Semester: V	
Programme: BIOTECHNOLOGY	
Course: Microbial Physiology	
Paper code: C3BT230522T/P	**Credits: 3 + 1**
Hours/week: 3 + 3	
Category: Core/MDC/SEC/VAC: Core	
Theory / Practical / Composite: Composite	
No of Modules in Theory: 2 (A + B)	
Course Overview:	

Theory

- This course explores the functional, regulatory, and metabolic principles governing microbial life.
- Emphasis is placed on cellular physiology, stress adaptation, transport mechanisms, energy metabolism, and global regulatory networks**,** enabling students to appreciate microbes as highly adaptable and efficient biological systems.
- The course includes an examination of environmental factors influencing microbial growth, along with analysis of diauxic growth kinetics.
- It familiarizes students to microbial stress responses, highlighting molecular mechanisms of stress sensing and adaptation, transcriptional and translational regulation, alternate sigma factors, stringent response, and two-component regulatory systems.
- A significant component of the course focuses on membrane transport systems, and energetics of transport, with special reference to iron acquisition and ABC transporters.
- The course further integrates nitrogen metabolism, detailing microbial participation in the nitrogen cycle, ammonia assimilation, nitrification, denitrification, and assimilative / dissimilative nitrate reduction, underscoring the ecological significance of microbes.
- Topics related to microbial growth physiology emphasize on bacterial reproductive strategies, cytoskeletal proteins, regulation of the bacterial cell cycle, chromosome replication and segregation, cytokinesis via the divisome complex, and peptidoglycan biosynthesis.
- The metabolic versatility of microorganisms is vividly explored through phototrophic metabolism, chemolithotrophy, and various fermentation pathways, with discussions on energetic efficiency, redox balance, and syntrophic interactions.
- Overall, this course promotes conceptual understanding, critical thinking, and systems-level integration**.** It bridges Microbial Physiology with Biochemistry, Molecular Biology, Environmental science, and Biotechnology**,** preparing students for higher education, research, Industrial Microbiology, environmental monitoring, and allied life-science careers.

Practical

- The Microbial Physiology Practical course is designed to provide hands-on training in fundamental experimental approaches used to study microbial growth, physiology, and functional diversity**.**
- This course complements the theory component by enabling students to translate conceptual knowledge into laboratory-based skills**,** data analysis, and scientific interpretation.

- This practical syllabus introduces students to quantitative analysis of microbial growth kinetics using the turbidometric method, allowing learners to generate and interpret bacterial growth curves and correlate growth phases with physiological states.
- Students will also investigate the effects of environmental parameters**,** such as temperature and salt concentration, on microbial growth, thereby reinforcing concepts of environmental adaptation and stress physiology.
- A major component of the course focuses on antimicrobial susceptibility testing**,** where students perform the Kirby–Bauer disc diffusion assay and determine Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) using broth dilution methods. These experiments build competence in Clinical and Applied microbiology**,** emphasizing antimicrobial resistance, data interpretation, and laboratory standardization.
- The course also introduces Microbial ecology and Applied Environmental Microbiology through the isolation of nitrogen-fixing bacteria from soil samples**,** highlighting the ecological significance of microorganisms in nutrient cycling and sustainable agriculture.
- Overall, the course emphasizes hands-on learning, problem-solving and data handling, preparing students for advanced practical courses, research laboratories, clinical diagnostics, and Biotechnology-related careers.

Course Outcome:
Theory
Module A
1. Remember Students will recall the physicochemical parameters governing microbial growth and physiology, including temperature, pH, water activity, oxygen availability, radiation, pressure, and growth kinetics such as diauxic growth.
2. Understand Students will develop an understanding of the molecular and cellular mechanisms underlying responses to environmental and physiological stresses in Bacteria and Archaea.
3. Apply Students will apply principles of membrane transport and nitrogen metabolism to elucidate nutrient uptake, ion homeostasis, transport energetics, Nitrogen assimilation, and microbial participation in Nitrogen cycling in nature.
4. Analyze Students will analyze stress sensing and adaptations, sigma factor regulation, stringent response, tmRNA-mediated quality control, two-component regulatory systems, osmoregulation, oxidative, heat, and pH stress responses, and transcriptional regulation in Bacteria and Archaea, based on thermodynamic efficiency, energy conservation, redox balance, ecological and industrial relevance, and environmental adaptability.
5. Evaluate Students will evaluate the numericals associated with microbial transport systems.
6. Create Students will be able to design integrative physiological models or problem-based interpretations integrating microbial growth, stress responses and transport systems to address environmental, industrial, or biogeochemical challenges.
Module B
1. Remember Students will recall the different consecutive steps in the bacterial peptidoglycan biosynthesis pathway, and major metabolic types of microbes.
2. Understand Students will develop an understanding of the microbial energy-generating strategies—phototrophy, chemolithotrophy, and fermentative metabolism, based on thermodynamic efficiency, energy conservation, redox balance, ecological and industrial relevance, and environmental adaptability.
3. Apply Students will apply their knowledge about fermentative metabolism of microbes for a better understanding of their forthcoming modules on Bioprocess Technology and Microbial Biotechnology.

4. Analyze Students will analyze bacterial cellular organization and growth physiology through studies on their different reproductive strategies, cytoskeletal dynamics (MreB), cell cycle regulation, chromosome replication and segregation, divisome assembly, and cytokinesis.
5. Evaluate Students will evaluate some higher order numericals on bacterial growth.
6. Create Students will be able to design integrative physiological models or problem-based interpretations integrating microbial growth and metabolic pathways to address environmental, industrial, or biogeochemical challenges.
Practical
1. Remember Students will recall the theoretical principles underlying bacterial growth kinetics, turbidometric measurements, environmental factors affecting bacterial growth (including temperature and salinity), and basic concepts of antibiotic action and resistance.
2. Understand Students will develop an understanding of the relationship between optical density (OD) and cell concentration, the physiological basis of temperature and osmotic stress on bacterial growth, the rationale of Kirby–Bauer disc diffusion and broth dilution assays of antibiotics, and the ecological significance of Nitrogen-fixing bacteria in soil ecosystems.
3. Apply Students will apply standard microbiological protocols to monitor the growth of *E. coli*, assess the effect of temperature and salt concentration on *E. coli* growth, perform antibiotic sensitivity tests, determine MIC and MBC values, and isolate Nitrogen-fixing bacteria from soil samples.
4. Analyze Students will analyze experimental data by plotting and interpreting bacterial growth curves, by comparing growth responses under varying environmental conditions with those under optimal, by determining MIC and MBC values of antibiotics, and correlating inhibition zone diameters with antibiotic susceptibility profiles.
5. Evaluate Students will critically evaluate microbial physiological responses to environmental stresses, bacterial susceptibility or resistance patterns to antibiotics, and interpret the ecological relevance of Nitrogen-fixing bacteria isolated from soil.
6. Create Students will be able t**o** design experimental modifications, data-driven interpretations, or problem-based experimental approaches to investigate microbial growth behavior, antimicrobial resistance trends, or functional microbial groups in environmental samples.
Prerequisites: **Basic knowledge about Microbiology, Prokaryotic & Eukaryotic Cell Biology**
SYLLABUS

Theory

UNIT/Module	CONTENT	HOURS or NUMBER OF CLASSES	CO Mapping	COGNITIVE LEVEL
MODULE A [25 marks]	**UNIT I: Effect of the environment on microbial growth:** Temperature - temperature ranges for microbial growth, classification based on temperature ranges and adaptations, pH-classification based on pH ranges and adaptations, solutes and water activity, oxygen concentration, radiation and pressure; diauxic growth curve. **UNIT II: Microbial stress response:** Mechanisms of	1.5 classes/ week	CO1 – CO6	K1 – K6

	sensing stresses: alternate σ factors, regulation of translation of RpoS (the general stress response activator); small molecules (The stringent response), tmRNA; global control networks: Bacterial Two-Component Regulatory Systems (EnvZ/OmpR system), Integrated Biochemical and Genetic Control networks of nitrogen assimilation, phosphate uptake and pho regulon, osmotic stress and osmoregulation (Trk, Kdp, and Kup systems in E. coli), oxidative stress response, heat shock response, pH stress and acid tolerance, bacterial efflux pumps; Transcription Controls in Archaea.			
	UNIT III: Transport processes: Metabolite Transport, Diffusion: Passive and facilitated, primary active and secondary active transport, group translocation (phosphotransferase system), symport (sodium-glucose co-transport), antiport (sodium/potassium antiport) and uniport (transport of glucose and lactose), Histidine permease system; electrogenic and electro-neutral transport (energetics), transport of iron; yeast ABC-transporters.			
	UNIT IV: Nitrogen metabolism: Nitrogen cycle (nitrification; denitrification; biological nitrogen fixation; ammonification and ammonia fluxes; Anammox); ammonia assimilation; assimilative and dissimilative nitrate reduction.			

Module B [20 marks]	**UNIT V: Growth physiology:** Reproductive strategies in bacterial cells; MreB and cell morphology; bacterial cell cycle (including chromosome replication & partitioning – MreB model, cytokinesis – Fts proteins and Divisome complex); peptidoglycan biosynthesis.	1.5 classes/ week	CO1 – CO6	K1 – K6
	UNIT VI: Phototrophic Metabolism: Photosynthesis and chlorophylls; anoxygenic photosynthesis; oxygenic photosynthesis; autotrophic pathways.			
	UNIT VII: Chemolithotrophy: Inorganic compounds as electron donors; oxidation of reduced sulfur compounds; hydrogen oxidation; iron oxidation.			
	UNIT VIII: Fermentation: Energetic and redox considerations; lactic and mixed acid fermentation; Clostridial and propionate fermentation; syntrophy.			

Practical

CONTENT	HOURS or NUMBER OF CLASSES
1. Study of Growth Kinetics of *E. coli* by turbidometric method and plotting of Growth Curve. 2. Effect of temperature and salt concentration on growth of *E. coli*. 3. Determination of antibiotic sensitivity/resistance of bacteria by Kirby-Bauer Disc-Diffusion method. 4. Determination of MIC/MBC of antibiotics by Broth-Dilution Method. 5. Isolation of nitrogen-fixing bacteria from a soil sample.	3 classes/week

Text Books

Theory text/references

Module A

1. Alberts B, *et al*. Molecular Biology of the Cell.
2. Karp G. Cell and Molecular Biology – Concepts and Experiments.
3. Weaver. Molecular Biology.
4. Madigan MT, Martinko JM, Bender KS, Buckley DH and Stahl DA. (2017). Brock Biology of Microorganisms.14th edition. Pearson Education, Limited.
5. Moat AG and Foster JW. (2002). Microbial Physiology. 4th edition. John Wiley & Sons.
6. Reddy SR and Reddy SM. (2005). Microbial Physiology. Scientific Publishers India.
7. Gottschalk G. (1986). Bacterial Metabolism. 2nd edition. Springer Verlag.
8. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.
9. Relevant Scientific Literature.

Module B

1. Bauman RW. (2011). Microbiology: With Diseases by Taxonomy. 3rd edition. Pearson / Benjamin Cummings.
2. Gottschalk G. (1986). Bacterial Metabolism. 2nd edition. Springer Verlag
3. Madigan MT, Martinko JM, Bender KS, Buckley DH and Stahl DA. (2017). Brock Biology of Microorganisms.14th edition. Pearson Education, Limited.
4. Moat AG and Foster JW. (2002). Microbial Physiology. 4th edition. John Wiley & Sons.
5. Reddy SR and Reddy SM. (2005). Microbial Physiology. Scientific Publishers India.
6. Stanier RY, Ingrahm JI, Wheelis ML and Painter PR. (1987). General Microbiology. 5th edition, McMillan Press.
7. Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. 7th edition. McGraw Hill Higher Education.
8. Relevant Scientific Literature.

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)

- 5 compulsory Multiple-Choice Type questions; each carrying 1 mark: 5 × 1 mark = 5 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 × 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 × 10 marks = 10 marks

Module B (20 Marks)

- 1 Compulsory Multiple-Choice Type Question – any 5 out of 7 questions; each of 2 marks: 5 × 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 × 10 marks = 10 marks

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

COs	CO Description	Cognitive levels
	Module A	
CO1	**Remember** Students will recall the physicochemical parameters governing microbial growth and physiology, including temperature, pH, water activity, oxygen availability, radiation, pressure, and growth kinetics such as diauxic growth.	K1
CO2	**Understand** Students will develop an understanding of the molecular and cellular mechanisms underlying responses to environmental and physiological stresses in Bacteria and Archaea.	K2
CO3	**Apply** Students will apply principles of membrane transport and nitrogen metabolism to elucidate nutrient uptake, ion homeostasis, transport energetics, **N**itrogen assimilation, and microbial participation in **N**itrogen cycling in nature.	K3
CO4	**Analyze** Students will analyze stress sensing and adaptations, sigma factor regulation, stringent response, tmRNA-mediated quality control, two-component regulatory systems, osmoregulation, oxidative, heat, and pH stress responses, and transcriptional regulation in Bacteria and Archaea, based on thermodynamic efficiency, energy conservation, redox balance, ecological and industrial relevance, and environmental adaptability.	K4
CO5	**Evaluate** Students will evaluate the numericals associated with microbial transport systems.	K5
CO6	**Create** Students will be able to design integrative physiological models or problem-based interpretations integrating microbial growth, stress responses and transport systems to address environmental, industrial, or biogeochemical challenges.	K6

Module B		
CO1	**Remember** Students will recall the different consecutive steps in the bacterial peptidoglycan biosynthesis pathway, and major metabolic types of microbes.	K1
CO2	**Understand** Students will develop an understanding of the microbial energy-generating strategies—phototrophy, chemolithotrophy, and fermentative metabolism, based on thermodynamic efficiency, energy conservation, redox balance, ecological and industrial relevance, and environmental adaptability.	K2
CO3	**Apply** Students will apply their knowledge about fermentative metabolism of microbes for a better understanding of their forthcoming modules on Bioprocess Technology and Microbial Biotechnology.	K3
CO4	**Analyze** Students will analyze bacterial cellular organization and growth physiology through studies on their different reproductive strategies, cytoskeletal dynamics (MreB), cell cycle regulation, chromosome replication and segregation, divisome assembly, and cytokinesis.	K4
CO5	**Evaluate** Students will evaluate some higher order numericals on bacterial growth.	K5
CO6	**Create** Students will be able to design integrative physiological models or problem-based interpretations integrating microbial growth and metabolic pathways to address environmental, industrial, or biogeochemical challenges.	K6