antibody b) small molecule compound c) antisense RNA d) monoclonal antibody	Solve	Understand
3	p53 is a) a tumor suppressor gene b) transcription factor c) oncogene d) both a and b	Assemble	Apply
4	How many volunteers are involved in Phase I clinical trials? a) 5-10 b) 20-80 c) 100-200 d) 1000-1500	Experiment	Analyze
5	HIV destroys only human ----------, and it is therefore impossible to get a completely accurate model organism to do research on HIV. a) RBCs b) monocytes	Employ	Skill

	c) sperms d) T Lymphocytes		
6	What is a cell line? a) Multilayer culture b) Transformed cells c) Multiple growth of cells d) Sub culturing of primary culture	Employ	Remember
7	Which of the following virus can cause cancer? a) Cytomegalovirus b) Herpes Simplex virus c) Hepatitis B Virus d) All of the above	Solve	Understand
8	All of the currently licensed drugs for systemic therapy of herpesvirus infections share the same target----------. a) Capsid b) Viral DNA polymerase c) Viral envelope d) Glycoprotein	Remember	Apply
9	---------- refers to the *development* of medications based on the study of the structures and functions of target molecule. *a)* Body Mass Index *b)* Potency and bioavailability *c)* Rational drug design *d)* Protein kinase	Remember	Analyze
10	One of the following Caspase is called as executioner caspase a) Caspase 1 b) Caspase 7 c) Caspase 8 d) Caspase 9	Remember	Skill
	PART – B Short Answer **The answer should not exceed 200 words Marks :5 x 3 = 15**		
11	Write a note on ELISA	Experiment	Remember
12	Write a note on cytokines	Analyze	Understand
13	What is a hit, and what is a lead? Also, name the differences.	Demonstrate	Apply
14	Name the 2 types of bioassays and 2 examples each.	Solve	Analyze
15	How do you develop an anti-cancer drug?	Use	Skill
PART – C Essay Answer **The answer should not exceed 400 words Marks: 5 x 7= 35**			
16	Explain the characteristics of cancer cells. Or Why do we have to identify new bio-active compounds?	Assemble	Remember
17	Explain two immunodiagnostics methods. Or Explain two different animal models of neurodegenerative diseases.	Experiment	Understand
18	Propose three methods to quantitate protein expression. Or	Demonstrate	Apply

	Hypothesize and propose a research project in the field of medical biotechnology.		
19	What is gene therapy? Explain with suitable examples. Or How cytokines are used in therapeutics? Explain with suitable examples.	Employ	Analyze
20	Explain the drug licensing procedure in India. Or What are the ethics to be followed in Biomedical research?	Solve	Skill

SEMESTER IV					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIB5403	**Bio-instrumentation techniques**	-	-	2	2

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

CO-1	Understand the working principles of major microbiological instruments.	**Understand & Apply**
CO-2	Operate basic laboratory instruments safely.	**Understand & Apply**
CO-3	Interpret analytical and molecular biology results.	**Apply, Analyze**
CO4	Apply instrumentation knowledge in microbiology research and diagnostics.	**Understand & Analyze**
CO5	Understand modern trends in bioinstrumentation.	**Apply, Analyze**

b. Syllabus

	Content	Hrs.
	1. Biosafety and PPE wearing, hazardous waste disposal and lab instrument record maintenance 2. Use and calibration of pH meter 3. Measurement of OD using spectrophotometer and multimode reader 4. Working with Laminar Air flow and Biosafety cabinets 5. Instrumentation Sterilization equipment 6. Centrifugation instrument principles and types (ultra and cooling centrifuges) 7. Cryopreservation of microbes at -80 degree and liquid nitrogen 8. Microscopy- light microscope, fluorescence and phase contrast 9. Chromatography- HPLC and GC 10. Nucleic acid and protein quantification using Nano-drop 11. Instrumentation thermal cyclers- PCR and qPCR	56

	12. Instrumentation of Electrophoresis	
	Reference books: • Principles and techniques of Biochemistry and Molecular biology. Keith Wilson, John M. Walker, Cambridge University Press. 7th Edition, 2013. • Microbiology laboratory methods for undergraduates. James G. Cappuccino, Natalie Sherman. Pearson / Benjamin Cummings imprint. 10th edition, 2014 • *Prescott's principles of Microbiology.* Joanne M. Willey, Linda Sherwood, Christopher J. Woolverton. McGraw-Hill Education. 12th Edition, 2022.	

SEMESTER - IV					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIB5044	**Bacteriology and Mycology**	4	-	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

Course Outcome		**Level**
CO-1	To understand the principles of bacterial classification, ultrastructure, and staining techniques based on classical and molecular criteria.	**Understand**
CO-2	To compare the structural, reproductive, ecological, and taxonomic features of major fungal groups and interpret their adaptive strategies.	**Understand/ Analyze**
CO-3	To analyze advanced bacterial cellular processes, including cytoskeletal functions, membrane transport, biofilm development, growth dynamics, and mechanisms of antimicrobial resistance.	**Analyze**
CO-4	To interpret genetic mechanisms in fungi—such as mating types, recombination, gene conversion—and apply this knowledge to understand their ecological and economic significance.	**Analyze/Apply**
CO-5	To apply concepts of virulence, immune evasion, and host–microbe interaction to evaluate mechanisms underlying infectious diseases and emerging pathogens.	**Apply**

b. Syllabus

Units	**Content**	**Hrs.**
I	**Basics of Bacteriology** Overview of bacterial classification based on Bergey's manual of determinative bacteriology – Gram negative bacteria, Gram positive bacteria, Mycoplasmas and Archaea; Classification based on serology, Biochemistry, 16s rRNA, G+C content and Molecular tools; Bacterial ultrastructure and organelles; Staining of bacteria and organelles.	12
II	**Basics of Mycology** General characteristics, structure and organization of fungi. Fungal reproduction - Vegetative, asexual and sexual. Adaptive & Developmental Changes: Life Cycle of myxobacteria, Aggregation and fruiting body formation. Endophytic fungi - symbiotic and opportunistic associations. Fungal ecology, distribution of yeasts and fungi.	12
III	**Advances in Bacteriology** Cytoskeleton in bacteria (FtsZ, MreB, CreS), Cell envelope diversity: Archaea vs. Bacteria, Bacterial growth kinetics: monoculture vs. mixed culture dynamics, Sporulation, germination, and differentiation, Antibiotic classes, molecular targets, and mode of action, Mechanisms of antimicrobial resistance (AMR): efflux pumps, β-lactamases, target modification, Multi-drug resistance (MDR).	12
IV	**Advances in Fungal Biology** Features of heterothallism, homothallism, mating types, Vegetative incompatibility, Polyploidy and aneuploidy. Neurospora- Tetrad analysis and linkage detection – 2-point and 3-point crosses - Mitotic recombination in Neurospora – Transposable elements - Gene conversion.	12
V	**Bacterial and Fungal Pathogenesis and Host Interactions** Concepts of virulence, pathogenicity islands, and toxin systems; Adhesion, invasion,	12

	intracellular survival strategies; Bacterial Type III, IV, VI secretion systems in disease, Bacterial Fungal host immune evasion strategies, Microbiome–host interactions and dysbiosis.	
	Tasks and Assignments: • Internal exams • A quiz on general Mycology • An assignment on Bacterial classification • Presenting an example of virulence and discussion about its implications **References:** • Madigan, M. T., Bender, K. S., Buckley, D. H., & Sattley, W. M. (2018). *Brock Biology of Microorganisms* (15th ed.). Pearson. • Willey, J. M., Sherwood, L., & Woolverton, C. J. (2019). *Prescott's Microbiology* (11th ed.). McGraw-Hill Education. • Deacon, J. W. (2013). *Fungal Biology* (4th ed.). Wiley-Blackwell. • Murray, P. R., Rosenthal, K. S., & Pfaller, M. A. (2021). *Medical Microbiology* (9th ed.). Elsevier. • Krebs, J. E., Goldstein, E. S., & Kilpatrick, S. T. (2018). *Lewin's Genes XII*. Jones & Bartlett Learning.	

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**3**	**2**	**3**	**3**
CO2	**2**	**1**	**3**	**2**	**3**
CO3	**2**	**2**	**2**	**1**	**2**
CO4	**3**	**1**	**3**	**2**	**2**
CO5	**3**	**3**	**2**	**3**	**3**

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	2	2	-	-	2
Seminar	-	-	2	2	-
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5

Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Essay- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No.	**Criteria**	**100%**	**75%**	**50%**	**25%**	**0%**	**Relation to COs**
1	**Content 50%**	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organiza -tion 50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

h. Rubric for Seminar

Sl. No.	**Criteria**	**100%**	**75%**	**50%**	**25%**	**0%**	**Relation to COs**
1	**Knowledge and Understanding 50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4
2	**Presentation 50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

Sl. No.	Model Questions	Specification	Level
	Part – A: Objective Type **Multiple Choice Marks: 10 x 1 = 10**		
1	Which mycotoxin is useful to treat post-partum complications? a. Aflatoxin b. Ergotamine c. Ochratoxin d. Fumonisins	Recognize	Remember
2	Which of the following statements is true? a. A dikaryotic ascus that forms in the ascocarp undergoes karyogamy, meiosis, and mitosis to form eight ascospores. b. A diploid ascus that forms in the ascocarp undergoes karyogamy, meiosis, and mitosis to form eight ascospores. c. A haploid zygote that forms in the ascocarp undergoes karyogamy, meiosis, and mitosis to form eight ascospores d. A dikaryotic ascus that forms in the ascocarp undergoes plasmogamy, meiosis, and mitosis to form eight ascospores.	Recall	Remember
3	The so-called simple septa of some fungi have a central pore and nearby associated organelles called a. Woronin bodies b. Dolipore c. Crozier d. Sterigma	Recognize	Remember
4	Neurospora crassa was used by Beadle and Tatum a. to produce citric acid and thus break the Italian lemon monopoly b. because it was easy to produce both asexual and sexual spores for experiments c. to identify mutants that were unable to synthesize single nutritional compounds d. to develop the one gene-one enzyme hypothesis	Recognize	Remember
5	The fertile region of ascocarp is referred to as; a. Trama b. Hymenium c. Hypothecium d. Stipe	Recognize	Remember
6	Which bacterial cytoskeletal protein is primarily involved in cell division?a)MreBb)CreSc)FtsZd) Tubulin	Recognize	Remember
7	CreS protein in bacteria is responsible for: A) Septum formation B) Cell wall synthesis C) Crescent cell shape D) Flagellar movement	Recall	Remember
8	Which of the following is a characteristic feature of Archaea cell envelopes? A) Peptidoglycan cell wall B) Presence of pseudomurein C) Lipopolysaccharide layer D) Chitin cell wall	Recall	Remember
9	Which mechanism contributes to antimicrobial resistance by actively removing antibiotics from the cell? A) Target modification B) Efflux pumps C) Gene conversion D) Sporulation	Identify	Remember
10	Which of the following proteins helps form Holliday junctions and promotes branch migration? A. Ruv ABC B. Rec G C. Rec A D. Rec BCDIn Neurospora, tetrad analysis is mainly used	Identify	Remember

	for: A) Protein analysis B) Mutation induction C) Genetic linkage studies D) Antibiotic screening		
	PART – B Short Answer **The answer should not exceed 200 words Marks :5 x 3 =15**		
11	Explain the significance of 16S rRNA analysis in bacterial classification.	Explain and cite	Remember
12	What are endophytic fungi? Mention their importance.	Explain	Understand
13	What are efflux pumps and how do they contribute to antimicrobial resistance?	Describe	Analyze
14	Differentiate between heterothallism and homothallism.	Differentiate	Analyze
15	Define pathogenicity islands and mention their significance in microbial virulence.	Describe	Remember
PART – C Essay Answer **The answer should not exceed 400 words Marks: 5 x 7= 35**			
16	Discuss the classification of bacteria based on Bergey's Manual of Determinative Bacteriology, highlighting Gram-positive bacteria, Gram-negative bacteria, Mycoplasmas, and Archaea. (or) Describe the ultrastructure of a bacterial cell and explain the principles and applications of different bacterial staining techniques.	Explain and cite	Remember
17	Describe the general characteristics, structure, and organization of fungi with suitable diagrams. (or) Explain the different modes of fungal reproduction and discuss aggregation and fruiting body formation in myxobacteria.	Explain	Understand
18	Explain the role of bacterial cytoskeletal proteins FtsZ, MreB, and CreS in maintaining cell structure and function. (or) Discuss the mechanisms of antimicrobial resistance in bacteria, including β-lactamases, target modification, efflux pumps, and multidrug resistance.	Describe	Analyze
19	Explain tetrad analysis in Neurospora and describe linkage detection using 2-point and 3-point crosses. (or) Discuss vegetative incompatibility, polyploidy, aneuploidy, transposable elements, and gene conversion in fungi.	Differentiate	Analyze
20	Discuss the various bacterial secretion systems (Type III, IV, and VI) and their role in disease pathogenesis. (or) Explain host immune evasion strategies employed by bacteria and fungi, and discuss microbiome–host interactions and dysbiosis.	Describe	Remember

SEMESTER - IV					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIB5045	Bacteriology and Mycology Practical	-	-	2	2

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	Course Outcome	**Level**
CO 1	To be able to perform fundamental microbiological techniques, including isolation, cultivation, staining, and morphological characterization of bacteria and fungi, and interpret their structural and cultural features.	**Apply, Analyze**
CO 2	To be able to apply quantitative methods such as growth curve analysis, biochemical tests, and motility assays to evaluate physiological characteristics and metabolic capabilities of microorganisms.	**Understand, Appy**
CO 3	To be able to analyze antimicrobial susceptibility, and the effectiveness of natural antimicrobial agents, enabling understanding of microbial resistance and control strategies.	**Apply, Analyze**
CO4	To be able to understand the strategies for cultivation of anaerobic bacteria	**Understand, Appy**
CO5	To be able to analyze the bacterial motility and effect of pH on growth of Fungi	**Apply, Analyze**

b. Syllabus

Units	**Content**	**Hrs.**
I	1. Isolation and cultivation of Bacteria using Selective and Differential media 2. Gram staining and Observation of Bacterial morphology 3. Isolation and identification of Fungi from soil and air samples 4. Observation of Yeast budding 5. Assessment of Antimicrobial activity of Plant extracts	56
II	6. Measurement of Bacterial growth curve 7. Bacteriological testing of water quality using Multiple Tube Fermentation Assay 8. Cultivation of anaerobic bacteria 9. Bacterial motility test - Semi solid agar stab method 10. Effect of pH on fungal growth	56
	Tasks and Assignments: Each student is required to submit the following: • Each student should discuss complete details of one of the display techniques. • Students should demonstrate the Gram staining. • Participate in the subject-oriented quiz. **References:** • Cappuccino, J. G., & Welsh, C. T. (2017). *Microbiology: A*	

	Laboratory Manual (11th ed.). Pearson. • Harley, J. P. (2016). *Laboratory Exercises in Microbiology* (10th ed.). McGraw-Hill. • Black, J. G., & Black, L. J. (2018). *Microbiology: Principles and Explorations* (10th ed.). Wiley. • Atlas, R. M. (2004). *Handbook of Microbiological Media* (3rd ed.). CRC Press	

EMESTER V					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIB5053	**Marine & Environmental Microbiology**	4	-	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO1	To introduce marine ecosystem and associated microbial communities. To gain knowledge on seafood contamination with microbes.	Understand
CO2	To study in detail the mechanisms employed by the extremophiles to survive in extreme environments.	Apply
CO3	To study the interactions between microorganisms at different trophic levels and their association with surrounding abiotic factors.	Understand
CO4	To gain knowledge on microbiology of aquatic environments and associated biogeochemical cycles	Analyze
CO5	To study the microbial communities of waste water, importance and process on waste water management. To understand the concept and importance of bioremediation and role of microbes in bioremediation.	Apply

b. Syllabus

Units	**Content**	**Hrs.**
I	**Introduction to Marine Ecosystem** Marine ecosystem: benthic & littoral zone, saltpan, mangroves and estuarine microbes, microbial loop - marine microbial communities - phytoplankton, protozoa, bacteria, fungi, and virus. Microbial endosymbionts – epiphytes – coral microbial association, sponge-microbial association.	12
II	**Microbes of Extreme Environments** Mechanism of extremophiles – halophiles –halorhodopsin – deep sea microbes – microbes of hydrothermal vents – thermophilic, alkalophilic, osmophilic and barophilic, psychrophilic microorganisms – hyperthermophiles and halophiles –importance in biotechnology.	12

III	**Microbial Ecology** concept of community, fluctuation and succession; Ecological pyramid; energy flow; food chain; food webs and their dynamism, stability and complexity of ecosystem; Interactions between microbes and organisms at trophic levels: commensalism, mutualism, parasitism and predation with examples; Microbial Communities: Microenvironment and niche; communities in soil, water, air; Biofilms, microbial mats and their significance. Major environmental conditions influencing microflora; Distribution of microorganisms in the aquatic environments – freshwater environment, estuaries and marine environment; Microbiology of drinking water; water pollution; purification of water for human consumption.	12

IV	**Dynamics of Marine Microbes** Carbon cycle: Phototrophic microbes, the oceanic carbonate system and global warming - Nitrogen cycle: Nitrogen fixers – Iron limitation – ocean fertilization - phosphorus cycle; Decomposition of organic matter; Bioleaching and biodeteroriation of natural and synthetic materials.	12
V	**Microbiology of Wastewater and Solid Waste Treatment** Wastewater characteristics; Effluent treatment processes (like trickling filter, activated sludge, oxidative pond, anaerobic digestion and chemical disinfection); Biological, aerobic, anaerobic, primary, secondary and tertiary treatments; Activated sludge and Anaerobic digestion process. Treatment of industrial effluents by microorganisms; Factors affecting the bioremediation process; Bioremediation of toxic waste sites; Role of microbes; Microbial degradation of environmental pollutants-industrial solvents, pesticides, petroleum hydrocarbons, xenobiotics; bioremediation practices and technologies; Biofuel production from organic wastes; Bioleaching.	12

	Tasks and Assignments: • Internal exams • A quiz on mechanisms of extremophiles • An assignment on abiotic and biotic factors in an ecosystem • Presenting an example of Bioremediation of toxic waste sites and its influence on environment **References:** • Marine Biology by Peter Castro and Michael, 10th edition by McGraw Hill (2015) • Extremophiles: Microbial Life in Extreme Environments by Horikoshi and Grant, Published by Wiley (1998) • Environmental Microbiology of Aquatic and Waste Systems by Nduka Okafor, Published by Springer (2011) • Environmental Microbiology: Fund amentals and Applications: Microbial Ecology by Bertrand et al. (2015), Published by Springer Nature.	

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**3**	**3**	**3**	**2**
CO2	**3**	**3**	**3**	**3**	**3**
CO3	**2**	**2**	**2**	**3**	**3**
CO4	**3**	**3**	**3**	**3**	**3**
CO5	**2**	**2**	**2**	**2**	**2**

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	2	2	-	-	2
Seminar	-	-	2	2	-
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part–A (Objective-10x1=10marks)	2	2	2	2	2
Part–B (ShortAnswer-5x3=15marks)	3	3	3	3	3
Part–C (Essay-5x7=35marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content 50%**	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO2,CO4, CO5
2	**Organiza-tion 50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO2,CO4, CO5

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Knowledge and Understanding 50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1,CO3
2	**Presentation 50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO1,CO3

i. Model Question Paper

Sl. No.	Model Questions	Specification	Level
Part–A:Objective Type Multiple Choice Marks:10x1=10			
1	1.____leached from mangrove litter, controls bacterial population and reduces harmful activities of virulent pathogens. A. Organic acids	Recognize	Remember

	B. Tannins C. Methane D. All of the above		
2	Blind roots to overcome respiration problem in anaerobic soil conditions A. Proproots B. Pneumatophores C. Stiltroots D. Adventitious roots	Recall	Remember
3	Zone beyond the continental shelf and occurs at depth of 150-4000 m A. Abyssal zone B. Bathyal zone C. Hadalzone D. Intertidal zone	Recognize	Remember
4	_____ Is the most common and diverse bacterial phyla in Sponges A. Chloroflexi B. Dendrilla C. Gamma- proteobacteria D. None of the above	Recognize	Remember
5	Enzyme isolated from halophilic bacteria of mangrove sediments A. Permease B. L-asparaginase C. Arylsulfayase D. All of the above	Recognize	Remember
6	Translocation of effectors of pathogen into the plant cell is done by which of the following secretion systems in bacteria? A. Type I B. Type II C. Type III D. All the above	Recognize	Remember
7	Which of the following statements is not applicable to Systemic acquired resistance (SAR)? A. SAR prepares plant for a second attack by pathogen B. SAR brings about local cell death and sealing off of the pathogen C. Both Salicilic acid and Jasmonic acid are involved in SAR D. SAR once acquired lasts for a period of several days	Recall	Remember
8	Which of the following Bacteria is responsible for causing disease in plants-spanning a very large number of families and hundreds of species? *A. Erwinia amylovora*	Recall	Remember

	B. Ralstonia solanacearum *C. Xanthomonas oryzae* D. *Botryti scinerea*		
9	Biological oxidation processes usually referred as biological treatment, are the most common form of A. Primary treatment B. Secondary treatment C. Tertiary treatment D. All of these	Identify	Remember
10	Which one of the following is not a biofertiliser? *A. Azotobacter* *B. Clostridium* *C. Bacillus thuringiensis* D. *Azolla*	Identify	Remember
PART–B Short Answer **The answer should not exceed 200words Marks:5x3=15**			
11	Write a short notes on shrimp diseases	Explain and cite	Remember
12	Write about importance of extremophiles in biotechnology	Explain	Understand
13	Describe the significance of ecological pyramid	Describe	Analyze
14	Explain the differences between bioleaching and biodeterioration	Differentiate	Analyze
15	Describe about biofuel production from organic wastes	Describe	Remember
PART–C Essay Answer **The answer should not exceed 400words Marks: 5x7=35**			
16	a) Define ecosystem and what are different types of ecosystems? (or) b) Explain the microbial diversity in mangrove ecosystem.	Explain and cite	Remember
17	a) Explain in detail the microbial diversity in estuaries. (or) b) Explain the spatial distribution of microorganisms in marine ecosystem	Explain	Understand
18	a) Explain the interaction between sponge-specific microbial symbionts (or) b) Explain in detail (with diagrams) the "salt-in" and "salt- out"strategy employed by halophiles for survival in Saline environments.	Describe	Analyze
19	a) List out 4 genome adaptations of thermophiles (or) b) Write an essay on halorhodopsin	Differentiate	Analyze

20	a) What is non-host resistance? Using well labelled diagrams, briefly explain the two types of non-host resistance inplants (or) b) What is the major mechanism of pathogen removal during activated sludge treatment	Describe	Remember

SEMESTER V					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIB5053	**Marine & Environmental Microbiology**	4	-	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO1	To introduce marine ecosystem and associated microbial communities. To gain knowledge on seafood contamination with microbes.	Understand
CO2	To study in detail the mechanisms employed by the extremophiles to survive in extreme environments.	Apply
CO3	To study the interactions between microorganisms at different trophic levels and their association with surrounding abiotic factors.	Understand
CO4	To gain knowledge on microbiology of aquatic environments and associated biogeochemical cycles	Analyze
CO5	To study the microbial communities of waste water, importance and process on waste water management. To understand the concept and importance of bioremediation and role of microbes in bioremediation.	Apply

b. Syllabus

Units	**Content**	**Hrs.**
I	**Introduction to Marine Ecosystem** Marine ecosystem: benthic & littoral zone, saltpan, mangroves and estuarine microbes, microbial loop - marine microbial communities - phytoplankton, protozoa, bacteria, fungi, and virus. Microbial endosymbionts – epiphytes – coral microbial association, sponge-microbial association.	12
II	**Microbes of Extreme Environments** Mechanism of extremophiles – halophiles –halorhodopsin – deep sea microbes – microbes of hydrothermal vents – thermophilic, alkalophilic, osmophilic and barophilic, psychrophilic microorganisms – hyperthermophiles and halophiles –importance in biotechnology.	12
III	**Microbial Ecology** concept of community, fluctuation and succession; Ecological pyramid; energy flow; food chain; food webs and their dynamism, stability and complexity of ecosystem; Interactions between microbes and organisms at trophic levels: commensalism, mutualism, parasitism and predation with examples; Microbial Communities: Microenvironment and niche; communities in soil, water, air; Biofilms, microbial mats and their significance. Major environmental conditions influencing microflora; Distribution of	12

	microorganisms in the aquatic environments – freshwater environment, estuaries and marine environment; Microbiology of drinking water; water pollution; purification of water for human consumption.	
IV	**Dynamics of Marine Microbes** Carbon cycle: Phototrophic microbes, the oceanic carbonate system and global warming - Nitrogen cycle: Nitrogen fixers – Iron limitation – ocean fertilization - phosphorus cycle; Decomposition of organic matter; Bioleaching and biodeteroriation of natural and synthetic materials.	12
V	**Microbiology of Wastewater and Solid Waste Treatment** Wastewater characteristics; Effluent treatment processes (like trickling filter, activated sludge, oxidative pond, anaerobic digestion and chemical disinfection); Biological, aerobic, anaerobic, primary, secondary and tertiary treatments; Activated sludge and Anaerobic digestion process. Treatment of industrial effluents by microorganisms; Factors affecting the bioremediation process; Bioremediation of toxic waste sites; Role of microbes; Microbial degradation of environmental pollutants-industrial solvents, pesticides, petroleum hydrocarbons, xenobiotics; bioremediation practices and technologies; Biofuel production from organic wastes; Bioleaching.	12
	Tasks and Assignments: • Internal exams • A quiz on mechanisms of extremophiles • An assignment on abiotic and biotic factors in an ecosystem • Presenting an example of Bioremediation of toxic waste sites and its influence on environment **References:** • Marine Biology by Peter Castro and Michael, 10th edition by McGraw Hill (2015) • Extremophiles: Microbial Life in Extreme Environments by Horikoshi and Grant, Published by Wiley (1998) • Environmental Microbiology of Aquatic and Waste Systems by Nduka Okafor, Published by Springer (2011) • Environmental Microbiology: Fund amentals and Applications: Microbial Ecology by Bertrand et al. (2015), Published by Springer Nature.	

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**3**	**3**	**3**	**2**
CO2	**3**	**3**	**3**	**3**	**3**
CO3	**2**	**2**	**2**	**3**	**3**
CO4	**3**	**3**	**3**	**3**	**3**
CO5	**2**	**2**	**2**	**2**	**2**

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	2	2	-	-	2
Seminar	-	-	2	2	-
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part–A (Objective-10x1=10marks)	2	2	2	2	2
Part–B (ShortAnswer-5x3=15marks)	3	3	3	3	3
Part–C (Essay-5x7=35marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content 50%**	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO2,CO4, CO5
2	**Organiza-tion 50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO2,CO4, CO5

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs

1	**Knowledge and Understanding 50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1,CO3
2	**Presentation 50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO1,CO3

i. Model Question Paper

Sl. No.	**Model Questions**	**Specification**	**Level**
Part–A:Objective Type Multiple Choice Marks:10x1=10			
1	1.____leached from mangrove litter, controls bacterial population and reduces harmful activities of virulent pathogens. A. Organic acids B. Tannins C. Methane D. All of the above	Recognize	Remember
2	Blind roots to overcome respiration problem in anaerobic soil conditions A. Proproots B. Pneumatophores C. Stiltroots D. Adventitious roots	Recall	Remember
3	Zone beyond the continental shelf and occurs at depth of 150-4000 m A. Abyssal zone B. Bathyal zone C. Hadalzone D. Intertidal zone	Recognize	Remember
4	Is the most common and diverse bacterial phyla in Sponges A. Chloroflexi B. Dendrilla C. Gamma- proteobacteria D. None of the above	Recognize	Remember
5	Enzyme isolated from halophilic bacteria of mangrove sediments A. Permease B. L-asparaginase	Recognize	Remember

	C. Arylsulfayase D. All of the above		
6	Translocation of effectors of pathogen into the plant cell is done by which of the following secretion systems in bacteria? A. Type I B. Type II C. Type III D. All the above	Recognize	Remember
7	Which of the following statements is not applicable to Systemic acquired resistance (SAR)? A. SAR prepares plant for a second attack by pathogen B. SAR brings about local cell death and sealing off of the pathogen C. Both Salicilic acid and Jasmonic acid are involved in SAR D. SAR once acquired lasts for a period of several days	Recall	Remember
8	Which of the following Bacteria is responsible for causing disease in plants-spanning a very large number of families and hundreds of species? *A. Erwinia amylovora* *B. Ralstonia solanacearum* *C. Xanthomonas oryzae* D. *Botryti scinerea*	Recall	Remember
9	Biological oxidation processes usually referred as biological treatment, are the most common form of A. Primary treatment B. Secondary treatment C. Tertiary treatment D. All of these	Identify	Remember
10	Which one of the following is not a biofertiliser? *A. Azotobacter* *B. Clostridium* *C. Bacillus thuringiensis* D. *Azolla*	Identify	Remember
PART–B Short Answer **The answer should not exceed 200words Marks:5x3=15**			
11	Write a short notes on shrimp diseases	Explain and cite	Remember
12	Write about importance of extremophiles in biotechnology	Explain	Understand
13	Describe the significance of ecological pyramid	Describe	Analyze
14	Explain the differences between bioleaching and biodeterioration	Differentiate	Analyze
15	Describe about biofuel production from organic wastes	Describe	Remember
PART–C Essay Answer **The answer should not exceed 400words Marks: 5x7=35**			
16	a) Define ecosystem and what are different types of ecosystems? (or) b) Explain the microbial diversity in mangrove	Explain and cite	Remember

	ecosystem.		
17	a) Explain in detail the microbial diversity in estuaries. (or) b) Explain the spatial distribution of microorganisms in marine ecosystem	Explain	Understand
18	a) Explain the interaction between sponge-specific microbial symbionts (or) b) Explain in detail (with diagrams) the "salt-in" and "salt- out"strategy employed by halophiles for survival in Saline environments.	Describe	Analyze
19	a) List out 4 genome adaptations of thermophiles (or) b) Write an essay on halorhodopsin	Differentiate	Analyze
20	a) What is non-host resistance? Using well labelled diagrams, briefly explain the two types of non-host resistance inplants (or) b) What is the major mechanism of pathogen removal during activated sludge treatment	Describe	Remember

SEMESTER - V					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIB5055	**Molecular Cell Biology**	4	-	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

Course Outcome		**Level**
CO-1	To understand the building blocks of cells.	**Understand**
CO-2	To understand how genetic information is stored and organized.	**Understand**
CO-3	To get insights in the Central dogma of life and its components	**Analyze**
CO-4	To understand and analyze how the cells maintain internal balance and respond to signals.	**Analyze Understand**
CO-5	Apply the basic knowledge to comprehend how cells grow, divide, and what happens when things go wrong.	**Apply**

b. Syllabus

Units	**Content**	**Hrs.**
I	**Cell Structure and Biomolecules** Basic properties of cells, Prokaryotic vs eukaryotic cells; Cell size, shape, and composition, Structure of biological membranes (fluid mosaic model), Membrane lipids and proteins; Introduction to biomolecules: DNA, RNA, Proteins; Overview of intracellular organelles: Nucleus, Mitochondria, Endoplasmic Reticulum, Golgi apparatus	12
II	**Nucleic Acids and Gene Organization** DNA as genetic material, Structure of DNA (Watson–Crick model), Forms of DNA (A, B, Z – basic idea); RNA types: mRNA, tRNA, rRNA; Basic RNA structure and functions, Gene concept and basic gene organization; Chromatin structure (nucleosome concept); Introduction to regulatory RNAs (miRNA, siRNA – basic roles)	12
III	**Gene Expression (Central Dogma)** DNA Replication: Semi-conservative replication (basic concept); Key enzymes: DNA polymerase, helicase, ligase; Transcription: RNA polymerase (basic role), Steps: initiation, elongation, termination, mRNA processing (capping, poly-A tail, splicing – overview); Translation: Genetic code (basic properties), Role of tRNA and ribosomes, Steps: initiation, elongation, termination.	12
IV	**Cell Function and Communication** Membrane transport: diffusion, active transport (basic), Vesicular transport: endocytosis and exocytosis, Basics of cell signalling; Types of signals (autocrine, paracrine, endocrine); Receptors (surface receptors – basic idea); Introduction to cytoskeleton (actin and microtubules); Protein targeting and secretion (simple overview).	12
V	**Cell Cycle, Death and Disease** Cell cycle phases (G1, S, G2, M); Mitosis (basic stages); Meiosis (overview and significance); Cell cycle regulation (basic checkpoints); Introduction to apoptosis vs necrosis;	12

	Basic idea of mutations (types and causes); DNA repair (simple overview); Cancer as a result of cell cycle defects	
	Tasks and Assignments: • Internal exams · A quiz on cellular organelles · An assignment on autophagy and cell death · Group discussion on DNA damage and repair mechanism **References:** • Alberts, B., Hopkin, K., Johnson, A., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2019). *Essential Cell Biology* (5th ed.). W. W. Norton & Company. • Cooper, G. M., & Hausman, R. E. (2019). *The Cell: A Molecular Approach* (8th ed.). Sinauer Associates / Oxford University Press. • Campbell, N. A., Reece, J. B., Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P. V., & Orr, R. B. (2017). *Biology: A Global Approach* (11th ed.). Pearson. • Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., & Scott, M. P. (2008). *Molecular Cell Biology* (5th ed.). W. H. Freeman and Company.	

c. Mapping of Program Outcomes with Course Outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**3**	**3**	**2**	**3**	**3**
CO2	**2**	**1**	**3**	**2**	**3**
CO3	**2**	**2**	**2**	**1**	**2**
CO4	**3**	**1**	**3**	**2**	**2**
CO5	**3**	**3**	**2**	**3**	**3**

d. Evaluation Scheme

	CO1	**CO2**	**CO3**	**CO4**	**CO5**	**Total**
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	**CO2**	**CO3**	**CO4**	**CO5**
Assignments	2	2	-	-	2
Seminar	-	-	2	2	-
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**

Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Essay- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No.	**Criteria**	**100%**	**75%**	**50%**	**25%**	**0%**	**Relation to COs**
1	**Content 50%**	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organiza-tion 50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

h. Rubric for Seminar

Sl. No.	**Criteria**	**100%**	**75%**	**50%**	**25%**	**0%**	**Relation to COs**
1	**Knowledge and Understanding 50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4
2	**Presentation 50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

i. Model Question Paper

Sl. No.	Model Questions	Specification	Level
	Part – A: Objective Type **Multiple Choice Marks: 10 x 1 = 10**		
1	Which of the following is a characteristic feature of prokaryotic cells? A) Membrane-bound nucleus B) Presence of mitochondria C) Absence of membrane-bound organelles D) Presence of Golgi apparatus	Recognize	Remember
2	According to the fluid mosaic model, the plasma membrane is composed mainly of: A) Cellulose and proteins B) Lipids and proteins C) DNA and RNA D) Chitin and lipids	Recall	Remember
3	Which form of DNA is the most common under physiological conditions? A) A-DNA B) B-DNA C) Z-DNA D) C-DNA	Recognize	Remember
4	Which RNA type carries amino acids to the ribosome during protein synthesis? A) mRNA B) rRNA C) tRNA D) miRNA	Recognize	Remember
5	Enzyme isolated from halophilic bacteria of mangrove sediments a. Permease b. L-asparaginase c. Arylsulfayase d. all of the above Which enzyme joins Okazaki fragments during DNA replication? A) Helicase B) DNA polymerase C) Ligase D) Primase	Recognize	Remember
6	The genetic code is read in groups of: A) Two nucleotides B) Three nucleotides C) Four nucleotides D) Five nucleotides	Recognize	Remember
7	Movement of molecules from a region of higher concentration to lower concentration is called: A) Active transport B) Endocytosis C) Diffusion D) Exocytosis	Recall	Remember
8	Which component of the cytoskeleton is mainly involved in chromosome movement during cell division?	Recall	Remember

	A) Actin filaments B) Intermediate filaments C) Microtubules D) Collagen fibers		
9	DNA replication occurs during which phase of the cell cycle? A) G1 phase B) S phase C) G2 phase D) M phase	Identify	Remember
10	Programmed cell death is known as: A) Necrosis B) Mutation C) Apoptosis D) Differentiation	Identify	Remember
	PART – B Short Answer **The answer should not exceed 200 words Marks :5 x 3 =15**		
11	Differentiate between prokaryotic and eukaryotic cells.	Explain and cite	Remember
12	What is a nucleosome?	Explain	Understand
13	What is meant by semi-conservative replication?	Describe	Analyze
14	Define endocytosis and exocytosis.	Differentiate	Analyze
15	Differentiate between apoptosis and necrosis.	Describe	Remember
PART – C Essay Answer **The answer should not exceed 400 words Marks: 5 x 7= 35**			
16	Describe the structure and functions of biological membranes based on the fluid mosaic model. (or) Explain the structure and functions of intracellular organelles such as nucleus, mitochondria, endoplasmic reticulum, and Golgi apparatus.	Explain and cite	Remember
17	Describe the Watson–Crick model of DNA structure and explain the different forms of DNA. (or) Discuss the structure and functions of mRNA, tRNA, and rRNA, and explain the concept of gene organization.	Explain	Understand
18	Explain the process of DNA replication and describe the role of major enzymes involved. (or) Describe the processes of transcription and translation in gene expression.	Describe	Analyze
19	Explain the different types of membrane transport and vesicular transport mechanisms. (or) Discuss the basics of cell signalling, receptors, and the role of cytoskeleton in cell function.	Differentiate	Analyze
20	Describe the stages of mitosis and explain their significance	Describe	Remember

	in cell division. (or) Discuss cell cycle regulation, mutations, DNA repair mechanisms, and the relationship between cell cycle defects and cancer.		

SEMESTER - V					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIB5056	Molecular Cell Biology Practical	-	-	2	2

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	Course Outcome	**Level**
CO 1	To provide hands-on experience in fundamental cell biology techniques, including microscopy, staining, organelle isolation, cell fractionation, and biomolecule quantification, enabling students to visualize and analyze cellular structures and functions.	**Apply, Analyze**
CO 2	To develop practical skills in experimental design, data collection, and interpretation, allowing students to understand principles such as cell division, membrane transport, cell viability, and macromolecule extraction.	**Understand, Appy**
CO 3	To train students in laboratory safety, accurate experimental execution, and scientific reporting, fostering competence in handling biological materials, maintaining lab records, and presenting results with clarity and precision.	**Apply, Analyze**
CO 4	To be able to work with protoplast systems and isolate cellular components	**Understand, Appy**
CO 5	To be able to isolate and quantify biomolecules like DNA, RNA and Proteins	**Apply, Analyze**

b. Syllabus

Units	**Content**	**Hrs.**
I	1. Microscopy and observation of cell types 2. Staining of intracellular organelles and nuclei in cells 3. Total cell count (Haemocytometer) 4. Estimation of Cell viability (Trypan Blue Assay) 5. DNA extraction from Plant or Bacterial cells	56
II	6. Quantification & Analytical Separation of DNA 7. Protein quantification (Bradford or Lowry method) 8. Separation of Cellular components by centrifugation 9. Preparation of viable Cell protoplasts 10. Isolation, quantification and purity analysis of RNA	56
	Tasks and Assignments: Each student is required to submit the following: • Each student should discuss complete details of DNA extraction methodology • Students should demonstrate the protein quantification technique • Participate in the subject-oriented quiz. **References:** • Cell Biology: A Laboratory Handbook (edited by Julio E. Celis)	

	• Cells: A Laboratory Manual (3-Volume Set) (edited by David L. Spector, Robert Goldman & Leslie Leinwand • Cell Biology Protocols (by J. Robin Harris, John M. Graham & David Rickwood) • Cell Biology: Assays – Essential Methods (edited by Geri Kreitzer)	

SEMESTER -IV					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIB 5061	Bioanalytical Techniques	3	-	-	3

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO 1	Understand the principle, operation, and applications of instruments like pH meters, fluorescence microscopy.	**Understand**
CO 2	Apply the electrophoresis techniques to separate biomolecules	**Apply**
CO 3	Understanding the principles of centrifugation and chromatography techniques and apply knowledge in biomolecules separation and purification	**Understand**
CO 4	Understand various assays used in drug discovery and basic research and analyze the results	**Analyze**
CO 5	Use scientific reasoning to interpret results of experiments	**Interpret**

b. Syllabus

Units	**Content**	**Hrs.**
I	**Unit I: Basics in analytical techniques** Introduction to bioanalytical techniques, scope and importance, basic laboratory practices and safety, accuracy and precision, sensitivity and specificity, nucleic acid quantification and protein estimation methods, pH and buffer, Enzyme assays, application of microscope in analyzing biological samples, fluorescence microscope, immunocytochemistry, immunohistochemistry and applications.	9
II	**Unit II**: **Electrophoretic Techniques** Electrophoresis-basic principles, procedure and applications of paper, cellulose acetate, polyacrylamide and agarose gel electrophoresis, electro-blotting, isoelectric focusing; 2D PAGE, immunoelectrophoresis, capillary electrophoresis and Pulsed Field Gel electrophoresis (PFGE).	9
III	**Unit III: Centrifugation and chromatography techniques** Principles of centrifugation, centripetal and centrifugal forces, factors affecting sedimentation rate, types of rotors, types of centrifugation and applications, cell fractionation, organelle isolation, biomolecule purification, ion exchange and affinity chromatography, Paper and	9

	Thin Layer chromatography, High-Performance Liquid Chromatography and their applications.	
IV	**Unit IV**: **Bioanalytical assays** ELISA, Cell based proliferation and viability assays, Nitric Oxide assay, Reactive Oxygen Species detection assay, kinase assays, enzyme activity assays, ATP quantitation assay, Cytokine assays, Cell analysis – cell sorting, flow cytometry, RNA quantitation and expression assays, protein quantitation and expression assays.	9
V	**Unit V: Applications and recent trends** Recent trends in Drug Discovery: High Throughput Screening, High Content Screening, Imaging instruments, cancer cell lines, primary cells, animal model, gene knockdown in drug discovery applications, Computer aided drug design, constrains in modern technologies, prospects.	9
	Tasks and Assignments: • Internal exams • A quiz • An assignment • Presentation **Reference Books** 1. Andreas Hofmann and Samuel Clokie, Wilson and Walkers Principles and Techniques of Biochemistry and Molecular Biology (2018). 2. Vasudevan Ramesh, Biomolecular and Bioanalytical Techniques: Theory, Methodology and Applications (2019). 3. Principles and Techniques of Biochemistry and Molecular Biology (2010) 7th Edition by Keith Wilson. 4. Physical Biochemistry: Principles and Applications by David Sheehan 2nd Edition, John Wiley & Sons (2009) 5. Bioanalytical Techniques, Sekhar Talluri, I.K. International Publishing House Pvt. Ltd. (2012)	

c. Mapping of Program Outcomes with Course Outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**3**	**2**	**2**	**2**	**2**
CO2	**3**	**3**	**3**	**2**	**3**
CO3	**3**	**3**	**2**	**3**	**2**
CO4	**3**	**2**	**3**	**3**	**3**
CO5	**2**	**2**	**2**	**2**	**2**

d. Evaluation Scheme

	CO1	**CO2**	**CO3**	**CO4**	**CO5**	**Total**
Internal	8	8	8	8	8	40

External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	**CO2**	**CO3**	**CO4**	**CO5**
Assignments	2	2	-	-	2
Seminar	-	-	2	2	-
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Part – A **(Objective - 10 x 1 = 10 marks)**	2	2	2	2	2
Part – B **(Short Answer - 5 x 3 = 15 marks)**	3	3	3	3	3
Part – C **(Essay- 5 x 7 = 35 marks)**	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No.	**Criteria**	**100%**	**75%**	**50%**	**25%**	**0%**	**Relation to COs**
1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organiza -tion** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

h. Rubric for Seminar

Sl. No.	**Criteria**	**100%**	**75%**	**50%**	**25%**	**0%**	**Relation to COs**

1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

i. Model Question Paper

Sl. No.	Model Questions	Specification	Level
	Part – A: Objective Type **Multiple Choice Questions Marks: 10 x 1 = 10**		
1	The pore size of polyacrylamide gels can be modified according to the protein sizes to be analyzed. How? a) By using a marker ladder containing higher molecular weights. b) By adjusting the ratio of acrylamide to bisacrylamide. c) By adjusting the temperature during gel preparation. By adjusting the pH of the employed buffer.	Analyze	Remember
2	How do you quantitate the antigen which is binding to the monoclonal antibody in ELISA? a) Centrifugation method b) using the antigen as standard c) using Bradford's method using western blot method	Understand	Understand
3	What is the main difference between SDS and Native Page? a) Native Page involves a blotting step. b) Proteins are analyzed oligomers with SDS Page c) Proteins are denatured for SDS Page analysis. Proteins are detected using antibodies with Native Page.	Remember	Apply
4	Chromatography is a physical method that is used to separate----------. a) Simple mixtures b) Complex mixtures c) Viscous mixtures	Understand	Analyze

	Metals		
5	Which force is involved in the Chromatograph? a) Hydrogen bonding b) London force c) Electric static force All of the above	Apply	Skill
6	Electrophoresis was developed by: a) Tswett b) Tsvedberg c) Tiselius d) Sanger	Remember	Apply
7	The speed of migration of ions in electric field depends upon: a) Shape and size of molecule b) Magnitude of charge and shape of molecule c) Magnitude of charge shape and mass of molecule Magnitude of charge and mass of molecule	Understand	Analyze
8	Thermus aquatics is the source of _____. a) Vent polymerase b) Primase enzyme c) Taq polymerase Both a and c	Apply	Skill
9	Reverse transcription PCR uses _____. a) RNA as a template to form DNA b) mRNA as a template to form cDNA c) DNA as a template to form ssDNA All of the above	Analyze	skill
10	Rodent model refers to a) Mouse b) Rat c) Hamsters Mouse, Rat, Hamsters	skill	Analyze
	PART – B Short Answer **The answer should not exceed 200 words Marks: 5 x 3 = 15**		
11	List the disadvantages of Transmission Electron Microscopy?	Remember	Skill
12	Summarize two types of protein estimation methods.	Understand	skill
13	Briefly explain the principle of Thin Layer Chromatography.	Apply	understand
14	How do you quantitate cell death? Explain at least two methods.	Remember	understand
15	What is cell line cross contamination? Briefly explain.	Apply	skill
PART – C Essay Answer **The answer should not exceed 400 words Marks: 5 x 7= 35**			
16	What are the different types of light microscopy available? How light microscopy works? Explain the gram staining. (Or) What are the difference between SEM and TEM? Why the SEM specimen coated with ultra-thin coating materials?	Understand	Apply

17	How DNA and protein microarray works? (Or) What are DNA markers? Explain.	Analyze	Skill
18	Differentiate 2D PAGE and PFGE? Or What is sandwich ELISA? Write the principle of ELISA.	skill	Understand
19	What is cytokine antibody array? How it is used in clinical research? Or Explain the principle of Flow cytometry. Mention 3 applications of Flow cytometry.	Understand	skill
20	How do you screen and identify an anti-inflammatory drugs? Propose a method by using high throughput screening. Or How do you screen to find out anti-cancer drug? Propose a method by using High content screening.	Apply	understand

SEMESTER VI					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIB5062	Medical Microbiology	4	-	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO 1	To understand the pathogenic microorganisms and their infection mechanisms, epidemiology.	Understand
CO 2	To understand the concepts of infection control, treatment and etiology.	Analyze
CO 3	To study on emerging and reemerging infections and communicable diseases.	Apply
CO 4	To understand the existing molecular and rapid diagnostic methods.	Understand
CO 5	To understand the concept of diagnostic biosensors, microfluidic devices and their development	Analyze

b. Syllabus

Units	**Content**	**Hrs.**
I	**Introduction to pathogens:** Introduction to Medical Microbiology – history, Classification of medically important microorganisms - Normal microbial flora and transient flora-Host bacterial interactions. Sepsis, Nosocomial and community acquired infections – Epidemiology of infectious diseases. Transmission of infectious diseases, their role in health & disease causation. Roles of ICMR and DHR in infection control.	12
II	**Medical Bacteriology**: Role of bacteria in disease, Staphylococcus and related organisms,	12

	Streptococcus, Enterococcus and other Gram Positive cocci, Bacillus, and Listeria, Corynebacterium and other Gram positive rods, Mycobacterium, Neisseria and related genera, Enterobacteriaceae, Vibrio, Campylobacter and Helicobacter, Pseudomonas and related organisms, Anaerobic spore-forming Gram positive bacilli, Anaerobic nonspore-forming Gram positive bacteria, Anaerobic Gram negative bacteria	
III	**Medical Virology:** Human herpesviruses, Human Papilloma virus, Adenoviruses, Picornaviruses, Coronaviruses, Orthomyxoviruses, Rhabdoviruses, Filoviruses, Flaviviruses, Arenaviridae, Retroviruses, hepatitis viruses, Unconventional agents and prions; oncoviruses, Measles, Mumps, Rubella, Chicken Pox, Hepatitis A, B,C, D and E, Poliomyelitis, Yellow fever, Dengue HIV, SARS-COVID and Rabies. .	12
IV	**Medical Mycology:** Role of fungi in diseases, Pathogenesis of fungal diseases; In-vitro diagnosis of fungal diseases; Superficial and cutaneous mycoses, Subcutaneous mycoses, Systemic mycoses caused by endemic dimorphic fungal pathogens, Opportunistic mycoses; Aspergillosis and candidiasis, Mycotoxins and mycotoxicosis;	12
V	**One health: Diagnostic methods and Point of care:** Microscopic Examination of samples; Biochemical method of microbial identification and tools; Nucleic acid detection (amplification and hybridization) based diagnostics: Enzyme-Linked Immunoassays and types, Isothermal amplification, Mass spectrometry based-microbial identification system, Point-of-care diagnostics and their importance, Microfluidics, lateral flow devices and preparation.	12
	Tasks and Assignments: • Internal exams • A quiz on pathogenic microbes and their identification • Seminar on infection spread control, and treatment • Group discussions on the topic of diagnostics **References:** 1. Microbiology, Prescott, Harley and Klein's. 7th edition McGraw Hill Medical Publication division. 2007. 2. Medical Microbiology. A Guide to Microbial Infections: Pathogenesis, immunity, Laboratory investigation and Control. David Greenwood. Mike Barer, Richard Slack and Will Irving. , 18th edition, Churchill Livingstone. 2012. 3. Clinical MicrobiologyMurray P.R., Pfaller M.A., Tenover F.C., & Yolken R.H. 2007. ASM Press 4. Medical Microbiology: An Introduction to Infectious	

	DiseasesSherris, John C. , 2nd Edition	

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**3**	**3**	**3**	**2**
CO2	**3**	**3**	**3**	**3**	**3**
CO3	**2**	**2**	**2**	**3**	**3**
CO4	**3**	**3**	**3**	**3**	**3**
CO5	**2**	**2**	**2**	**2**	**2**

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	2		-	2	2
Seminar	-	2	2	-	-
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Essay- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs

1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO4, CO5
2	**Organiza-tion** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO4, CO5

h. Rubric for Seminar

Sl. No.	**Criteria**	**100%**	**75%**	**50%**	**25%**	**0%**	**Relation to COs**
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO2, CO3
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO2, CO3

i. Model Question Paper

Sl. No.	**Model Questions**	**Specification**	**Level**
	Part – A: Objective Type **Multiple Choice** **Marks: 10 x 1 = 10**		
1	Incubation period for the *Plasmodium malariae* is----------. a. 6-12 days b. 10-17 days	Recall	Remember

	c. 12-16 days d. 28-30 days		
2	Strobila is also called a. Tail b. Head c. Trunk d. Neck	Recognize	Remember
3	Many different medical problems may be related to *Aspergillus fumigatus*. Select the option that represents the least likely outcome a. Thrush b. Colonization of tuberculous cavities in the lung c. Tissue invasion in immunocompromised host d. Allergy following inhalation of airborne particles of the fungus	Recall	Remember
4	A 2-year-old girl was diagnosed with acute bronchopneumonia, and her bronchial secretions contained large, multinucleated clumps of cells, suggesting that the infection was caused by a. *Bordetella pertussis* b. Epstein-Barr virus c. Rhinovirus d. Respiratory Syncytial Virus	Identify	Remember
5	Skin infected with _____ is usually red, warm, tender to the touch, swollen, and or painful. a) *Mycobacterium abscessus* b) *Mycobacterium leprae* *c) Mycobacterium tuberculosis* *d) Mycobacterium chelonae*	Recognize	Remember
6	Following is an antimalarial drug that is thought to increase ROS levels in target cells? **a) artemisinin** b) amphotericin b c) praziquantel d) pleconaril	Identify	Remember
7	Toxins that are stable at 100° C for 30 minutes resist hydrolysis by gastric enzymes are_____ a) Cytotoxins b) Enterotoxins c) exotoxins d) all the above	Recall	Remember

8	Which statement is correct for Brucella a) Gram positive cocci, aerobic, non-motile b) Gram negative cocci, anaerobic, non-motile c) Gram positive cocci, anaerobic, and motile d) Gram negative cocci, aerobic, non-motile	Identify	Remember
9	*The bacterial plasma membrane is composed primarily of protein and phospholipid in the ration of* *a) **3:1** b) 2:2 c) 1:3 d) 3:2*	Recall	Remember
10	A disease constantly present at some rate of occurrence in a particular location a) Epidemic b) **Endemic** c) d) out break d) disease prevalence	Recall	Remember
	PART – B Short Answer **The answer should not exceed 200 words Marks:5 x 3 = 20**		
11	A) What can I expect if I have an *E. coli* infection? B) Pathogenicity of A. baumannii	Differentiate	Remember
12	Detail the fecal microbiota and treatment of Diarrhoea	Demonstrate	Understand
13	Discuss up on retro virus structure and their examples	Describe	Analyze
14	What are aflatoxins?	Explain	Analyze
15	How does the microbiome affect immunity and contribute to disease?	Interpret	Remember
PART – C Essay Answer **The answer should not exceed 400 words Marks: 5 x 7= 35**			
16	a) Explain in detail a) Sepsis b) Nosocomial and community acquired infections Or b) Classification of pathogens and Epidemiology of infectious diseases.	Explain	Understand
17	a) Detail: Pseudomonas aeruginosa and their culturing characteristics, treatment and control Or Detail: Staphylococcus related toxins and their mechanism of infection	Differentiate	Remember
18	a) Explain: Human papilloma virus and their structural component and epidemiology Or b) Mechanism of SARS-Covid 19 infection in human.	Explain	Understand
19	a) What are Superficial and cutaneous mycoses, Subcutaneous mycoses Or	Explain	Understand

	b) What are the established molecular diagnostics available for fungal infections?		
20	a) How one health and AMR are inter connected? explain it in detail. Or b) Explain Zoonosis and control measures using an example		Analyze

SEMESTER-VI					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIB5063	**Medical Microbiology Practical**	**-**	**-**	2	**2**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO1	To gain proficiency in the fundamental techniques used in culturing infectious/pathogenic microorganisms	**Understand & Apply**
CO2	Identification of microorganisms using biochemical methods and studying their antimicrobial profile, MIC, IC50.	**Understand & Apply**
CO3	Determination of biofilm formation and diagnostic methods	**Apply, Analyze**
CO4	Analysing the antibiotic susceptibility of an bacterium	**Understand & Analyze**
CO5	Isolation and characterization and biochemical assays to identify the pathogens	**Apply, Analyze**

b. Syllabus

Units	**Content**	**Hrs.**
I	1. Isolation of normal microflora from skin, oral cavity 2. Determining the biofilm forming ability of bacteria-Congo red assay 3. Determining the MIC of antimicrobial compounds 4. Antibiogram- antibiotic susceptibility test-Kirby Bauer test 5. Biofilm disintegration studies using different antimicrobials	15
II	6. Phage as an antibacterial – isolation of phage from sewage 7. Phage enrichment and time kill assay 8. PCR as a diagnostic tool 9. Isothermal PCR 10. Enzyme-linked immunosorbent assay- ELISA	15

	Tasks and Assignments: Each student is required to submit the following: • Hand on staining techniques • Isolation and characterization of microorganisms • Internal exams • Maintaining record notebooks • Group discussion **References** 1. Mackie & Mccartney Practical Medical Microbiology.Elsevier, 14th edition. 1997. ISBN 978-8131203934 2. Medical Microbiology Practical Book, by Dr. Mirdushri. Bluerose Publishers Pvt. Ltd.; First Edition,2022. 3. Practical Clinical Microbiology and Infectious DiseasesA Hands-On Guide. Edited By Firza Alexander Gronthoud. CRC press 2021.	

SEMESTER - VI					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIBEC01	Advanced cell systems	3	-	-	3

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

Course Outcome		**Level**
CO-1	To understand the structural organization, dynamics, and functional interactions of cellular organelles, including organelle biogenesis, turnover, and contact sites, and relate these to cellular physiology and homeostasis.	**Understand**
CO-2	To analyze the mechanisms of intracellular trafficking, vesicle formation and transport, membrane dynamics, and organelle communication, and evaluate their roles in secretion, endocytosis, and autophagy.	**Analyze**
CO-3	To understand and analyze how signal transduction pathways, cell-cycle regulation, and stress response mechanisms (apoptosis, autophagy, senescence) maintain cellular homeostasis and coordinate survival decisions.	**Understand**
CO-4	To apply and analyze the principles of cell–cell communication, extracellular vesicle biogenesis, intercellular signaling, and adhesion mechanisms to explain coordinated multicellular behavior and tissue-level processes.	**Apply**

CO-5	To apply knowledge of cellular systems to experimental and translational contexts, including synthetic biology, organoid modeling, systems biology, and therapeutic or biotechnological applications of cell biology.	**Apply**

b. Syllabus

Units	Content	Hrs.
I	**Cellular Architecture, Organelles & Organelle Dynamics** Organelle biogenesis and turnover; organelle contact sites (e.g., mitochondria–ER, mitochondria–lysosome), dynamics of endomembrane system; organelle remodeling under stress; cytoskeleton–organelle interactions; super-resolution microscopy of subcellular structures.	9
II	**Intracellular Trafficking, Membrane Dynamics & Vesicular Transport** Endocytosis and exocytosis mechanisms; vesicle formation, budding, trafficking, fusion/fission; membrane identity and lipid signaling (phosphoinositides, lipid rafts); regulation of secretion vs endocytosis under stress or cell-wall/ membrane perturbations; exosome / extracellular vesicle biology.	9
III	**Signal Transduction, Cell Cycle, Autophagy & Stress Responses** Signal transduction pathways and their cross-talk; regulation of cell-cycle checkpoints and transitions; coordination between cell-cycle regulators and autophagy; stress response (nutrient, oxidative, DNA damage); senescence; regulated cell death (apoptosis, necrosis, autophagy-linked death)	9
IV	**Cellular Systems & Communication: Extracellular Vesicles, Cell–Cell Signaling, and Intercellular Interactions** Extracellular vesicles (exosomes, microvesicles) biogenesis and intercellular communication; membrane trafficking in secretion of signaling molecules; cell–cell communication via vesicles; intercellular junctions and adhesion dynamics; signaling via secreted factors; immune signaling.	9
V	**Systems, Synthetic & Translational Cell Biology: Organoids, Synthetic Biology, Disease Models, and Therapeutic Applications** Synthetic biology of cells—engineering membrane systems and organelles; building minimal or synthetic cells; organoid and 3D cell-culture systems; disease modeling at the cellular and organoid level; integrating –omics (transcriptomics, proteomics, metabolomics) with cell systems; computational modeling of cell systems and intracellular dynamics.	9
	Tasks and Assignments: • Internal exams · A quiz on Cellular systems · An assignment on Translational Cell Biology · Group discussion on Cell signalling **References:** • Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2022). *Molecular Biology of the Cell* (7th Edition). Garland Science.	

	• Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., & Matsudaira, P. (2021). *Molecular Cell Biology* (9th Edition). W.H. Freeman. • Cooper, G. M. (2023). *The Cell: A Molecular Approach* (9th Edition). Oxford University Press. • Golebiewska, U., & Szymańska, E. (2019). *Advanced Cell Biology: Principles and Techniques*. Springer.	

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**3**	**2**	**3**	**3**
CO2	**2**	**1**	**3**	**2**	**3**
CO3	**2**	**2**	**2**	**1**	**2**
CO4	**3**	**1**	**3**	**2**	**2**
CO5	**3**	**3**	**2**	**3**	**3**

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	2	2	-	-	2
Seminar	-	-	2	2	-
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Essay- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs

1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organiza-tion** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

h. Rubric for Seminar

Sl. No.	**Criteria**	**100%**	**75%**	**50%**	**25%**	**0%**	**Relation to COs**
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

i. Model Question Paper

Sl. No.	**Model Questions**	**Specification**	**Level**
	Part – A: Objective Type **Multiple Choice** **Marks: 10 x 1 = 10**		
1	Organelle contact sites are important for: A) DNA replication only B) Inter-organelle communication and metabolite exchange C) Ribosome synthesis D) Cell wall formation	Recognize	Remember
2	Super-resolution microscopy is mainly used to: A) Measure cell mass	Recall	Remember

	B) Visualize subcellular structures beyond the diffraction limit C) Sequence DNA D) Detect proteins only in nuclei		
3	Which process involves uptake of materials into the cell through vesicle formation? A) Exocytosis B) Endocytosis C) Diffusion D) Osmosis	Recognize	Remember
4	Lipid rafts are primarily associated with: A) Protein degradation B) Membrane signaling and trafficking C) DNA replication D) Cell wall synthesis	Recognize	Remember
5	Programmed cell death involving controlled cellular dismantling is called: A) Necrosis B) Senescence C) Apoptosis D) Differentiation	Recognize	Remember
6	Autophagy is primarily involved in: A) Protein synthesis B) Cellular degradation and recycling C) DNA replication D) Cell adhesion	Recognize	Remember
7	Exosomes are formed mainly through: A) Ribosomal assembly B) Endosomal pathways C) DNA recombination D) Cell division	Recall	Remember
8	Intercellular junctions primarily function in: A) ATP synthesis B) Cell adhesion and communication C) Protein degradation D) Lipid metabolism	Recall	Remember
9	Organoids are best described as: A) Artificial chromosomes B) Three-dimensional cell culture systems resembling organs C) Vesicular transport proteins D) Cell membrane receptors	Identify	Remember
10	Transcriptomics is the study of: A) Proteins B) Metabolites C) RNA transcripts D) Lipids	Identify	Remember
	PART – B Short Answer **The answer should not exceed 200 words Marks :5 x 3 =15**		

11	What are organelle contact sites? Give one example.	Explain and cite	Remember
12	Define exosomes.	Explain	Understand
13	What is autophagy?	Describe	Analyze
14	Differentiate between exosomes and microvesicles.	Differentiate	Analyze
15	What are synthetic cells?	Describe	Remember
PART – C Essay Answer **The answer should not exceed 400 words Marks: 5 x 7= 35**			
16	Explain organelle biogenesis, turnover, and remodeling under cellular stress conditions. (or) Discuss cytoskeleton–organelle interactions and the applications of super-resolution microscopy in studying subcellular structures.	Explain and cite	Remember
17	Describe the mechanisms of endocytosis and exocytosis and explain vesicle budding, trafficking, and fusion. (or) Discuss membrane identity, lipid signaling, and the regulation of secretion and endocytosis during cellular stress.	Explain	Understand
18	Explain signal transduction pathways and their role in regulation of the cell cycle. (or) Discuss stress responses in cells, including oxidative stress, DNA damage response, senescence, and regulated cell death.	Describe	Analyze
19	Explain the biogenesis and functions of extracellular vesicles in intercellular communication. (or) Discuss membrane trafficking, intercellular junctions, and immune signaling in cellular communication.	Differentiate	Analyze
20	Discuss the principles of synthetic biology and the engineering of membrane systems and organelles. (or) Explain organoid systems, disease modeling, and the integration of omics technologies with computational modeling in modern cell biology.	Describe	Remember

SEMESTER - VI					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIBECO2	Virology	3	0	0	3

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO 1	Explain the structure, composition, and classification of viruses and sub-viral particles.	Understand
CO 2	Analyze the mechanisms of viral replication and host cell damage.	Analyze
CO 3	Evaluate vaccines, antiviral drugs, and molecular tools used to control viral diseases.	Apply
CO 4	Apply laboratory and diagnostic techniques to cultivate, detect, and quantify viruses.	Skill
CO 5	Discuss emerging viral threats, factors driving outbreak risks, and therapeutic uses of viruses.	Understand

b. Syllabus

Units	**Content**	**Hrs.**
I	**Definitive properties of viruses**: Morphology, Ultrastructure, Chemical composition (proteins, nucleic acids, and enzymes). Classification and nomenclature (Baltimore Groups I-VII). Sub-viral particles (Discovery, Structure, Classification, replication, and diseases caused, viroids and prions). Cellular basis of viral life. General aspects of plant and animal viral diseases.	10
II	**Viral Life Cycles, Replication, and Pathogenesis:** Viral Life Cycle Stages (Attachment, Penetration, Uncoating, General Genome Replication, Transcription, Translation, Assembly, and Release). Lytic vs. Lysogenic Cycles (Bacteriophage example). Viral Persistence and Latency. Mechanism of Host Cell Damage (Host cell 'shut off', Apoptosis, Necrosis, Alteration of signaling pathways). Tropism and Spread.	10
III	**Control Strategies of Viral Infection** Viral Vaccines (introduction, preparation, new technology). Antiviral Drugs and Therapy (antivirals, antiviral gene therapy, antiretrovirals—mechanism of action and drug resistance). Modern approaches for virus control (Antisense RNA, siRNA, ribozymes, in silico drug design). Model Phages/Viruses (T-phages, Cyanophages, Baculovirus).	8
IV	**Diagnostic Virology and Cultivation:** Biological activity of viruses. Detection and Enumeration (physical, biological, immunological, and molecular methods). Isolation, Purification, and Cultivation (Embryonated eggs, laboratory animals, and cell cultures). Infectivity assays (plaque assays, Fusion assay, Focus-forming assay, CPE, TCID50), Diagnostic Methods (Serological methods, PCR-based assays, Immunohistochemistry). Model Systems (Cell culture, worm, and animal models for studying viral infections).	8
V	**Emerging Viruses and Future Directions:**	10

	Emerging Diseases (Definition, sources, and causes of emergent virus diseases). Viruses and the Future (Promises and problems). Prospectus in Modern Virology (Viruses as therapeutic agents, viruses for gene delivery, oncolytic viruses, bacteriophage therapy). Importance of studying modern virology and global health security challenges.	
	Tasks and Assignments: • Each student is required to submit the following: • Assignments on the underlying mechanism of entry, fusion and replication of viruses of their own choice. • Model making of viruses's structure and their genetic material an deliver a seminar on the same topic. • Midterm Internal exams References 1. Cellular and Molecular Immunology (11th Edition) by Abul K. Abbas, Andrew H. Lichtman, Shiv Pillai, and Sarah Henrickson; Elsevier (2025). 2. Kuby Immunology (8th International / Adapted Edition) by Jenni Punt, Sharon Stranford, Patricia Jones, and Judith A. Owen; Macmillan International Higher Education / W.H. Freeman (2024). 3. Janeway's Immunobiology (10th Edition) by Kenneth Murphy and Casey Weaver; W. W. Norton & Company (2022). 4. Roitt's Essential Immunology (13th Edition**)** by Peter J. Delves, Seamus J. Martin, Dennis R. Burton, and Ivan M. Roitt; Wiley-Blackwell (2017). **5.** Textbook of Immunology by Dr. Hardeep Kaur, Dr. Ravi Toteja, and Dr. Seema Makhija; Dreamtech Press / Wiley India (2020).	

c. Mapping of Program Outcomes with Course Outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	3	2	3
CO2	3	3	3	3	3	3
CO3	3	3	3	3	3	3
CO4	2	2	1	3	2	2
CO5	1	1	1	1	2	3

d. Evaluation Scheme

	CO1	**CO2**	**CO3**	**CO4**	**CO5**	**Total**
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	**CO2**	**CO3**	**CO4**	**CO5**

Assignments/Seminar	1	1	1	1	1
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	6	6	6	6	6

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short answer question - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Easy question - 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No.	**Criteria**	**100%**	**75%**	**50%**	**25%**	**0%**	**Relation to COs**
1	**Content 50%**	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported.	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organiza-tion 50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

h. Rubric for Seminar

Sl. No.	**Criteria**	**100%**	**75%**	**50%**	**25%**	**0%**	**Relation to COs**

1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

i. Model Question Paper

Sl. No.	**Model Questions**	**Specification**	**Level**
	Part – A: Objective Type **Multiple choice 10 x 1 = 10**		
1	1. What is significant about Foot- and-mouth disease virus? a) It was the first filterable animal virus b) Human adults are frequently infected by this virus c) It is an enveloped virus d) d) It belongs to Rhabdoviridae	Recall	Remember
2	2. The flu virus has developed a high rate of resistance to which of the following drugs? a) Rimantidine b) Zanamivir c) Ribavirin d) Amantadine	Recall	Remember
3	Why do class 3 viruses transcribe a mRNA rather than simply disassociate and use the positive RNA as mRNA? a) Virions carry RNA transcriptase enzyme into the cell b) The virion RNA is translated into a single large polyprotein c) More energy efficient than denaturing the dsRNA d) (D) dsDNA is unstable	Recognize	Remember
4	Regarding HIV binding to it's target cells: a) It binds to CD4 coreceptor only before fusion with host cell membrane. b) It binds to CD4 as well as CCR5 chemokine coreceptors. c) It binds to CD4 and CXCR4 chemokine coreceptors for fusion.	Recognize	Remember

	d) It binds to CD4 and either of CCR5 or CXCR4 coreceptors for fusion with host cell membrane.		
5	Which of the following experimental requirements makes the siRNA approach unsuitable for determining the consequence of silencing a gene of interest in an established cell line a) Expression of the gene of interest is integral to cell viability b) End point RT-PCR and western blots are the only available validation assays c) Lipofectamine is the only available delivery method d) (D) The cell line proliferation rate is relatively slow	Recall	Remember
6	----------is a variation of the plaque assay, but instead of relying on cell lysis in order to detect plaque formation, it employs immunostaining techniques. a) The Endpoint dilution assay b) The focus forming assay c) The MTT assay d) The ELISA	Recognize	Remember
7	If there is a capsomere at each of the 12 vertices of a simple capsid; how this capsomere is termed when it is surrounded by five other capsomeres a) Penton b) Polyhedra c) Icosahedral d) d) Helical	Recognize	Remember
8	When the genomes of negative-sense RNA viruses are purified and introduced into cells that are permissive to the original intact virus, what will occur? a) No infection because virus transcriptase is not present b) Infection occurs because viral transcriptase is present c) Higher rate of viral replication using RNA polymerases d) Attenuation	Recognize	Remember
9	The term used to define when one of the influenza genes or RNA strands is substituted with a gene or strand from another influenza virus from a different animal host. a) Antigenic drift b) Antigenic shift c) Mutagenic shift d) Antigenic mutation	Identify	Remember
10	Measles caused by? a) Poxviruses b) Influenza c) Morbilliviruses d) Mortalliviruses	Identify	Remember
	PART – B Short Answer **The answer should not exceed 200 words. Marks : 5 x 3 = 15**		
11	Describe the structural forms used in the building of icosahedron viral particles	Explain	Understand

12	Write short notes on the following: a) SubgenomicRNA b) Leaky Scanning	Differentiate Define	Understand
13	Write short notes on the following: a) HAART b) Acyclovir	Cite Examples	Understand
14	Write short notes on the following: a) Plaque assay b) Acyclovir	Illustrate	Apply
15	Explain zoonotic spillover and its urban link	Describe	Analyse
	PART – C Essay Answer **The answer should not exceed 400 words. Marks: 5x7= 35**		
1.	Explain the organization of the Adeno, Herpes and Tobacco mosaic virus in terms of triangulation units, helical turn, number of capsomers, etc. Or a) Describe various human receptor molecules involved in the attachment of viruses b) Explain the underlying mechanisms of viral-receptor interaction of Poliovirus an Influenza A virus	Explain	Understand
2.	Cells produce mRNA by transcription of their DNA genomes. By contrast, single-stranded RNA genome viruses have three different strategies with respect to viral mRNA production. Briefly describe the production of mRNA for each of the following viruses. a) Poliovirus b) SARS-CoV-2 c) Influenza Or Classify DNA and RNA viruses based on the Baltimore scheme	Differentiate Define	Understand
3	a. Explain the distinct mechanisms of action by which antisense RNA and small interfering RNA (siRNA) silence viral gene expression. b. Discuss how RNA viruses rapidly develop drug resistance against conventional antiretroviral therapies. Mention one specific structural or genetic strategy used to overcome this challenge in clinical settings. Or a. Describe the platform of mRNA vaccines. Detail how they are formulated to enter host cells and how they induce both humoral and cellular immune responses without using live viral particles. b. Highlight the significance of Baculoviruses or Cyanophages as model viral systems. Explain one major biotechnological or ecological application for which these specific viruses are utilized.	Cite Examples	Understand
4	When 0.1 ml of a 1:10^5 dilution of the poliovirus stock is plated on a "lawn" of HeLa cells, an average of 200 plaques	Calculate Illustrate	Apply

	are observed. I.What is the titer of this stock? (3 marks) II. what is the multiplicity of infection (MOI) when 0.1 ml of this stock infects 10 ml of HeLa cells containing 10^5 cells/ml? (4 marks) Or a. Describe the step-by-step procedure for cultivating viruses using embryonated chicken eggs. b. Describe the experimental setup and underlying principle of the Enzyme-Linked Immunosorbent Assay (ELISA) used for diagnosing viral infections.		
5	a. Discuss the mechanism and clinical potential of oncolytic viruses in modern medicine. How do they selectively target cancer cells while sparing healthy tissue? b. Explain how viruses are engineered as vehicles for **gene delivery**. Highlight one major 'promise' (advantage) and one major 'problem' (safety concern) associated with viral vector therapy. Or a. In the context of rising antibiotic resistance, evaluate the prospects of bacteriophage therapy. What makes phages a viable alternative to traditional antibiotics, and what is a primary limitation of this therapy? b. Analyze the relationship between modern virology and global health security.	Describe	Analyse

SEMESTER -VII					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIB5071	Recombinant DNA Technology	3	1	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO 1	To understand the steps involved in rDNA technology	Remember
CO 2	To get a clear picture on various cloning strategies	Understand
CO 3	To understand the expression of recombinant proteins in *E.coli*	Apply
CO 4	To explain key techniques used in rDNA technology	Analyze
CO 5	To understand its applications in medical and agricultural field	Skill

b. Syllabus

Units	**Content**	**Hrs.**
I	Importance and outline of rDNA technology, control of gene expression in bacteria and eukaryotes, enzymes used in rDNA technology, types of vectors, vector elements, selectable markers, viral vectors, various plasmids used in cell and molecular biology research, Shuttle vectors.	12
II	Blotting techniques, Polymerase chain reaction (PCR) and its applications; Types of PCR and their applications, Labelling of DNA, RNA and proteins by radioactive isotopes, non-radioactive labelling, autoradiography, site-directed mutagenesis, RFLP, RAPD, AFLP, exon cloning, chromosome walking and jumping, EMSA, RNase A protection assay, DNAse I foot printing assay.	12
III	Gene isolation, gene transfer techniques, genomic DNA library and cDNA library construction, partial digestion of genomic DNA, transformation, transfection, stable transfection, promoter analysis, Ligation independent cloning system, the Gateway cloning system, blue-white colony screening, Replica plating, gene expression analysis, Protein expression analysis, Posttranslational modification analysis, issues in transgene expression, DNA sequencing methods.	12
IV	Factors influencing the expression of recombinant proteins; purification of recombinant proteins - His-tag, GST-tag, expression of recombinant proteins – E. coli, mammalian cells, insect cells, Protein Engineering, Protein Chip technology, Cancer Proteomics, Antibody microarrays, Protein modifications, Protein structure & folding. Immunoprecipitation of proteins and protein complexes.	12

V	Transgenic animals, Gene therapy, Gene editing technology, agricultural and medicinal applications, commercially important transgenic plants, Therapeutic proteins used in human health care, Industrial applications, Biosafety guidelines for recombinant DNA research in India.	12
	Tasks and Assignments: • Internal exams • A quiz • An assignment • Presentation **References:** 1. Principles and Gene Manipulation and Genomics, Seventh Edition (2014), S.B. Primrose. 2. Gene Cloning and DNA Analysis: An Introduction. Seventh Edition (2016), T.A. Brown, Wiley publications. 3. Molecular cloning. A Laboratory Manual. Michael R. Green, Joseph Sambrook, 2012, Cold Spring Harbor Laboratory Press. 4. Recombinant DNA 2nd Edition. Watson, James D. and Gilman, M. (2001) W.H Freeman and Company, New York. 5. Molecular Biotechnology: Principles Application of Recombinant DNA 2nd Edition. Glick, B. R. and Pasternak, J. J. (1998) ASM press Washington DC. 6. Genetic Engineering. Ahluwalia, K. B. (2002) New Age International (P) Ltd. 7. An Introduction to Genetic Engineering 2nd edition Desmond Nicholl S.T. (2002) Cambridge University Press. 8. Genetic Engineering: An introduction to Gene analysis and exploitation in eukaryotes. Kingsman and Kingsman (1998) Blackwell Scientific Publication, Oxford. 9. DNA cloning: A Practical Approach. Glover and Hames (2001) Oxford University Press.	

c. Mapping of Program Outcomes with Course Outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**2**	**3**	**3**	**3**	**2**
CO2	**2**	**3**	**2**	**2**	**3**
CO3	**3**	**2**	**2**	**2**	**3**
CO4	**2**	**2**	**2**	**3**	**3**
CO5	**2**	**2**	**2**	**2**	**2**

d. Evaluation Scheme

	CO1	**CO2**	**CO3**	**CO4**	**CO5**	**Total**
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	2	2	-	-	2
Seminar	-	-	2	2	-
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Essay- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content 50%**	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO5
2	**Organiza-tion 50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2, CO5

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs

1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO4
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4

i. Model Question Paper

Sl. No.	Model Questions	Specification	Level
	Part – A: Objective Type **Multiple Choice Questions** **Marks: 10 x 1 = 10**		
1	Transfection is, transfer of a) plasmid to bacteria b) plasmid to cell line c) plasmid to virus d) d) protein to cell line	Find out	Remember
2	The cells in your skin have a different shape and different functions from the cells in your livers because the two types of cells have different ----------. a) DNA b) proteins c) lipids d) carbohydrates	Solve	Understand
3	The enzyme DNA polymerase can work only in a) 3'→ 5' direction b) 5'→ 3' direction c) Both the direction d) 5'→ 5' direction	Assemble	Apply
4	Transient gene over expression means a) Permanently over expressing a gene b) Over expression of a gene in transformed cells c) Temporarily over expressing a gene d) Over expression of gene in untransformed cells	Experiment	Analyze
5	TRIzol can be used to extract a) DNA b) RNA c) Proteins d) DNA, RNA, Proteins	Employ	Skill

6	Which is correct in the following a) Proteins → DNA b) cDNA → mRNA c) DNA → mRNA d) Proteins →mRNA	Employ	Remember
7	Rodent model refers to a) Mouse b) Rat c) Hamsters d) Mouse, Rat, Hamsters	Solve	Understand
8	Ampicillin kills a) Eukaryotic cells b) plant cells c) bacteria d) virus	Remember	Apply
9	*lacZ* codes for ----------. a) Trypsin b) Beta-galactosidase c) Kinase *d)* phosphatase	Remember	Analyze
10	All of the following enzymes are involved in DNA replication except: a) helicase b) primase c) DNA polymerase d) RNA polymerase	Remember	Skill
	PART – B Short Answer **The answer should not exceed 200 words Marks :5 x 3 = 15**		
11	Does the protein level always correlate with the expression level of a gene? Analyze.	Experiment	Remember
12	Which of the following cellular components contain DNA and which contain RNA? Mitochondria; endoplasmic reticulum; nucleus; nucleolus; chloroplast; cytoplasm.	Analyze	Understand
13	The lac operon is an inducible operon. Why and what does this mean?	Demonstrate	Apply
14	Why is the activity of most nucleases inhibited by the addition of a chelating agent such as EDTA?	Solve	Analyze
15	Mention three monoclonal antibodies which are used for the treatment of any disease.	Use	Skill
PART – C Essay Answer **The answer should not exceed 400 words Marks: 5 x 7= 35**			
16	What are the conditions that contribute to the star activity and how it can be inhibited? Or Compare three different endonucleases.	Assemble	Remember
17	What do you understand by replica plating? Discuss its importance in “insertional inactivation”.	Experiment	Understand

	Or Explain the trp Operon in detail.		
18	Propose three methods to quantitate gene expression Or Hypothesize and propose a research project in the field of genetic engineering.	Demonstrate	Apply
19	How RFLP can be used to find out a culprit in a crime scene? Cite example. Or How do you make genomic and cDNA libraries? Explain the differences and uses of these libraries.	Employ	Analyze
20	Explain different gene therapy approaches with suitable examples. Or Briefly explain the Gene editing technology	Solve	Skill

SEMESTER VII				
COURSE CODE	**COURSE TITLE**	**TYPE**	**CREDITS**	**HOURS / WEEK**
MIB 5072	RECOMBINANT DNA AND PROTEIN TECHNOLOGY PRACTICAL	CCP	2	2 h

Course Outcome		**Level**
CO-1	To get hands on experience on pH meter, gel electrophoresis techniques and experiments involved in cloning techniques	**Apply, Analyze**
CO-2	Able to isolate RNA from mammalian cells	**Understand, Apply**
CO-3	Able to quantitate proteins and to count eukaryotic cells using hemocytometer	**Apply, Analyze**
CO-4	Able to do nuclear staining	**Apply**
CO-5	Able to handle the fluorescence microscope	**Apply**

S.NO.	**List of Practical:**	**HOURS / WEEK**
1	1. pH meter 2. Agarose Gel Electrophoresis 3. SDS-PAGE	**2H**

	4. RNA isolation 5. Plasmid isolation 6. Fluorescence microscope demonstration 7. Protein quantification 8. Quantification of eukaryotic cells using hemocytometer 9. Nuclear staining method 10. Restriction enzyme digestion and ligation 11. Transformation/Transfection 12. Cell culture demonstration	
2	**Reference books:** 1. Recombinant DNA Laboratory Manual, Revised Edition by Judith W. Zyskind, Academic Pres, Inc. 2002. 2. Recombinant DNA 2nd Edition, Watson, James D. and Gilman M. (2001) W. H. Freeman and Company, New York. 3. Molecular Biotechnology: Principles Application of Recombinant DNA 2nd Edition. Glick, B. R. and Pasternak, J.J. (1998) ASM Press Washington DC. 4. DNA cloning: A Practical approach. Glover and Hames (2001) Oxford University Press.	

SEMESTER- VII					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIB 5073	**Agromicrobiology**	4	-	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO1	Define with cite examples the role and distribution of microorganisms in agriculture	Understand
CO2	Illustrate and apply knowledge of role of microbes in plant interactions	Apply
CO3	Examine and understand the various types of biofertilizers	Analyze
CO4	Interpret and explain key plant pathogens and role of microbes in plant Disease control	Understand
CO5	Demonstrate the use of agricultural waste and biofuel production	Skill

b. Syllabus

Units	**Content**	**Hrs.**
I	**Introduction** Introduction and historical development of Agricultural microbiology; Contributions of various scientists in the field of agricultural microbiology; Distribution and importance of soil microorganisms and the factors influencing the activities of soil microorganisms; Importance of soil and plant associated microbes – rhizosphere, spermosphere, phyllosphere, epiphytic and endophytes.	12
II	**Microorganisms role in Bio-geo chemical cycles** Carbon, sulphur, iron, phosphorus & nitrogen cycles; Rhizospheric microorganisms and its importance; Siderophores; PGPM-Plant growth promoting microorganisms; Plant-microbe interactions; Mechanisms of plant growth promotion. Biofertilzers – classification and importance.	12
III	**Plant diseases** Major plant disease symptoms caused by various microorganisms viz., fungi, bacteria and viruses; Stages of disease development; relationship between disease cycles and factors influencing them; Mechanism of cuticle and cell wall degradation by microbes; production of secondary metabolites – fungal toxins; Plant diseases – Principles, symptoms and control; Fungal – General characteristics and different fungal diseases in plants; Bacterial – Blight of rice and blast of rice; citrus canker – Xanthomonas; Viral and mycoplasma – Bud necrosis of groundnut, citrus mosaic, little leaf of brinjal, tomato leaf curl	12

IV	**Biological Plant Diseases Control and importance** Principles of plant disease control; biocontrol of plant pests and diseases; Integrated pest and disease management – concepts and components; Biopesticides – Bacillus thuringiensis, Pseudomonas syringe; Biocontrol -by Trichoderma, use of Baculovirus, NPV virus, protozoa & fungi; Use of endophytic fungi as biocontrol agent against plant diseases.	12
V	**Agro-waste management** Recycling of agricultural wastes; biogas production; composting and vermicomposting; mushroom cultivation; biofuels and value-added products generation via microbes; Traditional and advanced methods of agricultural waste management.	12
	Tasks and Assignments: Each student is required to submit the following: • A write-up on the underlying Agro-waste management Practices • Seminar on Biological disease ontrol • A mini project on Biofertilizer production • Internal exams • **References** • SoilMicrobiology by N.S. SubbaRao, 4th edition, Publishedby Oxford and IBH Publishing (2017) • SoilMicrobiology,EcologyandBiochemistry,4thedition,editedbyEldor A.Paul,PublishedbyElsevier(2015) • SoilMicrobiology,2ndeditionbyRobertL.TateIII(2000) • Biofertilizers,volume1:AdvancesinBio-inoculants,editedbyRakshit, Meena, Parihar, Singh and Singh, Published by Elsevier (2021)	

c. Mapping of Program Outcomes with Course Outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	3	3	2
CO2	3	3	3	3	3
CO3	2	2	2	3	3
CO4	3	3	3	3	3
CO5	2	2	2	2	2

d. Evaluation Scheme

	CO1	**CO2**	**CO3**	**CO4**	**CO5**	**Total**
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	**CO2**	**CO3**	**CO4**	**CO5**

Assignments	2	2	-	-	2
Seminar	1	1	2	2	-
Test	4	4	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Part–A (Objective-10x1=10marks)	2	2	2	2	2
Part–B (ShortAnswer-5x3=15marks)	3	3	3	3	3
Part–C (Essay-5X 7=35marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No.	**Criteria**	**100%**	**75%**	**50%**	**25%**	**0%**	**Relation to COs**
1	**Content 50%**	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported.	Content is not sound	Not attended	CO1,CO2, CO4
2	**Organiza-tion 50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1,CO2, CO4

h. Rubric for Seminar

Sl. No.	**Criteria**	**100%**	**75%**	**50%**	**25%**	**0%**	**Relation to Cos**

1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO5
2	**Presentation 50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO5

i. Model Question Paper

Sl. No.	**Model Questions**	**Specification**	**Level**
Part–A: Objective Type **Multiple choice 10x 1 =10**			
1	The term rhizosphere was coined by A. Ruinen B. Hiltner C. AlbertFranks D. Beijerinck	Recognize	Remember
2	Actinorhizal plants involved in nitrogen fixation was first observed by ____ A. Woronin B. Hiltner C. Albert Franks D. Beijerinck	Recall	Remember
3	Chemical inhibition of one plant by another is due to A. Soil fatigue B. Soil sickness C. Allelopathy D. Fungistatis	Recognize	Remember
4	Possible mechanisms for PGPR group of microbes for surviving in rhizosphere A. Niche exclusing B. Competition for substrate C. Production of antibiotics D. All of the above	Recognize	Remember
5	Aerobic decomposition of protein for ammonia A. Proteolysis B. Putrefaction C. Ammonification D. Nitrification	Recall	Remember
	_____Are dominant at and below the chemocline		

6	A. Sulfate reducing bacteria B.Methanogenic bacteria C.Cyanobacteria D. Green Sulphur bacteria	Recognize	Remember
7	The mechanism of Quorum sensing is utilized by the bacterial cells to determine? A. the size of the bacterial population B. the availability of nutrients for bacterial colonies C. the speed of water flow among the bacterial colonies D. The density of the population	Recall	Remember
8	For, which of the following plant disease the causative pathogenis NOT a viroid? A Citrus Exocortis B. Potato Spindle Tuber C. Citrus Greening D. Coconut Cadang– Cadang	Recall	Remember
9	Which of the following is *not* a systematic fungicide? A. DithaneM-45. B. Vitavax C. Tilt D. Metalaxyl	Identify	Remember
10	Who discovered the famous Bordeaux mixture? A. Robert Koch	Identify	Remember
	B. Anton de Bary C. Pierre M. Millardet D. Adolf Mayer		
PART–B Short Answer **The answer should not exceed 200 words (Marks:5x3=15)**			
11	What are biofertilizers?	Define	Remember
12	Illustrate the Integrated Pest Management approaches?	Explain	Describe
13	Describe about various biocontrol agents?	Cite Examples	Understand
14	Write about Plant growth Promoting Rhizobacteria?	Explain	Understand
15	Analyze the importance of various Biopesticides?	Cite Examples	Describe
	PART–B Essay Answer **The answer should not exceed 400words (5x7=35)**		
16	a) Describe the major biofertilizers and their target crops. or b) Compare and differentiate between AM fungi and Ectomycorrhizal fungi association with plant.	Explain	Understand

17	a) Explain in detail the nitrogen fixing biofertilizers. or b) Illustrate the role of biofertilizers in maintaining soil fertility and agriculture.	Differentiate Define	Understand
18	Explain the positive interactions between plants and microorganisms. or Draw the steps involved information of nitrogen fixing nodule.	CiteExamples	Understand
19	Explain in detail microbial transformation of nitrogen and phosphorus? or Describe in detail the principles of biological control of plant diseases?	Explain Discuss	Understand
20	What is plant Pathometry? Describe the methods used in sampling plants for disease assessment? or What are biopesticides? How does they work? Explain with suitable example?	Illustrate	Apply

SEMESTER VII					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIB5074	Microbiology in Food & Industry	4	-	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO 1	Understand the role of microorganisms in the food industry and product development.	Understand
CO 2	Learn about food spoilage, food-borne diseases and food preservation methods.	Understand, Apply
CO 3	Gain knowledge on the large-scale production of microbial metabolites.	Analyze, Apply
CO 4	Understand the basic techniques of strain improvement and the fermentation process.	Understand, Apply
CO 5	Learn about food safety standards, quality control and regulatory systems.	Apply

b. Syllabus

Units	**Content**	**Hrs.**
I	**Basis of Food & Industrial Microbiology:** History and importance of industrial microbiology; Industrially important microorganisms: Screening, isolation, purification and maintenance; Strain improvement through random mutation and genetic engineering; types of fermentation. Bioreactors: types and functions, Microbial growth phases and basics of growth kinetics.	12
II	**Food spoilage, detection and Preservation:** Microorganisms involved in food spoilage of major food groups; Detection and Enumeration of microorganisms and their products in food: Culture dependent and Culture independent methods; Food preservation: use of temperatures, Significance of psychrophilic microbes in cold-stored and frozen foods, Drying, Chemical preservatives, Modified atmosphere and Radiation.	12
III	**Microbial products and their industrial applications:** Microbial production of metabolites: Primary vs secondary metabolites. Pathways involved in secondary metabolite production, Commercial production of antibiotics (penicillin), overview of Organic acids and alcohol production. Microbial transformations: steroids and alkaloids production. Large-scale production of recombinant molecules- insulin, vaccines and anticancer agents. Applications of Metabolic engineering in large-scale production of microbial products.	12
IV	**Fermentation Technology and Industrial Products:** Fermented Food products and beverages: Bread, Yogurt, cheese, wine, beer; Pathways involved in primary metabolite production, Commercial production of organic acids (acetic acid and lactic acid) Commercial production of important amino acids (glutamic	12

	acid, lysine), and vitamins (riboflavin and vitamin A). Industrial enzymes production: Cellulases, Amylases, Lipases and Proteases; Enzymes involved in microbial biotransformation.	
V	**Food Quality Standards and Regulatory Systems:** General principles of food safety and risk management, Food borne pathogens and recent concerns; Safe food alternative (organic, clean-label foods); Microbiological standards in food testing; HACCP and ISO systems for food safety. Regulatory practices and Government policies (FSSAI and FDA); Applications of biosensors in food and Pharma analsyis.	12
	Tasks and Assignments: • Internal exams • A quiz on fermented microbial products • An assignment on food spoilage detection • Presentation on microbial metabolites and their applications **References:** 1. Arun K. Bhunia, 2008, Foodborne Microbial Pathogens- Mechanisms and Pathogenesis, Food, 2. Doyle, M. P. & Beuchat, L. R., 2007, Food Microbiology- Fundamentals and Frontiers, ASM Press. 3. W. Crueger & A. Crueger (2017). Cruegers Biotechnology: A Text Book of Industrial Microbiology. Edited by K.R. Aneja. Panima Publishing Corporation. 4. P.F. Stanbury, W. Whitaker & S.J. Hall (2016). Principles of Fermentation Technology. 3rd edition. Elsevier publication. 5. Nduka Okafor, Benedict C. Okeke (2017). Modern Industrial Microbiology and Biotechnology. 2nd Edition: CRC Press Publishers.	

c. Mapping of Program Outcomes with Course Outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**3**	**3**	**3**	**3**	**2**
CO2	**3**	**3**	**3**	**3**	**3**
CO3	**2**	**2**	**2**	**3**	**3**
CO4	**3**	**3**	**3**	**3**	**3**
CO5	**2**	**2**	**2**	**2**	**2**

d. Evaluation Scheme

	CO1	**CO2**	**CO3**	**CO4**	**CO5**	**Total**
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	2	2	-	2	
Seminar	-	-	2	-	2
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Essay- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content 50%**	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO4
2	**Organiza-tion 50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2 CO4

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs

1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO5
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO5

i. Model Question Paper

Sl. No.	**Model Questions**	**Specification**	**Level**
	Part – A: Objective Type **Multiple Choice** **Marks: 10 x 1 = 10**		
1	Shredded cabbage is the starting product for which of the following fermented food? a) Sauerkraut b) Pickles c) Green olives d) Sausage	Recall	Remember
2	_____ are code of good practices comprising basic principles, procedures and means required for safe food production. a) GMP b) PRP c) GLP d) HACCP	Recognize	Remember
3	Aflatoxin residues can be found in a) Cereals and grains b) Honey c) Dry fruits d) Milk and dairy products	Recall	Remember
4	Which of the following statements are true regarding botulinum toxins a) It's an enterotoxin b) Produced by a gram-negative bacteria c) It's a neurotoxin d) None of the above	Identify	Remember
5	Clostridium perfingens poisoning is associated with a) Milk products		Remember

	b) Grains c) Carbonated drinks d) Meat products	Recognize	
6	Water activity can act as a) An intrinsic factor determining the likelihood of microbial proliferation b) An intrinsic factor c) A processing factor d) All the above	Identify	Remember
7	Why yeast strain can't be used, when starch containing substrates are used for ethanol production? a) Starch is not a suitable substrate for the production of ethanol b) Yeast does not synthesis sufficient amylases to rapidly hydrolyze the starch c) Yeast convert it into pentose sugar d) None of the above	Recall	analyze
8	Sugar and salt act as preservatives by: a) Killing microorganisms directly b) increasing the water content of food c) increasing the acid content of the food d) binding water so it is not available for microorganisms	Identify	Remember
9	Given below are some of the facts about the food contamination caused by fungi. Which of the following statement is NOT correct? a) Contamination of fungi can produce Mycotoxin b) Most commonly known mycotoxin is Aflatoxins. c) Ergot alkaloids area also mycotoxins. d) All of them are correct	Recall	identify
10	In the citric acid production, the pH of the reaction mixture in the fermenter should be maintained at: a) 7.0 b) 5.0 to 6.0 c) 8.0 to 9.0 d) 1.0 to 6.0	Recall	Remember
	PART – B Short Answer **The answer should not exceed 200 words Marks:5 x 3 = 15**		
11	Write a short note on fed-batch fermentation process	Explain	Remember
12	Write a note on organisms involved in spoilage of fruits and vegetables.	Recall	Remember
13	Write a short note on a) Vaccines b) Penicillin production	Describe	Analyze
14	Describe in brief about the enzymes involved in microbial biocatalysis	explain	Analyze
15	Write a brief note on applications of biosensors	Describe	Remember

PART – C Essay Answer **The answer should not exceed 400 words Marks: 5 x 7= 35**			
16	a) Write in detail about the isolation purification and maintenance of industrially important microorganisms. (Or) b) Describe in detail about the design, types and functional characteristics of bioreactors	Explain	Understand
17	a) What is the significance of food spoilage detection? Explain various culture independent methods of detection of food pathogens. (Or) b) Explain in detail about various food preservation methods with their principles.	Describe	analyze
18	a) State difference between microbial primary and secondary metabolites. Explain the importance of metabolic engineering in enhanced metabolite production with the help of a metabolite pathway. (Or) b) Write a descriptive note on microbial transformation of steroids.	analyze	differentiate
19	a) Write a note on Commercial production of tryptoph Production and applications of amylases and lipases (Or) b) What is the significance of hops in malt beverages? Explain the process of malt beverage production in detail.	Explain	Discuss
20	a) Write a brief note on HACCP and Safe food alternatives (Or) b) Explain food safety and quality with a note on microbiological criteria of foods and their significance.	Remember	Describe

SEMESTER VII					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIB5075	Microbiology in Food & Industry Practical			2	2

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO 1	Isolate and identify food-borne pathogenic bacteria using standard microbiological techniques.	skill
CO 2	Demonstrate microbial culture preservation techniques and assess milk quality.	analyze
CO 3	Isolate and screen industrially important microorganisms producing enzymes and antibiotics from environmental samples.	analyze
CO 4	Perform antibiotic sensitivity testing and MIC determination to evaluate antimicrobial effectiveness.	skill
CO 5	Identify microorganisms using biochemical tests and analyze the effect of different preservatives on bacterial growth.	skill

b. Syllabus

Units	**Content**	**Hrs.**
	1. Isolation and identification of food –borne pathogenic bacteria from contaminated foods and dairy products. 2. Preservation of microbial cultures (Glycerol stock preparation) 3. Determination of the quality of milk sample by the methylene blue reductase test. 4. Bacteriological Examination of water quality. 5. Isolation of amylase/protease/lipase-producing microorganisms from soil 6. Isolation of yeast from grapes 7. Screening of antibiotic-producing microorganisms from soil 8. Antibiotic sensitivity test: a) Kirby Bauer's method and b) MIC determination 9. Identification of Microorganisms using Biochemical tests (IMViC, TSI, Urease, Catalase and Oxidase) 10. Effect of preservatives on Bacterial growth (Salt, sugar, vinegar and spices)	30
	Tasks and Assignments: Each student is required to submit the following: • A continuous assessment • A practical viva voce • Demonstration of determination of milk quality • Restriction mapping results • Maintaining record notebooks • Group discussion	

	References: 1. Harley and Prescott (1996), Laboratory Exercises in Microbiology, McGraw Hill Higher Education, 3rd Edition 2. Bull, Alan T. and Junker, Beth and Katz, Leonard and Lynd, Lee R. and Masurekar, Prakash and Reeves, Christopher D. and Zhao, Huimin, eds. (2010). Manual of Industrial Microbiology and Biotechnology, 3rd Edition. ASM Press. 3. James G Cappuccino., Natalie Sherman. 2004. Microbiology: A laboratory manual, 6th edition, Pearson Education.	

SEMESTER VII					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIBEC03	Antimicrobial resistance and One health	3	-	-	3

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO 1	Understand the categories of antimicrobials and their action mechanism	Understand
CO 2	Understand the phage therapy, and their application, isolation and characterization	Analyze
CO 3	Understand the research tools that help in understanding the AMR mechanisms and resistant genes.	Apply
CO 4	Understanding the basics of resistance biology	Understand
CO 5	Understanding one health and its role in AMR	Analyze

b. Syllabus

Units	**Content**	**Hrs.**
I	**Antimicrobials**- Introduction to infections and spread, Pandemic, epidemic, hot spots, Spreading of AMR to the human, animals, and community, importance of infection control, **Antibiotics**: history of antibiotics, classifications of antibiotics, disruption of microbiome, synthesis, actinobacteria, and other microorganisms in the production of antibiotics, different types, bacteriocin, mechanism of action, and their applications. defensins- antimicrobial peptides and their mechanisms of action,	12
II	**Bacteriophage** an alternative antibiotics, and phage therapy, isolation and characterization of phage, phage life cycles, MOI, phage titration abd enrichment, phage cocktails, studying the phage resistance in bacteria, fitness cost, phage synergy	12
III	**Mechanisms of Resistance**: Introduction, AMR surveillance, and containment program of NCDC, antimicrobial Resistance formation, MDR, XDR, ESKAPE pathogens, development and causes of resistance.resistance genes, horizontal gene transfers, innate and passive immunity, CRISPR-CAS in resistance formation, clinical,	12

	research, and microbiological perspective of resistant formation.	
IV	**AMR Tools**: Antimicrobial susceptibility testing, agar disk diffusion method, Minimum inhibition concentration, minimum bacterial concentration, neutralizing quorum signals, biofilm disintegration, live dead analysis. Phenotypical and genotypical characterizations of resistance formation, application of NGS in studying the resistance mechanisms, mutations, AMR genes, and relevant genes.	12
V	**One health:** Concept and history of One Health, Evolution of human–animal–environment interactions, **S**cope and Principles of One Health, Global One Health initiatives and policies, Roles of WHO, FAO, WOAH (OIE), UNEP, and CDC, Sustainable Development Goals (SDGs) and One Health, Emerging and re-emerging infectious diseases, Spillover events and pathogen transmission dynamics. Climate change and infectious diseases	12
	Tasks and Assignments: • Internal exams • A quiz on antimicrobial drugs and their mechanism • Seminar on resistance formation in bacteria • Group discussions on tools to study AMR. **References:** 1. Rustam Aminov. Insights in Antimicrobials, Resistance & Chemotherapy: 2021 2. Archana Madhav, Robert C. Will & Ankur Mutreja. 2020. The Evolution of Microbial Defence Systems Against Antimicrobial Agents. 3. Sanjucta Dutta & T. Ramamurthy, 2020. Influence of Abiotic Factors in the Emergence of Antibiotic Resistance	

c. Mapping of Program Outcomes with Course Outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**3**	**3**	**3**	**3**	**2**
CO2	**3**	**3**	**3**	**3**	**3**
CO3	**2**	**2**	**2**	**3**	**3**
CO4	**3**	**3**	**3**	**3**	**3**
CO5	**2**	**2**	**2**	**2**	**2**

d. Evaluation Scheme

	CO1	**CO2**	**CO3**	**CO4**	**CO5**	**Total**
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	2		-	2	2
Seminar	-	2	2	-	-
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Essay- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content 50%**	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO4, CO5
2	**Organiza-tion 50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO4, CO5

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs

1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO2, CO3
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO2, CO3

i. Model Question Paper

Sl. No.	**Model Questions**	**Specification**	**Level**
	Part – A: Objective Type **Multiple Choice** **Marks: 10 x 1 = 10**		
1	Which of the following antimicrobial drugs is synthetic? **a) sulfanilamide** b) penicillin c) actinomycin d) neomycin	Recall	Remember
2	Which of the following combinations would most likely contribute to the development of a superinfection? a) long-term use of narrow-spectrum antimicrobials **b) long-term use of broad-spectrum antimicrobials** c) short-term use of narrow-spectrum antimicrobials d) short-term use of broad-spectrum antimicrobials	Recognize	Remember
3	Which clinical situation would be appropriate for treatment with a narrow-spectrum antimicrobial drug? a) treatment of a polymicrobic mixed infection in the intestine b) prophylaxis against infection after a surgical procedure **c) treatment of strep throat caused by culture identified *Streptococcus pyogenes*** d) empiric therapy of pneumonia while waiting for culture results	Recall	Remember
4	From the following is not a type of β-lactam		Remember

	antimicrobial? a) penicillins **b) glycopeptides** c) cephalosporins d) monobactams	Identify	
5	From the following is not an appropriate target for antifungal drugs? a) ergosterol b) chitin c) **cholestero**l d) β(1→3) glucan	Recognize	Remember
6	Following is an antimalarial drug that is thought to increase ROS levels in target cells? **a) artemisinin** b) amphotericin b c) praziquantel d) pleconaril	Identify	Remember
777	Which of the following resistance mechanisms is the most nonspecific to a particular class of antimicrobials? a) drug modification b) target mimicry c) target modification **d) efflux pump**	Recall	Remember
8	Which of the following types of drug-resistant bacteria do not typically persist in individuals as a member of their intestinal microbiota? **a) MRSA** b) VRE c) CRE d) ESBL-producing bacteria	Identify	Remember
9	Diseases that are naturally transmitted between animals and humans are called: a) Autoimmune diseases b) Genetic diseases c) Zoonotic diseases d) Nutritional diseases	Recall	Remember
10	The “One Health” concept primarily recognizes the connection between: a) Human and plant health only b) Human, animal, and environmental health c) Animal and industrial health d) Environmental and economic health only	Recall	Remember
	PART – B Short Answer **The answer should not exceed 200 words Marks:5 x 3 = 20**		
11	Tabulate antibiotics types and mechanisms of inhibition	Differentiate	Remember
12	Demonstrate the antimicrobial susceptibility assays	Demonstrate	Understand

13	Define the mechanisms of anti-phage mutations in bacteria.	Describe	Analyze
14	What are the drivers of fungal resistance?	Explain	Analyze
15	What are the principles of one health?	Interpret	Remember
PART – C Essay Answer **The answer should not exceed 400 words Marks: 5 x 7= 35**			
16	a) What are all the examples of cell wall degrading antibiotics? and detail their mechanism of action Or b) Interpret the role of antibiotics in damaging the general microbiome.	Explain	Understand
17	a) Describe in detail: 1. What are defensins? 2. How do you analyze live/dead results? Or b) What are quorum signals and how do they help form stable biofilms?	Differentiate	Remember
18	a) 1. What is prophage? 2. What are the bacterial receptors are well known for phage adsorption? Or b) Elaborate on Fitness cost in bacteria due to phage resistant	Explain	Understand
19	a) 1) Interpret on AMR survillence 2) Draw a frequency polygon (3 Marks) O**r** b) Demonstrate the relation between AMR and horizontal gene transfer	Explain	Understand
20	a) How one health and AMR are inter connected? explain it in detail. Or b) Explain Zoonosis and control measures using an example		Analyze

SEMESTER - VII					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIBEC04	**Algal Bioresources and Biotechnology**	3	-	-	3

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO 1	To understand the algal classification and cultivations methods.	Understand
CO 2	To Gain in depth knowledge and skills on algal primary and secondary metabolites uses and their industrial applications.	Skill
CO 3	To study the properties and applications of algae in marine environment.	Apply
CO 4	Analyze the existing conservation and control method for algae.	Analyze
CO 5	To gain knowledge on algal stress responses and genetic engineering techniques for algae.	Understand

b. Syllabus

Units	**Content**	**Hrs.**
I	**Introduction to Algae and Their Cultivation** Basic characteristics of algae and classification, Evolution of algal chloroplasts (basic idea of endosymbiosis), Introduction to algal isolation, purification, and culture methods, Basics of algal growth (growth curve and factors affecting growth), Common culture media for freshwater and marine algae, Basic nutrient uptake concepts (simple explanation of Michaelis–Menten, Monod and Droop models).	9
II	**Algal Components and Their Uses** Overview of algal primary and secondary metabolites, Extraction of bioactive compounds from algae and their commercial importance; Algal immobilization – basic principle and common applications, Microalgae in Human welfare – Nutraceuticals; Pharmaceuticals; Biofertilizers; Bio-fuel, bioplastics, Introduction to algal biotechnology and its role in industry, Basic idea of transgenic (genetically modified) algae and related limitations.	9
III	**Algae in marine environment** Basic physico-chemical properties of seawater related to algal growth, Intertidal seaweeds, zonation patterns and factors affecting distribution of intertidal seaweeds, Introduction to remote sensing for monitoring algae, Carbon sequestration by algae, Algae as bioindicators, Bioluminescent algae.	9
IV	**Conservation and control methods** Secondary metabolites from microalgae as chemical defence, Algal toxins and their consequences on aquatic environments and trophic level, Algal genetic resource centres, culture collections and their importance; Methodological strategies for conservation of algae, Algae as pollution indicators, methods of controlling algae.	9
V	**Algal Stress Biology and Introduction to Genetic Engineering** Algae in extreme environments and their survival strategies, Basic	9

	abiotic stresses (light, temperature, nutrients, salinity, etc.) affecting algae, *Chlamydomonas reinhardtii* as model organism, Introduction to genome editing tools, Overview of random mutagenesis and simple gene modification concepts, Common algal databases and plasmids, Fundamentals of synthetic biology in algae.	
	Tasks and Assignments: • Internal exams • A quiz on importance of Algal metabolites and their applications in industries. • An assignment on conservation and control methods of algae. • Presenting a scientific idea on genetic engineering and metabolites synthesis from algae. **References:** • Phycology (4th Edition) R.L. Lee, Cambridge University Press, 2008 • Barsanti, laura and paolo gualtieri 2005 Algae-Anatomy, Biochemistry and Biotechnology. Taylor & Francis, London, New York. • Algae- Anatomy, Biochemistry and biotechnology-L. Barsanti& P. Gualtieri. Taylor & Francis,2006 • Andersen RA (2005). Algal Culturing Techniques. Physiological Society of America. Elsevier Academic Press, USA.	

c. Mapping of Program Outcomes with Course Outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**3**	**3**	**3**	**3**	**2**
CO2	**3**	**3**	**3**	**3**	**3**
CO3	**2**	**2**	**2**	**3**	**3**
CO4	**3**	**3**	**3**	**3**	**3**
CO5	**2**	**2**	**2**	**2**	**2**

d. Evaluation Scheme

	CO1	**CO2**	**CO3**	**CO4**	**CO5**	**Total**
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	**CO2**	**CO3**	**CO4**	**CO5**
Assignments	2	2	-	2	
Seminar	-	-	2	-	2
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Essay- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content 50%**	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO4
2	**Organiza -tion 50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2 CO4

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Knowledge and Understanding 50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO5

2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO5

i. Model Question Paper

Sl. No.	**Model Questions**	**Specification**	**Level**
	Part – A: Objective Type **Multiple Choice** **Marks: 10 x 1 = 10**		
1	Cell walls of diatoms are impregnated with _____ a) Chitin b) Cellulose c) Starch d) Silica	Recall	Remember
2	Chloroplasts of algae embedded in the midst of the cytoplasm is known as _____ a) Parietal b) Asteroidal c) Central d) Periphera	Recognize	Remember
3	Which of the following are water-soluble pigments? a) Chlorophyll b) Biloproteins c) Crotenoids d) Fucoxanthin	Recall	Remember
4	Bioluminescence is a phenomenon associated with a)Chrysophyta b) Phaeophyta c) Pyrrophyta d) Hlorophyte	Identify	Remember
5	Which among the following is a pathogenic algae for humans? a) Prototheca b) Chlorella c) Cephaleuros d) Acanthopeltis	Recognize	Remember
6	Chlamyodomonas reinhardtii is a green _____ algae. a) Unicellular b) Di-cellular c) Multicellular d) Either unicellular or di-cellular	Identify	Remember
7	The xanthophyte walls are typically of _____		Remember

	a) Chitin b) Cellulose c) Cellulose and pectin d) Starch	Recall	
8	Kelps are which of the following type of algae? a) Red algae b) Yellow algae c) Brown algae d) Green algae	Identify	Remember
9	In Chlamydomonas the most common method of sexual reproduction is _____ a) Isogamy b) Heterogamy c) Oogamy d) Spore formation	Recall	Remember
10	Which of the following is a colonial green alga? a) Chlamydomonas b) Chlorella c) Volvox d) Spirogyra	Recall	Remember
	PART – B Short Answer **The answer should not exceed 200 words Marks:5 x 3 = 20**		
11	Explain different stages of algal growth using a growth curve?	Explain	Remember
12	Write a short note on bioplastic production from microalgae?	Explain	Understand
13	Describe in brief about the significance of marine algae?	Describe	Analyze
14	What is the significance of algal culture collection centres? State two examples.	Differentiate	Analyze
15	Describe characteristics of *Chlamydomonas reinhardti*, which makes it to be considered as a model organism.	Describe	Remember
PART – C Essay Answer **The answer should not exceed 400 words Marks: 5 x 7= 35**			
16	a) Write a note on: 1. Types of movements in algae 2. Large-scale algal cultivation methods (Or) b) State two examples of algal culture medium and explain in detail about the nutrient uptake models in algae with the help of pictorial representation.	Explain	Understand
17	a) What are bioactive compounds? State three examples and explain in detail about the extraction of bioactive compounds from algae and their commercial importance. (Or) b) Write a note on 1. Algal immobilization 2. Bioengineering of microalgae	Differentiate	Remember

18	a) Write a note on 1. Algae as bioindicators 2. Bioluminescent algae (Or) b) Explain in detail about the intertidal sea weeds, zonation patterns and factors affecting the distribution of intertidal sea weeds.	Explain	Understand
19	a) Write a descriptive note on algal toxins explaining their consequences on aquatic environments and trophic level. (Or) b) What is the significance of controlling algal growth? Explain physical and chemical methods of controlling algal growth.	Explain	Understand
20	a) State two examples of algae in extreme environments. Describe in detail the survival mechanisms of extremophilic algae. (Or) b) Describe in detail about the gene editing tools for algae with their applications and significance in large-scale production.	Discuss	Analyze

SEMESTER VIII					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIB5082	Research Methodology and Publication ethics	4	-	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	To understand the importance of research ethics	Understand
CO 2	To gain knowledge on scientific misconducts and importance of intellectual honesty.	Analyze
CO 3	To gain knowledge on publications ethics and common publication misconducts.	Apply
CO 4	To know about open access publication initiatives and software tools to identify predatory journals.	Understand
CO 5	To understand the research Indexing databases, Citation databases and Research Metrics.	Analyze

b. Syllabus

Units	Content	Hrs.
I	Philosophy and ethics Introduction to philosophy: definition, nature and scope, concept, branches; Ethics: definition, moral philosophy, nature of moral judgements and reactions.	12
II	Scientific conduct Ethics with respect to science and research; Intellectual honesty and research integrity; Scientific misconducts: Falsification, Fabrication and Plagiarism (FFP); Redundant Publications: duplicate and overlapping publications, salami slicing; Selective reporting and misrepresentation of data	12
III	Publication ethics: definition, introduction and importance; Best practices / standards setting initiatives and guidelines: COPE, WAME, etc.; Conflicts of interest; Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, types; Violation of publication ethics, authorship and contributor ship; Identification of publication misconduct, complaints and appeals; Predatory publisher and journals.	12
IV	Open access publishing Open access publications and initiatives; SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies;	12

	Software tool to identify predatory publications developed by SPPU; Journal finger / journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer, Journal Suggester, etc.	
V	Publication misconduct Group Discussion: a) Subject specific ethical issues, FFP, authorship b) Conflicts of interest c) Complaints and appeals: examples and fraud from India and abroad Software tools; Use of plagiarism software like Turnitin, Urkund and other open-source software tools	12
	Tasks and Assignments: • Internal exams • A quiz on research design and types • An assignment on statistical data analysis. • An assignment on model paper writing (referencing and plagiarism tools will be used to evaluate) References: • Nicholas H. Steneck. *Introduction* to the Responsible Conduct of Research. Office of Research Integrity. 2007. Available at: https://ori.hhs.gov/sites/default/files/rcrintro.pdf • The Student's Guide to Research Ethics By Paul Oliver Open University Press, 2003. • Responsible Conduct of Research By Adil E. Shamoo; David B. Resnik Oxford University Press, 2003. • Ethics in Science Education, Research and Governance Edited by Kambadur Muralidhar, Amit Ghosh Ashok Kumar Singhvi. Indian National Science Academy, 2019. ISBN : 978- 81-939482-1-7. • Anderson B.H., Dursaton, and Poole M.: Thesis and assignment writing, Wiley Eastern 1997. • Bijorn Gustavii: How to write and illustrate scientific papers? Cambridge University Press. • Bordens K.S. and Abbott, B.b.: Research Design and Methods, Mc Graw Hill, 2008. • Graziano, A., M., and Raulin, M., L.: Research Methods – A Process of Inquiry, Sixth Edition, Pearson, 2007	

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	2
CO2	3	3	3	3	3
CO3	2	2	2	3	3

CO4	3	3	3	3	3
CO5	2	2	2	2	2

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	20	20	20	20	20	100

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments		2	-	2	2
Seminar	2	-	2	-	-
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Essay- 5 x 7 = 35 marks)	7	7	7	7	7
Total	12	12	12	12	12

g. Rubric for Assignments

Sl. No.	**Criteria**	**100%**	**75%**	**50%**	**25%**	**0%**	**Relation to COs**
1	**Content** **50%**	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO2, CO4, CO5

2	**Organiza-tion** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO2, CO4, CO5

h. Rubric for Seminar

Sl. No.	**Criteria**	**100%**	**75%**	**50%**	**25%**	**0%**	**Relation to COs**
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1, CO3
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO1, CO3

i. Model Question Paper

Sl. No.	**Model Questions**	**Specification**	**Level**
	Part – A: Objective Type **Multiple Choice** **Marks: 10 x 1 = 10**		
1	To gain familiarity with a phenomenon or to achieve new insights into it is what type of research study? a. descriptive research studies b. diagnostic research studies c. exploratory or formulative research studies d. hypothesis-testing research studies	Recall	Remember
2	Experimental research and surveys are examples of		Remember

	_____ research. a. Longitudinal research b. Cross-sectional research c. Empirical research d. Developmental research	Recognize	
3	A research design with enough provision for protection against bias and must maximise reliability is _____ design a. Flexible design b. Observatory design c. Rigid design d. Operational design	Recall	Remember
4	What is the appropriate statistical test for comparing the mean scores of three groups (control, experimental A, and experimental B) that were randomly assigned in a study after treatment? a. the correlation coefficient b. chi square c. the t-test d. the analysis of variance	Identify	Remember
5	What method is used to determine the significance of an ANOVA test? a. Chi-square b. Student T test c. F test d. p-value	Recognize	Remember
6	The variability of the observed values around their respective treatment means can be measured by the _____ sum of squares. a. treatment b. error c. interaction d. total	Identify	Remember
7	Plagiarism can be avoided by the use of a) Direct Quotation b) Paraphrasing c) Summarizing	Recall	Remember

	d) All of the above		
8	One can use direct quotes a) Up to one page b) Up to one para c) Up to three lines d) Up to one line e)	Identify	Remember
9	Plagiarism can lead to a) Retraction of your published paper b) Suspension/ termination from a job c) Rejection of thesis d) All of the above	Recall	Remember
10	Plagiarism detection software checks plagiarism by providing a) Similarity index b) Citation index c) Content index d) None of these e)	Recall	Remember
	PART – B Short Answer **The answer should not exceed 200 words Marks:5 x 3 = 20**		
11	Detail Research design	Explain and cite	Remember
12	Briefly discuss the steps in Research Process	Explain	Understand
13	Explain the sampling and non-sampling error with suitable examples. Explain the sampling and non-sampling error with examples.	Describe	Analyze
14	What are the problems in measuring encounters?	Differentiate	Analyze
15	Explain in detail the various types of plagiarism?	Describe	Remember
PART – C Essay Answer **The answer should not exceed 400 words Marks: 5 x 7= 35**			
16	What is scientific method of research? Differentiate between scientific and non-scientific methods. a) What is scientific method of research? Differentiate between scientific and non- scientific methods. Or	Explain	Understand

	b) What is a research problem and how do you select and define it?		
17	a) What are the important components of research design? Or What do you mean by hypothesis sand and describe of process of hypothesis testing?	Differentiate	Remember
18	a) What are all the types of publication misconduct? b) Coding and non-coding RNA and their functions	Explain	Understand
19	a) Explain the peer review process and types Or b) What is conflict of interest in research? And Write a detailed note on prevention of plagiarism	Explain	Understand
20	a) Explain the various components while drafting a manuscript? Or b) 1. what are the tools available for detecting plagiarism? Why Turnitin is more preferred compared to rest of the software's? (4 marks) 2. How to avoid text and image plagiarism? (3 marks)	Discuss	Analyze

SEMESTER - VIII					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIB5084	**Multi-omics Biology**	4	-	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO 1	Understand the basics of genomics, Sequencing methods and Comparative genomics	Understand
CO 2	Gain knowledge on Genomic mapping	Skill
CO 3	Understand the concept of Epigenetics	Apply
CO 4	Learn the basics of proteomic and bioinformatic tools for proteomics data analysis.	Analyze
CO 5	Study the applications of Genomics and Proteomics	Understand

b. Syllabus

Units	**Content**	**Hrs.**
I	**Introduction to Genomics** Introduction to Genomics, DNA sequencing methods – manual & automated: Maxam & Gilbert and Sangers method. Pyrosequencing, Genome Sequencing: Shotgun & Hierarchical (clone contig) methods, Computational analysis of sequences: gene annotation, alignment,	12

	genetic variation polymorphism, phylogenetics. Comparative genomics: Basic concepts and applications.	
II	**Genomic mapping & Epigenetics** Genetic markers – VNTR, mini and micro satellites, STS, SNPs, ESTs. Types of genome maps, Mapping techniques – Physical and genetic mapping, Practical uses genome maps. Epigenetic phenomena: heritable alternate states of gene activity, Epigenetic mechanisms regulating genome accessibility. Tools for epigenetic data analysis; DNA microarray: database and basic tools.	12
III	**Proteomics** Introduction to Proteomics: Protein and peptide microarray-based technology, Identification and analysis of proteins by 2D analysis, tryptic digestion of protein and peptide fingerprinting, mass spectrometry, clinical proteomics and disease biomarkers, protein-protein interactions.	12
IV	**Metabolomics** Introduction to metabolomics; methods employed to study metabolism; flux balance analysis, radioactive isotopes tracking, metabolic engineering: transfer of gene/pathways to redirect metabolic flow; limitations of metabolic engineering	12
V	**Applications of multi-omics approaches** Analysis of the human genome, application of proteome analysis- drug development and toxicology, pharmaceutical applications, proteomics in drug discovery in humans, phage antibodies as tools, capstone project on genomics and proteomics, applications of integrated omics in disease diagnosis.	12
	Tasks and Assignments: • Internal exams • A quiz on importance of genomics and proteomics analysis in research. • An assignment on comparative and functional genomic approaches. • Presenting a scientific idea with the use of genomic and proteomics technique. **References:** • Brown T.A. (2010), Gene Cloning & DNA Analysis, 6nd Edition, Wiley-Blackwell, New York. • Bioinformatics- a Practical Guide to the Analysis of Genes and Proteins by Baxevanis, A.D. and Francis Ouellellette, B.F., Wiley India Pvt Ltd. 2009 • Primrose, S.B. and Twyman, R.M., Principles of gene manipulation and genomics. Blackwell Publishing (2006) • Campbell, M.A and Heyer L.J., Discovering Genomics, Proteomics and Bioinformatics, 2nd Edition, CSHL Press, Pearson/Benzamin Cummings San Francisco, USA, 2007.	

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**3**	**3**	**3**	**2**
CO2	**3**	**3**	**3**	**3**	**3**
CO3	**2**	**2**	**2**	**3**	**3**
CO4	**3**	**3**	**3**	**3**	**3**
CO5	**2**	**2**	**2**	**2**	**2**

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	2	2	-	2	
Seminar	-	-	2	-	2
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Essay- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content 50%**	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO4

2	**Organiza-tion** **50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO2 CO4

h. Rubric for Seminar

Sl. No.	**Criteria**	**100%**	**75%**	**50%**	**25%**	**0%**	**Relation to COs**
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO3, CO5
2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO5

i. Model Question Paper

Sl. No.	**Model Questions**	**Specification**	**Level**
	Part – A: Objective Type **Multiple Choice Marks: 10 x 1 = 10**		
1	The study of the full complement of proteins expressed by a genome is called _____ a) Proteome b) Proteomics c) Genomics d) Protein formation	Recall	Remember
2	The effects of protein on an entire organism is described in _____ a) Phenotypic function b) Cellular function c) Molecular function d) Structural genomics	Recognize	Remember

3	The network of interactions engaged in by protein at cellular level is described in _____ a) Phenotypic function b) Cellular function c) Molecular function d) Structural genomics	Recall	Remember
4	Sequencing of genomic DNA is included in _____ a) Phenotypic function b) Cellular function c) Molecular function d) Structural genomics	Identify	Remember
5	What is the goal of structural proteomics project? a) To crystallize and determine the structure of as many proteins as possible, in many cases with little or no existing information about protein function b) To identify and sequence of all the genes present in the human body c) To introduce new genes to human beings d) To remove disease causing genes from humans	Recognize	Remember
6	Genes of different species but possessing a clear sequence and functional relationship to each other are _____ a) Ortholog b) Synteny c) Paralog d) Microarray	Identify	Remember
7	Collection of microscopic DNA spots attached to the solid surface are _____ a) Ortholog b) Synteny c) Paralog d) Microarray	Recall	Remember
8	Small cDNA sequence that represents a unique segment of an active gene is called a) SNPs b) SnRNAs c) ESTs d) contigs	Identify	Remember
9	International Human Genome project was initiated by a) National Institute of Health (NIH) b) Celera genomics c) US Department of Energy (DoE) d) NIH and US DoE	Recall	Remember
10	All are genome sequencing strategies except a) Edman degradation method b) short gun library c) Whole genome short gun sequencing d) Directed gene sequencing	Recall	Remember

	PART – B Short Answer **The answer should not exceed 200 words Marks:5 x 3 = 15**		
11	Write a note on Comparative genomics and its applications.	Explain and cite	Remember
12	Describe uses of DNA microarray and commonly used tools for microarray data analysis?	Explain	Understand
13	Define biomarkers. How are protein biomarkers useful in clinical proteomics?	Describe	Analyze
14	Differentiate between metabolomics and metabolic engineering.	Differentiate	Analyze
15	Define phage antibodies. Mention their importance as research tools.	Describe	Remember
PART – C Essay Answer **The answer should not exceed 400 words Marks: 5 x 7= 35**			
16	a) Explain the concept of genome sequencing and discuss the different strategies used for sequencing whole genomes (10 marks)? Or b) Explain pyrosequencing in detail, including its principle, methodology, advantages, and applications.?	Explain	Understand
17	a) Define Epigenetics. Describe various epigenetic mechanisms regulating genome accessibility Or a) Describe the principle, methodology, and applications of DNA microarray technology.	Differentiate	Remember
18	a) Explain the principle and procedure of two-dimensional gel electrophoresis (2D-PAGE) in protein analysis. Or b) Write a detailed account on clinical proteomics and its applications in disease diagnosis.	Explain	Understand
19	a) Discuss in detail the integration of metabolomics and metabolic engineering in industrial biotechnology and its importance. O**r** b) Explain the transfer of genes and metabolic pathways in metabolic engineering with suitable examples.	Explain	Understand
20	a) Define phage antibodies and explain their applications as research and diagnostic tools. Or b) Write a detailed account on the integration of genomics, proteomics, and metabolomics in healthcare.	Discuss	Analyze

SEMESTER VIII					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
MIB5085	Bioethics, Biosafety and Intellectual property Right	3	1	-	3

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO 1	To understand the moral principles in performing ethical research	**Understand**
CO 2	Get an insight into Biosafety guidelines and biosafety levels	**Understand**
CO 3	To gain Knowledge of working principles in a laboratory taking all safety measures, handling of live cultures, disposal of wastes	**Apply**
CO 4	Gain Knowledge about Intellectual Property Rights and Understand guidelines to protect biological inventions	**Understand**
CO 5	To prepare a valid IPR application for the innovations and to understand the application procedures and regulations	**Analyze**

b. Syllabus

Units	**Content**	**Hrs.**
I	**BIOETHICS** Jurisprudential Basis of Bioethics-Necessity and paradigm of bioethics, development of bioethics- understanding law- ethics and bioethics - human dignity and human rights - Principles of Bioethics: Protecting future generations, Protection of the environment, the biosphere and biodiversity, Investigations- relevance- ethics in human and animal research, Embryonic cell research - Bioterrorism, Social and ethical implication of biological weapons	12
II	**BIOSAFETY: INTRODUCTION AND GUIDELINES:** Introduction to biosafety and Biohazards; Biological Safety Cabinets & their types; Primary Containment for Biohazards; and safe disposal of biohazards and laboratory wastes, sharps and glasses, Biosafety, Levels of Specific Microorganisms. International and national bio safety guidelines and regulations; NABL accredition for labs, PPEs, gloves and other protection for lab safety.	12
III	**RISK ANALYSIS AND GUIDELINES**: Role of Institutional Biosafety Committees (IBSC) and approvals in controlling GMOs/LMOs- Concerns and Challenges Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Testing of Drugs on Human volunteers Public and Non-Governmental Organizations(NGOs)Participation in Biosafety and protection of Biodiversity	12
IV	**INTRODUCTION TO IPR**: IPR, forms of IPR, and Intellectual property protection. Concept of property with respect to intellectual creativity, Tangible and Intangible property. Copyright, trademarks, service marks, trade secret, and geographical index. Search engines for	12

	patent and prior art checks, Concepts related to patents, novelty, inventive-step, non-obviousness, utility, anticipation, etc.	
V	**INTRODUCTION TO IPR**: IPR, forms of IPR, and Intellectual property protection. Concept of property with respect to intellectual creativity, Tangible and Intangible property. Copyright, trademarks, service marks, trade secret, and geographical index. Search engines for patent and prior art checks, Concepts related to patents, novelty, inventive-step, non-obviousness, utility, anticipation, etc.	12
	Tasks and Assignments: • Internal exams • A quiz on antimicrobial drugs and their mechanism • Seminar on resistance formation in bacteria • Group discussions on tools to study AMR. **References:** 1. Rustam Aminov. Insights in Antimicrobials, Resistance & Chemotherapy: 2021 2. Archana Madhav, Robert C. Will & Ankur Mutreja. 2020. The Evolution of Microbial Defence Systems Against Antimicrobial Agents. 3. Sanjucta Dutta & T. Ramamurthy, 2020. Influence of Abiotic Factors in the Emergence of Antibiotic Resistance	

c. Mapping of Program Outcomes with Course Outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**3**	**3**	**3**	**3**	**2**
CO2	**3**	**3**	**3**	**3**	**3**
CO3	**2**	**2**	**2**	**3**	**3**
CO4	**3**	**3**	**3**	**3**	**3**
CO5	**2**	**2**	**2**	**2**	**2**

d. Evaluation Scheme

	CO1	**CO2**	**CO3**	**CO4**	**CO5**	**Total**
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	**CO2**	**CO3**	**CO4**	**CO5**
Assignments	2		-	2	2
Seminar	-	2	2	-	-
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Essay- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content 50%**	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO4, CO5
2	**Organiza -tion 50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organization	Not attended	CO1, CO4, CO5

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Knowledge and Understanding 50%**	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO2, CO3

2	**Presentation** **50%**	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO2, CO3

i. Model Question Paper

Sl. No.	**Model Questions**	**Specification**	**Level**
	Part – A: Objective Type **Multiple Choice** **Marks: 10 x 1 = 10**		
1	**Which principle of bioethics refers to "doing good"?** A. Justice B. Autonomy C. Beneficence D. Confidentiality	Recall	Remember
2	**Bioethics mainly deals with:** A. Geological studies B. Ethical issues in biology and medicine C. Agricultural economics D. Computer programming	Recognize	Remember
3	**Informed consent means:** A. Giving medicine without permission B. Treating patients secretly C. Providing adequate information before participation or treatment D. Forcing participation in research	Recall	Remember
4	**Biosafety refers to:** A. Protection of computers from viruses B. Safe handling of biological materials C. Financial safety in laboratories D. Protection of buildings from fire	Identify	Remember
5	**Which of the following is considered personal protective equipment (PPE)?** A. Incubator B. Microscope C. Gloves D. Centrifuge	Recognize	Remember
6	**Which biosafety level is required for handling highly dangerous pathogens like Ebola virus?** A. BSL-1 B. BSL-2 C. BSL-3 D. BSL-4	Identify	Remember
777	**Which disinfectant is commonly used in**		Remember

	laboratories? A. Sodium hypochlorite B. Sugar solution C. Distilled water D. Ethanol-free perfume	Recall	
8	**Which of the following protects inventions and new technologies?** A. Trademark B. Copyright C. Patent D. Trade secret	Identify	Remember
9	**A trademark is mainly used to protect:** A. Scientific theories B. Brand names and logos C. Research data D. Laboratory protocols	Recall	Remember
10	**Copyright protection is mainly applicable to:** A. Machines and devices B. Literary and artistic works C. Industrial chemicals D. Plant varieties	Recall	Remember
	PART – B Short Answer **The answer should not exceed 200 words Marks:5 x 3 = 20**		
11	Define bioethics and explain its importance in healthcare and research.	Describe	Analyze
12	What is informed consent? Why is it essential in biomedical research?	Demonstrate	Understand
13	What is the function of a biosafety cabinet?	Describe	Analyze
14	Why is personal protective equipment (PPE) important in laboratories?	Explain	Analyze
15	What is trade secret? explain with example.	Interpret	Remember
PART – C Essay Answer **The answer should not exceed 400 words Marks: 5 x 7= 35**			
16	a) Discuss the major principles of bioethics—autonomy, beneficence, non-maleficence, and justice—with suitable examples. OR b) Explain the ethical issues involved in genetic engineering, stem cell research, and cloning.	Explain	Understand
17	a) Describe the importance of informed consent and confidentiality in biomedical research and clinical practice. OR b) Discuss the role of ethics committees in regulating human and animal research, highlighting important international ethical	Differentiate	Remember

	guidelines such as the Nuremberg Code and the Declaration of Helsinki		
18	a) Explain the concept of biosafety and discuss the different biosafety levels (BSL-1 to BSL-4) with their features and applications. OR b) Describe the various laboratory bios afety practices and personal protective measures followed while handling pathogenic microorganisms.	Explain	Understand
19	a) Discuss the importance of biomedical waste management in laboratories and explain the methods used for segregation, treatment, and disposal of biohazardous waste. OR b) Explain the working principles, types, and applications of biosafety cabinets and discuss their role in preventing laboratory-acquired infections.	Explain	Understand
20	a) Geographical index explain with examples Or b) Flow chart on patent filing and explain the importance of novelty in IPR.	Understand	Analyze