Semester: VII	
COURSE: MAJOR 3	
Paper Title: Microbial Biotechnology	
Paper code:	**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 in Microbial Biotechnology provides an in-depth and mechanistic understanding of the exploitation of microorganisms and their biomolecules for industrial, medical, environmental, and food applications.
- The course begins with Enzyme Biotechnology, emphasizing the industrial production and purification of thermostable Taq DNA polymerase, followed by detailed study of enzyme immobilization techniques, with critical comparison to whole-cell immobilization systems. Metabolic Engineering will address pathway reconstruction, gene cloning, gene overexpression, flux balance optimization, and regulatory control, along with a few inherent constraints.
- Microbial polymer production will cover biosynthesis and regulation of extracellular polysaccharides like xanthan gum and biodegradable polyesters like bioplastics, highlighting their structural properties and commercial relevance.
- Large-scale microbial biotransformations will be explored through modification of steroids, along with which environmentally-sustainable microbial technologies will be examined, including bioremediation, biomining, biopulping, biofertilizers and plant growth-promoting rhizobacteria (PGPR), biopesticides, biosurfactants, biosensors, microbial retting, and composting processes.
- Food biotechnology will encompass microbial fermentation for bread, cheese, and soy sauce productions; biosynthesis of nucleotides and Vitamin B_{12}; and antimicrobial preservation using bacteriocins.
- Industrial fermentation processes will include production of L-lysine, penicillin, citric acid, mushrooms, and recombinant biopharmaceuticals such as human insulin, interferon, and Hepatitis B vaccine.
- Advanced biotechnological applications will cover phage therapy, botox, biohydrogen production, marine microbial biotechnology, microbial fuel cells, and microbial biosynthesis of fragrances.
- The course concludes with microbiome biotechnology in human health, focusing on gut microbiota-derived therapeutics, Fecal Microbiota Transplantation (FMT), and probiotic formulations such as Acidophilus milk, thereby integrating Molecular Biology, Metabolic Engineering, Fermentation Technology, and Translational Microbiology within a sustainable biotechnological framework.

Practical

- The Microbial Biotechnology practical course is designed to provide hands-on training in fundamental Industrial and Applied Microbiological techniques.
- Students will perform alcoholic fermentation using yeasts to understand anaerobic metabolism.
- Preparation of yogurt and isolation of probiotics will be done to explore lactic acid fermentation.
- Practical exposure to Enzyme Biotechnology will be achieved through the production and quantitative assay of α-amylase using immobilized whole cells of *Bacillus subtilis*, enabling students to understand immobilization principles and enzyme kinetics in bioprocesses.
- Additionally, learners will isolate, purify and preliminarily characterize bacteria and fungi from spoilt food samples.

• Overall, the practical syllabus integrates fermentation technology, industrial enzyme applications and food microbiology, and microbial isolation techniques to build technical competency and analytical skills relevant to research and industrial biotechnology.
Course Outcome:
Theory
Module A
1. Remember Students will recall the fundamental concepts of Enzyme Biotechnology, including the steps in the production of Taq DNA polymerase and methods of enzyme immobilization; the reactions in microbial production of xanthan and bioplastics, and in microbial biotransformation of steroids and sterols.
2. Understand Students will develop an understanding of the mechanism of enzyme immobilization; of the principles of gene cloning and overexpression in metabolic engineering; and of the underlying basis of microbial bio-transformation and environmentally-sustainable microbial technologies.
3. Apply Students will apply basic knowledge of Enzyme Biotechnology to understand the applications of glucose isomerase and penicillin acylase; and implement metabolic engineering concepts to propose strategies for enhanced metabolite production.
4. Analyze Students will analyze the efficiency of immobilized enzyme systems versus whole-cell systems, and the differences between various microbial polymer production, biotransformation and environmental bioprocess pathways.
5. Evaluate Students will critically evaluate the selection and maintenance of appropriate high-yielding microbial systems, and monitoring of various control parameters for different production purposes.
6. Create Students will design conceptual strategies for improved enzyme immobilization systems, and develop novel metabolic engineering approaches for enhanced product yields.
Module B
1. Remember Students will remember the key terminologies, metabolic pathways, microbial strains, and genetic constructs involved in microbial production of fermented foods and food additives, industrial metabolites, and recombinant therapeutics.
2. Understand Students will develop an understanding of the biochemical, molecular, and physiological mechanisms, and of bioprocess control parameters for microbial fermentation processes for food and condiment production; of metabolic regulation and pathway engineering for amino acid and organic acid biosyntheses; of secondary metabolite production by filamentous fungi; and of, Recombinant DNA Technology (RDT) strategies for therapeutic protein and vaccine productions.
3. Apply Students will apply their knowledge to optimize fermentation parameters for large-scale production of food products, amino acids, organic acids, and microbial biomass; to implement recombinant expression systems for therapeutic proteins and vaccines; to utilize microbial systems for sustainable bioenergy production; and to apply phage-based approaches and microbiome modulation strategies in therapeutic contexts.
4. Analyze Students will analyze the differences in regulatory mechanisms controlling primary and secondary metabolism in industrial microorganisms; in genetic engineering strategies employed in recombinant protein production systems; in economic and sustainability aspects of conventional versus bio-based production systems; and in between bacteriocins and other alternative food preservation technologies.
5. Evaluate Students will critically evaluate biosafety, regulatory compliance, and ethical considerations associated with recombinant therapeutics and vaccines; environmental sustainability and techno-economic feasibility of biohydrogen, microbial electricity, and marine biotechnological applications; and clinical efficacy and safety concerns of microbiome-based interventions such as FMT and probiotic therapies.
6. Create Students will design conceptual strategies for improved biohydrogen and microbial electricity productions.
Practical
1. Remember Students will remember the key steps in the basic protocol for alcohol and yogurt productions; for immobilization of whole bacterial cells; and for the standard microbiological

methods for isolation, enumeration, and preliminary identification of bacteria and fungi from spoilt food.
2. Understand Students will develop an understanding of the role of inoculum/starter cultures; of the parameter controls during alcohol and yogurt productions; and, of the principle of microbial enzyme production and the kinetics of α-amylase-catalyzed hydrolysis of starch.
3. Apply Students will apply their knowledge to optimize alcohol and yogurt productions and isolate probiotic strains from yogurt; to produce α-amylase using immobilized whole cells and perform relevant enzyme assays; and, to isolate, purify and preliminarily characterize bacteria and fungi isolated from spoilt food samples.
4. Analyze Students will analyze experimental data to ascertain enzyme activity and hence, compare the efficiency of immobilization of whole cells with regard to free cells; to differentiate between the different groups of microbes isolated from spoilt food; and to correlate physicochemical changes in food with the kind of spoilage microbes.
5. Evaluate Students will evaluate enzyme activity, and also the preventive strategies for minimizing microbial spoilage for ensuring food safety.
6. Create Students will be able to design and propose better fermentation protocols to enhance alcohol and yogurt yields, and probiotic viability.
Prerequisites: **Basic knowledge about Microbiology, Microbial Physiology, Bioprocess Technology**
SYLLABUS
Theory

UNIT/Module	CONTENT	HOURS or NUMBER OF CLASSES	CO Mapping	COGNITIVE LEVEL
MODULE A [20 marks]	**UNIT I: Enzyme Biotechnology & Metabolic Engineering:** Production of Enzyme used in RDT (Taq DNA polymerase); Enzyme immobilization – techniques, advantages, large scale applications of immobilized enzymes (glucose isomerase and penicillin acylase); comparison with whole-cell immobilization; Metabolic Engineering	1 class/ week	CO1 – CO6	K1 – K6
	UNIT II: Microbial Polymer Productions: Polysaccharides (xanthan), polyesters (bioplastics).			
	UNIT III: Large-scale Applications of Microbes in Bio-transformations: Microbe-based transformation of steroids and sterols.			

	UNIT IV: Large-scale Applications of Eco-friendly Microbes: Bioremediation; biomining; biopulping; biopesticides, biofertilizers (including PGPRs); biosurfactants; biosensors; microbial retting; composting.			
Module B [25 marks]	**UNIT V: Food Technology:** Microbial production of food (bread, cheese), food additive (nucleotides, Vitamin B_{12}), condiment (soy sauce), flavors; Food preservation (bacteriocins).	2 classes/ week	CO1 – CO6	K1 – K6
	UNIT VI: Industrial Production Processes: Amino acid (L-Lysine); chemotherapeutic agent (penicillin); microbial biomass (mushroom); organic acid (citric acid); recombinant therapeutic protein (human insulin; interferon); recombinant vaccine (Hepatitis B vaccine).			
	UNIT VII: Advanced Biotechnological Applications: Phage therapy; botox; gaseous fuel (biohydrogen); marine biotechnology; microbial electricity (bacterial batteries); microbial fragrances.			
	UNIT VIII: Microbiome Biotechnology in Human Health: Therapeutics from gut bacteria (including Fecal Microbiota Transplantation and Acidophilus Milk).			

Practical

CONTENT	HOURS or NUMBER OF CLASSES
1. Alcoholic fermentation by yeasts. 2. Making of yogurt and isolation of probiotics. 3. Production and assay of α-amylase using immobilized whole cells of *Bacillus subtilis*. 4. Isolation of bacteria/fungi from spoilt food samples.	3 classes/week

Text Books

Theory text/references

1. Casida LE. (1991). Industrial Microbiology. 1st edition. Wiley Eastern Limited.

2. Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd edition. Panima Publishing Co. New Delhi.
3. Das HK. (2005). Text Book of Biotechnology. 2nd edition. Wiley Dreamtech India (P) Ltd.
4. Dubey RC. (2010 Reprint Edition). A Text Book of Biotechnology. S. Chand & Company Ltd.
5. Madigan MT, Martinko JM and Parker J. (2003). Brock Biology of Microorganisms.10th edition. Pearson / Benjamin Cummings.
6. Patel AH. (1996). Industrial Microbiology. 1st edition, Macmillan India Limited.
7. Salle AJ. (1974). Fundamental Principles of Bacteriology. 7th edition, 2005 27th Reprint. Tata McGraw-Hill.
8. Stanbury PF, Whitaker A and Hall SJ. (2006). Principles of Fermentation Technology. 2nd edition, Elsevier Science Ltd.
9. Waites MJ, Morgan NL, Rockey JS, Higton G. (2001). Industrial Microbiology - An Introduction. 2002 Indian Reprint Edition. Blackwell Publishing.
10. Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. 7th edition. McGraw Hill Higher Education.
11. P. M. Doran, "Bioprocess Engineering Principles," 2nd Edition, Academic Press, Waltham, 2013.

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

Module B (25 Marks)
1 Compulsory Question – objective-type: 5 × 1 mark = 5 marks; Any 2 out of 3 questions, each of 10 mark, with subparts (no sub-part will be more than 5 marks, and less than 1 mark): 2 x 10 marks = 20 marks.

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

COs	CO Description	Cognitive levels
	MODULE A	
CO1	**Remember** Students will recall the fundamental concepts of Enzyme Biotechnology, including the steps in the production of Taq DNA polymerase and methods of enzyme immobilization; the reactions in microbial production of xanthan and bioplastics, and in microbial biotransformation of steroids and sterols.	K1
CO2	**Understand** Students will develop an understanding of the mechanism of enzyme immobilization; of the principles of heterologous gene cloning and overexpression in metabolic engineering; and of the underlying basis of microbial bio-	K2

	transformation and environmentally-sustainable microbial technologies.	
CO3	**Apply** Students will apply basic knowledge of Enzyme Biotechnology to understand the applications of glucose isomerase and penicillin acylase; and implement metabolic engineering concepts to propose strategies for enhanced metabolite production.	K3
CO4	**Analyze** Students will analyze the efficiency of immobilized enzyme systems versus whole-cell systems, and the differences between various microbial polymer production, biotransformation and environmental bioprocess pathways.	K4
CO5	**Evaluate** Students will critically evaluate the selection and maintenance of appropriate high-yielding microbial systems, and monitoring of various control parameters for different **production** purposes.	K5
CO6	**Create** Students will design conceptual strategies for improved enzyme immobilization systems, and develop novel metabolic engineering approaches for enhanced product yields.	K6
MODULE B		
CO1	**Remember** Students will remember the key terminologies, metabolic pathways, microbial strains, and genetic constructs involved in microbial production of fermented foods and food additives, industrial metabolites, and recombinant therapeutics.	K1
CO2	**Understand** Students will develop an understanding of the biochemical, molecular, and physiological mechanisms, and of bioprocess control parameters for microbial fermentation processes for food and condiment production; of metabolic regulation and pathway engineering for amino acid and organic acid biosyntheses; of secondary metabolite production by filamentous fungi; and of, Recombinant DNA Technology (RDT) strategies for therapeutic protein and vaccine productions.	K2
CO3	**Apply** Students will apply their knowledge to optimize fermentation parameters for large-scale production of food products, amino acids, organic acids, and microbial biomass; to implement recombinant expression systems for therapeutic proteins and vaccines; to utilize microbial systems for sustainable bioenergy production; and to apply phage-based approaches and microbiome modulation strategies in therapeutic contexts.	K3
CO4	**Analyze** Students will analyze the differences in regulatory mechanisms controlling primary and secondary metabolism in industrial microorganisms; in genetic engineering strategies employed in recombinant protein production systems; in economic and sustainability aspects of conventional versus bio-based production systems; and in between bacteriocins and other alternative food preservation technologies.	K4
CO5	**Evaluate** Students will critically evaluate biosafety, regulatory compliance, and ethical considerations associated with recombinant therapeutics and vaccines; environmental sustainability and techno-economic feasibility of biohydrogen, microbial electricity, and marine biotechnological applications; and clinical efficacy and safety concerns of microbiome-based interventions such as FMT and probiotic therapies.	K5
CO6	**Create** Students will design conceptual strategies for improved biohydrogen and microbial electricity productions.	K6