

<b>Semester: 3</b>	
<b>Course: Major 1</b>	
<b>Paper Title: Microbiology</b>	
<b>Paper code: C2BT230312T/P</b>	<b>Credits: 3+1</b>
<b>Hours/week: 3+3</b>	
<b>Category: Core/MDC/SEC/VAC: Core</b>	
<b>Theory / Practical / Composite: Composite</b>	
<b>No of Modules in Theory: 2 (A + B)</b>	
<b>Course Overview:</b>	
<b>Theory</b>	
<ul style="list-style-type: none"> <li>• This course provides a foundational understanding of Microbiology as a Subject, tracing the historical development and evolution of the discipline, while introducing the phenomenal contribution of eminent scientists in the same.</li> <li>• Emphasis is placed on the growth physiology, reproductive strategies, and nutrition of bacteria, with detailed discussions on their cell morphology and ultrastructure.</li> <li>• The course introduces essential concepts related to pure culture techniques and preservation methods, along with an overview of Water, Food, and Dairy Microbiology as the sub-disciplines.</li> <li>• Students will also gain insights into the significance of human microbiome and its regulation of human behavior, and the fundamental principles of physical, chemical, and biological methods of control of microbial growth.</li> <li>• The course also emphasizes on core concepts of molecular Microbial Taxonomy and systematics, and an overview of microbial diversity.</li> <li>• In addition, the course covers the sub-disciplines of Air and Soil Microbiology, highlighting the role of microorganisms in biogeochemical cycles and a proper ecosystem functioning.</li> <li>• A basic introduction to Virology is included, addressing virus structure, traditional methods of virus classification, and virus replication cycles with reference to a few selected ones.</li> <li>• Overall, this course lays a strong conceptual foundation for advanced studies in Microbiology and its diverse applications in Environmental, Industrial, and Medical Sciences.</li> </ul>	
<b>Practical</b>	
<ul style="list-style-type: none"> <li>• The Microbiology Practical component introduces students to fundamental microbiological techniques essential for understanding microbial structure, cultivation, identification, and quantification, thereby strengthening their analytical and technical abilities.</li> <li>• Through hands-on laboratory training, students will gain practical exposure to maintenance of aseptic techniques and development of safety awareness for working in a Microbiology Laboratory, culture media preparation, microbial cultivation, and different staining methods used for microscopic observation of samples.</li> <li>• By engaging in standard methods of pure culture isolation by techniques such as streak plate and serial dilution-spread plate, enumeration of microorganisms (total count and viable count), and isolation and enumeration of bacteriophages, students are expected to build a strong foundation for advanced studies, research, and careers in Microbiology, Biotechnology, Healthcare, and allied Life Science disciplines.</li> </ul>	

<b>Course Outcome:</b>
<b>Theory</b>
<b>Module A</b>
<b>1. Remember</b> Students will be able to recall the historical milestones, key contributors, fundamental concepts that led to the development and evolution of Microbiology as a scientific discipline, and the functions of different parts of the bacterial ultrastructure.
<b>2. Understand</b> Students will develop an understanding of bacterial cell morphology, ultrastructure, nutrition, and modes of reproduction. They will comprehend the principles underlying bacterial growth and nutrition, concept of pure culture and their preservation techniques, the role of microorganisms in Water-, Food- and Dairy-systems, and the human microbiome and its importance for a healthy, disease-free life.
<b>3. Apply</b> Students will apply basic microbiological principles to explain different methods used for controlling unwanted microbial growth in the environment and human body.
<b>4. Analyze</b> Students will analyze the basics of bacterial growth kinetics.
<b>5. Evaluate</b> Students will evaluate the numericals on bacterial growth kinetics, and different methods of microbial control and preservation in terms of effectiveness and application.
<b>6. Create</b> At an introductory level, students will be encouraged to integrate concepts from Bacteriology and Environmental Microbiology to construct conceptual models explaining host-microbe interactions of various types.
<b>Module B</b>
<b>1. Remember</b> Students will be able to remember the different classification schemes and nomenclature patterns of bacteria and archaea, and different key terms in Virology.
<b>2. Understand</b> Students will develop an understanding of the life cycles of selected bacteriophages, viroids, and prions.
<b>3. Apply</b> Students will apply the basic concepts of Air and Soil Microbiology from a practical perspective to interpret microbial involvement in biogeochemical cycles of nature, and of Virology through description of virus structure and classification.
<b>4. Analyze</b> Students will analyze microbial diversity using Molecular Taxonomy and other modern classification techniques in Systematics, and One-Step Growth Curve of virus infection cycle to determine key parameters like latent period, burst size, and replication kinetics.
<b>5. Evaluate</b> Students will evaluate the differences between diverse groups of microorganisms and viruses, and their modes of replication by examining the characteristics, phylogeny, and ecological significance.
<b>6. Create</b> At an introductory level, students will be encouraged to integrate concepts from Bacteriology, Environmental Microbiology and Virology to construct conceptual models explaining microbial and virus interactions in natural hosts and ecosystems.
<b>Practical</b>
<b>1. Remember</b> Students will remember how to apply appropriate aseptic techniques and laboratory safety practices for maintaining sterility during microbiological experiments.
<b>2. Understand</b> Students will develop an understanding of how to prepare and sterilize culture media required for the growth and maintenance of microorganisms, using standard laboratory procedures.
<b>3. Apply</b> Students will apply their knowledge of basic aseptic techniques to cultivate microorganisms in pure culture using broth and solid media (slant and stab cultures), and isolate pure cultures of bacteria using streak plate (four-way and continuous) and serial dilution–spread plate methods.

**4. Analyze** Students will analyze the principles and protocols of Simple-, Gram-, Endospore-, Negative-, and Acid-fast staining techniques to differentiate between microorganisms based on differences in their cellular architecture.

**5. Evaluate** Students will evaluate the numericals associated with enumeration of microorganisms (total count using Petroff-Hausser counting chamber and viable count using the pour plate method), and isolation and enumeration of bacteriophages (PFU) from water or sewage samples using the double agar layer technique, and interpret the results.

**6. Create** Students will be able to design a complete microbiological experiment by selecting an appropriate (selective) culture medium to cultivate an unknown bacterium aseptically from a natural (mixed culture) sample by a suitable pure culture isolation technique, followed by its staining, cell counting, and preliminary identification.

**Prerequisites: Basic knowledge about Biology, Classification & Systematics, Cell Biology**

**SYLLABUS**

**Theory**

<b>UNIT/ Module</b>	<b>CONTENT</b>	<b>HOURS or NUMBER OF CLASSES</b>	<b>CO Mapping</b>	<b>COGNITIVE LEVEL</b>
<b>Module A [25 marks]</b>	<b>UNIT I: Fundamentals, History and Evolution of Microbiology:</b> Fundamentals of Microbiology; history and evolution of Microbiology: spontaneous generation (abiogenesis) vs. biogenesis, contributions of Anton von Leeuwenhoek, Louis Pasteur and Robert Koch (including Koch's Postulates).	2 classes/ week	CO1 – CO6	K1 – K6
	<b>UNIT II: Bacterial cell morphology and ultrastructure:</b> Morphology of bacterial cells (size, shape and arrangement); ultrastructure of a typical bacterial cell (eubacterial and archaebacterial cell walls; spheroplasts, protoplasts and L-forms; periplasmic space; eubacterial and archaebacterial cell membranes; glycocalyx, capsule, slime layer & S-layer; nucleoid; plasmids and episomes; flagella, endoflagella, pili and fimbriae; ribosomes;			

	mesosomes; inclusion bodies; gas vacuoles; endospore).			
	<p><b>UNIT III: Bacterial growth (reproduction):</b>          Bacterial growth (reproductive) strategies; bacterial growth curve and different phases of growth; bacterial growth kinetics - calculation of number of generations, mean growth rate constant and mean generation time; synchronous growth; diauxic growth; factors affecting bacterial growth.</p>			
	<p><b>UNIT IV: Bacterial nutrition and pure culture preservation:</b>          Nutritional categories of bacteria; nutrients for bacteria (macro- and micro-nutrients); concept of pure culture; preservation of pure cultures.</p>			
	<p><b>UNIT V: Water microbiology:</b> Public health and water quality; overview of BIS regulations; basic concepts of BOD and COD; microbial (bacterial and viral) pollutants of water; indicator organisms - coliforms (fecal and non-fecal) and non-coliforms; water-borne human diseases.</p>			

	<p><b>UNIT VI: Food microbiology:</b> Food as a microbial growth medium - factors (extrinsic and intrinsic) affecting food-borne microorganisms; normal microflora and spoilage microflora of food; food spoilage; food-borne diseases (food-borne intoxications and infections); food safety and FSSAI regulations; food preservation methods; fermented foods; basic concepts of probiotics and prebiotics.</p>			
	<p><b>UNIT VII: Dairy microbiology:</b> Milk as a microbial growth medium; types of microorganisms in milk (biochemical; temperature-characteristic and pathogenic); gradation of milk; sources of microorganisms in milk; Pasteurization of milk &amp; phosphatase test; undesirable microorganisms in milk; milk-borne diseases of human origins; fermented milk; ice cream.</p> <p><b>UNIT VIII: Human microbiome:</b> Normal microbiome of the human body; gut microbiome and its regulation of human behavior; psychobiotics.</p>			

	<p><b>UNIT IX: Controlling microbial growth in the environment and in the body:</b> Antiseptics (germicides), sterilants, disinfectants and sanitizers; antimicrobial control by physical agents (heat, low temperature, filtration and radiation), chemical agents (phenol and phenolics, alcohol, and halogens) and antimicrobial agents (including drug resistance mechanisms).</p>			
<p><b>Module B [20 marks]</b></p>	<p><b>UNIT I: Microbial taxonomy and systematics:</b> Molecular phylogeny (rRNA based), sequence alignment and phylogenetic trees; concept of species in microbiology; taxonomic methods in systematics; classification and nomenclature of bacteria and archaea, Bergey's Manual of Systematic Bacteriology.</p>	1 class/week	CO1 – CO6	K1 – K6
	<p><b>UNIT II: Diversity in microbial world:</b> Phylogenetic overview; general characteristics and eco-logical significance of key genera of prokaryotic and eukaryotic microbes: Bacteria - Archaeobacteria; Eubacteria; Mycoplasma; Bacteroidetes; Protists; Fungi; Algae.</p>			
	<p><b>UNIT III: Air microbiology:</b> Air as a microbial growth medium; droplet nuclei and bio-aerosols; air-borne microorganisms &amp; Stoke's Law; factors affecting air-borne microorganisms; air-borne human diseases.</p>			

	<p><b>UNIT IV: Soil Microbiology and biogeochemical cycles:</b> Soil as a microbial habitat, soil composition and formation, rhizosphere; Vegetated and dryland soils as microbial habitats; Arid soils; Phylogenetic snapshot of soil bacterial and archaeal diversity; Biogeochemical cycles: Carbon cycle, Nitrogen cycle, Phosphorus cycle, Sulphur cycle.</p>			
	<p><b>UNIT V: Introduction to Virology:</b> Viral evolution; Isolation, cultivation and identification of viruses; Structure of a virion; Baltimore Classification; Overview of the viral life cycle – One-Step Growth Curve; bacteriophages – lytic and lysogenic cycles; single-stranded DNA bacteriophages (Phage <math>\phi</math>X174, M13), double-stranded DNA Bacteriophages (T7 and Mu); Viroids and Prions.</p>			
<b>Practical</b>				
<b>CONTENT</b>				<b>HOURS or NUMBER OF CLASSES</b>
<ol style="list-style-type: none"> <li>1. Maintenance of sterility and growing microbes in the laboratory</li> <li>2. Preparation of culture media</li> <li>3. Cultivation of microorganisms in pure culture in broth and agar (slant, stab).</li> <li>4. Staining methods: Simple staining, Gram staining, Endospore staining, Negative staining and Acid-fast staining (demonstration)</li> <li>5. Isolation of pure culture of bacteria by Streak-plate (four-way &amp; continuous) and Serial-Dilution-Spread plate methods</li> </ol>				3 classes/week

6. Enumeration of microorganisms - total count (by Petroff-Hausser Counting chamber) & viable count (by Pour-plate method)	
7. Isolation and enumeration of bacteriophages (PFU) from water/sewage sample using double agar layer technique	

### **Text Books**

#### **Theory text/references**

1. Bauman RW. (2019). Microbiology: With Diseases by Taxonomy. 6th edition. Pearson / Benja-min Cummings.
2. Jay JM, Loessner MJ and Golden DA. (2005). Modern Food Microbiology. 7th edition, CBS Publishers and Distributors, Delhi, India.
3. William C. Frazier, Dennis C. Westhoff, N.M. Vanitha. (2017). Food Microbiology, 5th Edition. McGraw Hill Education.
4. R G Buckley. (2019). Environmental Microbiology. CBS Publishers and Distributors, Delhi, India.
5. Michael Madigan, Jennifer Aiyer, Daniel Buckley, W. Sattley, David Stahl (2021). Brock Biol-ogy of Microorganisms. 16th edition. Pearson / Benjamin Cummings.
6. Pelczar MJ, Chan ECS and Krieg NR. (2022). Microbiology. 5th Edition. Affiliated East West Press Private Limited New Delhi.
7. Salle, A.J. (1974). Fundamental Principles of Bacteriology. TMH / 7th Edition. Tata McGraw Hill.
8. Roger Y Stanier, John L Ingraham, Mark L Wheelis, Page R Painter (2005). General Microbiology. 5th Edition. Palgrave Macmillan.
9. Gerard Tortora, Berdell Funke, Christine Case, Derek Weber, Warner Bair III. (2020). Microbiology: An Introduction. 13th edition. Pearson Education.
10. Joanne Willey, Kathleen Sandman, Dorothy Wood. (2022). ISE Prescott's Microbiology. 12th Edition. McGraw Hill Higher Education.
11. Jacquelyn G. Black, Laura J. Black (2018). Microbiology: Principles and Explorations. 10th Edition. Wiley Publications.
12. Ronald M. Atlas. (2020). Principles of Microbiology. Second Edition (India Ed). McGraw-Hill.
13. N.S. Subbarao. (2017). Soil Microbiology. MedTech Publishers.
14. Edward K. Wagner, Martinez J. Hewlett. (2003). Basic Virology. 2nd Edition. John Wiley & Sons.
15. Dimmock, Easton and Leppard. (2016). Introduction to Modern Virology. 7th Edition. Wiley-Blackwell
16. Vincent R. Racaniello, Glenn F. Rall, Anna Marie Skalka, S. Jane Flint, Lynn W. Enquist. (2015). Principles of Virology: Vol I-II. 4th Edition. ASM Press.
17. David M. Knipe, Peter M. Howley. (2006). Fields Virology. 5th Edition. Lippincott Williams and Wilkins.

#### **Practical text/references**

1. Experiments in Microbiology, Plant Pathology, Tissue culture and Microbial Biotechnology – K. R. Aneja. 6th Edition (2022). New Age International Private Limited.
2. Laboratory Manual of Microbiology and Biotechnology – K. R. Aneja. 2nd Edition. (2017). MedTech Publishers.
3. Microbiology: A Laboratory Manual – Cappuccino and Sherman. 10th Edition. (2013). Pearson Benjamin Cummings Publishers.
4. Practical Microbiology – Dr. R.C. Dubey, D K Maheshwari (2023 Ed). S Chand and Company Publishing.

**Evaluation (100):****Theory (60)**

CIA- 10; Assignment – 02; Attendance – 03; Semester Exam- 45

**Practical (40)**

CA- 30; Attendance – 02; Semester Exam- 08

**Paper Structure for Theory Semester Exam Module:****Module A (25 Marks)**

1 Compulsory Question – objective-type (any 5 out of 7 questions; each of 1 mark):  $1 \times 5$  marks = 5 marks; Any 2 out of 3 questions; each of 10 marks, with subparts (no sub-part will be more than 5 marks, and less than 1 mark):  $2 \times 10$  marks = 20 marks.

**Module B (20 Marks)**

1 Compulsory Question – any 5 out of 7 questions; each of 2 marks, with subparts (no sub-part will be less than 1 mark):  $5 \times 2$  marks = 10 marks; Any 1 out of 2 questions; each of 10 marks, with subparts (no sub-part will be more than 5 marks, and less than 1 mark):  $1 \times 10$  marks = 10 marks.

**COURSE OUTCOMES (COS) AND COGNITIVE LEVEL MAPPING (THEORY)**

COs	CO Description	Cognitive levels
<b>MODULE A</b>		
<b>CO1</b>	<b>Remember</b> Students will be able to recall the historical milestones, key contributors, fundamental concepts that led to the development and evolution of Microbiology as a scientific discipline, and the functions of different parts of the bacterial ultrastructure.	K1
<b>CO2</b>	<b>Understand</b> Students will develop an understanding of bacterial cell morphology, ultrastructure, nutrition, and modes of reproduction. They will comprehend the principles underlying bacterial growth and nutrition, concept of pure culture and their preservation techniques, the role of microorganisms in Water-, Food- and Dairy-systems, and the human microbiome and its importance for a healthy, disease-free life.	K2
<b>CO3</b>	<b>Apply</b> Students will apply basic microbiological principles to explain different methods used for controlling unwanted microbial growth in the environment and human body.	K3
<b>CO4</b>	<b>Analyze</b> Students will analyze the basics of bacterial growth kinetics.	K4
<b>CO5</b>	<b>Evaluate</b> Students will evaluate the numericals on bacterial growth kinetics, and different methods of microbial control and preservation in terms of effectiveness and application.	K5
<b>CO6</b>	<b>Create</b> At an introductory level, students will be encouraged to integrate concepts from Bacteriology and Environmental Microbiology to construct conceptual	K6

	models explaining host-microbe interactions of various types.	
<b>MODULE B</b>		
<b>CO1</b>	<b>Remember</b> Students will be able to remember the different classification schemes and nomenclature patterns of bacteria and archaea, and different key terms in Virology.	K1
<b>CO2</b>	<b>Understand</b> Students will develop an understanding of the life cycles of selected bacteriophages, viroids, and prions.	K2
<b>CO3</b>	<b>Apply</b> Students will apply the basic concepts of Air and Soil Microbiology from a practical perspective to interpret microbial involvement in biogeochemical cycles of nature, and of Virology through description of virus structure and classification.	K3
<b>CO4</b>	<b>Analyze</b> Students will analyze microbial diversity using Molecular Taxonomy and other modern classification techniques in Systematics, and One-Step Growth Curve of virus infection cycle to determine key parameters like latent period, burst size, and replication kinetics.	K4
<b>CO5</b>	<b>Evaluate</b> Students will evaluate the differences between diverse groups of microorganisms and viruses, and their modes of replication by examining the characteristics, phylogeny, and ecological significance.	K5
<b>CO6</b>	<b>Create</b> At an introductory level, students will be encouraged to integrate concepts from Bacteriology, Environmental Microbiology and Virology to construct conceptual models explaining microbial and virus interactions in natural hosts and ecosystems.	K6