Anekant Education Society's

Tuljaram Chaturchand College,

of Arts, Science & Commerce, Baramati

(Autonomous)

Syllabus (CBCS) for T. Y. B. Sc. Microbiology

(2022 Pattern)

w.e.f.

June 2024

COURSE STRUCTURE FOR T. Y. B. Sc. MICROBIOLOGY (2022 Pattern) (w.e.f. June 2024)

Sr. No.	Class	Semester	Code	Paper	Paper Title	Credit	Marks (I+E)
1	T.Y.B.Sc.	V	USMB351	Theory	MEDICAL MICROBIOLOGY-I	3	40+60
2	T.Y.B.Sc.	V	USMB352	Theory	GENETICS AND MOLECULAR BIOLOGY- I	3	40+60
3	T.Y.B.Sc.	V	USMB353	Theory	ENZYMOLOGY	3	40+60
4	T.Y.B.Sc.	V	USMB354	Theory	IMMUNOLOGY – I	3	40+60
5	T.Y.B.Sc.	V	USMB355	Theory	FERMENTATION TECHNOLOGY-I	3	40+60
6	T.Y.B.Sc.	V	USMB356 A	Elective Theory Paper I	FOOD AND DAIRY MICROBIOLOGY	3	40+60
7	T.Y.B.Sc.	V	USMB356 B	Elective Theory Paper II	MICROBIAL TECHNOLOGY	3	40+60
8	T.Y.B.Sc.	V	USMB357	Practical Course I	APPLIED MICROBIOLOGY	2	40+60
9	T.Y.B.Sc.	V	USMB358	Practical Course II	BIOCHEMISTRY	2	40+60
10	T.Y.B.Sc.	V	USMB359	Practical Course III	CLINICAL MICROBIOLOGY	2	40+60
11	T.Y.B.Sc.	V	Certificate course		RELATED TO SUBJECT	2	
					Total	**26**	
11	T.Y.B.Sc.	VI	USMB361	Theory	MEDICAL MICROBIOLOGY-II	3	40+60
12	T.Y.B.Sc.	VI	USMB362	Theory	GENETICS AND MOLECULAR BIOLOGY-II	3	40+60
13	T.Y.B.Sc.	VI	USMB363	Theory	METABOLISM	3	40+60
14	T.Y.B.Sc.	VI	USMB364	Theory	IMMUNOLOGY – II	3	40+60
15	T.Y.B.Sc.	VI	USMB365	Theory	FERMENTATION TECHNOLOGY-II	3	40+60
16	T.Y.B.Sc.	VI	USMB366 A	Elective theory paper I	AGRICULTURAL AND ENVIRONMENTAL MICROBIOLOGY	3	40+60
17	T.Y.B.Sc.	VI	USMB366 B	Elective theory paper II	NANOBIOTECHNOLOGY	3	40+60
18	T.Y.B.Sc.	VI	USMB367	Practical Course IV	BIOCHEMISTRY & MOLECULAR BIOLOGY	2	40+60
19	T.Y.B.Sc.	VI	USMB368	Practical Course V	HEMATOLOGY AND DIAGNOSTIC IMMUNOLOGY	2	40+60
20	T.Y.B.Sc.	VI	USMB369	Practical Course VI	PROJECT	2	40+60
					Total	**24**	
					Grand Total		

I: Internal Examination

E: External Examination

SYLLABUS (CBCS) FOR T.Y.B.Sc. Microbiology
(w. e. from Nov, 2024)

Name of the Programme : T.Y.B.Sc. Microbiology
Program Code : USMB
Class : T.Y.B.Sc.
Semester : VI
Course Type : Theory
Course Name : Medical Microbiology-II
Course Code : USMB361
No. of Credits : 03
No. of Lectures :48

Course Objectives:

1. Understanding Chemotherapy Concepts: To introduce students to the fundamental concepts of chemotherapy, including selective toxicity, bioavailability, and mechanisms of action of various antimicrobial agents.
2. Mechanisms of Antimicrobial Action: To provide detailed insights into how different classes of antimicrobial agents act on bacteria, fungi, viruses, and protozoa.
3. Drug Resistance Mechanisms: To explore the mechanisms behind drug resistance, including the alteration of target sites, drug inactivation, and metabolic bypass.
4. Protozoan and Fungal Parasites Study: To educate students on the classification, life cycles, pathogenicity, and laboratory diagnosis of major protozoan and fungal pathogens.
5. Viral Pathogens Study: To study the characteristics, pathogenesis, and diagnostic methods for various human and animal viral pathogens, with an emphasis on contemporary viruses like HIV, COVID-19, and Dengue.
6. Laboratory Diagnosis Techniques: To familiarize students with various laboratory diagnostic techniques, including serological tests, for identifying and managing parasitic and viral infections.
7. Prophylaxis and Chemotherapy: To discuss prophylactic measures and chemotherapy options for managing infections caused by protozoan, fungal, and viral pathogens.

Course Outcomes :

CO1 Understanding Chemotherapy: Students will be able to explain the key principles of chemotherapy, including selective toxicity, MIC, MBC, and LD-50 values.

CO2 Antimicrobial Mechanisms: Students will gain a comprehensive understanding of how different antimicrobial agents affect bacterial, fungal, viral, and protozoan cells at the molecular level.

CO3 Drug Resistance Knowledge: Students will be able to identify and explain the various mechanisms of drug resistance, understanding their implications in clinical settings.

CO4 Protozoan and Fungal Pathogen Identification: Students will be proficient in classifying and diagnosing infections caused by major protozoan and fungal pathogens, understanding their life cycles, pathogenicity, and treatment options.

CO5 Viral Pathogen Analysis: Students will be able to describe the virion characteristics, pathogenesis, and diagnostic methods for a range of human and animal viral pathogens.

CO6 Diagnostic Skills: Students will be equipped with practical knowledge of laboratory diagnosis, including serological tests, for detecting parasitic and viral infections.

CO7 Prophylaxis and Chemotherapy Application: Students will be capable of recommending appropriate prophylactic measures and chemotherapy treatments for infections caused by protozoan, fungal, and viral pathogens.

Credit No.	Topic	Number of lectures
I	**Chemotherapy**	**16**
	Unit1. Introduction to Chemotherapy: a. Concept of Selective toxicity, Bioavailability of Drug, MIC, MBC & LD-50 value b. Routes of drug administration	 2 2
	Unit2. Mode of action of following antimicrobial agents on: a. Bacteria: i) Cell wall (Betalactams,Cycloserine,Bacitracin) ii) Cell membrane (Polymyxin,Monensin) iii) Protein synthesis (Streptomycin,Tetracyclin) iv) Nucleic Acids (Nalidixicacid,Rifamycin) v) Enzyme inhibitors(Trimethoprim,Sulfadrugs) b. Fungi (Griseofulvin,AmphotericinB,Nystatin) c. Viruses (Acyclovir, Remdesivir,Zidovudine) d. Protozoa (Metronidazole,Mepacrine)	 5 2 2 1
	Unit3. Mechanism and reasons of drug resistance Alteration in target site, Blockage of transport of drug, Inactivation of drug Metabolic bypass	2
II	**Study of protozoan and fungal parasites:**	**16**
	Unit 1. Study of following groups of parasites (with respect to – Classification, lifecycle, Morphological characteristics, Viability characteristics, Pathogenicity, Pathogenesis, Symptoms, Laboratory diagnosis (serological diagnosis wherever applicable), Prophylaxis and Chemotherapy): *a. Plasmodium* *b. Entamoeba*	 5 4
	Unit 2 : Study of following groups of fungal pathogens (with respect to– Morphological and cultural characteristics, Classification, Pathogenecity, Pathogenesis, Symptoms, Laboratory diagnosis, Prophylaxis and Chemotherapy): *a. Candida,* *b. Aspergillus*	 4 3
III	**Study of human viral pathogens**	**16**

	Unit1: Study of human pathogenic viruses: (with respect to – Virion characteristics, Viability characteristics, Pathogenicity, Pathogenesis, Symptoms, Laboratory diagnosis including serological diagnosis, Epidemiology, Prophylaxis and Chemotherapy): a. HIV b. COVID-19(SARS-CoV-2)virus c. Dengue virus d. Influenza virus e. Poliovirus f. Rabies virus g. Hepatitis A& B virus	3 2 2 2 2 2 3

References:

1. Tortora ,G.J., Funke, B.R.,Case, C.L,1992. Microbiology: An introduction 5th Edition, Benjamin Pub. Co. NY
2. Roitt,P.I:Mims,C.J. Medical Microbiology
3. Chakraborty,P.,2003A textbook of Microbiology, 2nd Edition New Central Book Agency, India.
4. Medical Microbiology editedby Samuel Baron. Fourth Edition. (University of Texas Medical Branch of Galvesion)
5. Sherris, John C,Ed, Medical Microbiology: an Introduction to infectious diseases. Elsevier Publication IInd edition.
6. Virulence mechanisms of bacterial pathogens (Second edition) by Roth, Bolin, Brogden Minion and Michael.
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8. Wolfgang K. Joklik,1992, Zinsser Microbiology 20th Edition, McGraw-Hill Professional Publishing.
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Mapping of Program Outcomes with Course Outcomes

Weightage:1=weak or low relation, 2=moderate or partial relation, 3=strong or direct relation

	Program Outcomes								
Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	2	1	2	1	2	1	1	2
CO2	3	3	2	2	2	2	1	1	2
CO3	3	3	2	2	2	2	1	1	2
CO4	3	2	2	2	2	2	1	2	2
CO5	3	2	2	2	2	2	1	2	2
CO6	3	3	2	2	2	2	1	1	2
CO7	3	3	2	2	2	3	2	2	2

Justification for the mapping

PO1: Disciplinary Knowledge

- CO1, CO2, CO3, CO4, CO5, CO6, CO7: All COs contribute strongly to PO1 as they provide comprehensive knowledge of chemotherapy, antimicrobial mechanisms, drug resistance, pathogen identification, and diagnostics, which are fundamental to the discipline of microbiology.

PO2: Critical Thinking and Problem Solving

- CO1: Understanding chemotherapy principles aids in critically assessing treatment options.
- CO2: Grasping antimicrobial mechanisms fosters critical thinking about drug interactions.
- CO3, CO6, CO7: Analyzing drug resistance and diagnostics directly involves problem-solving skills.
- CO4, CO5: Understanding pathogen identification helps in applying critical thinking to diagnosis and treatment**.**

PO3: Social Competence

- CO1, CO2, CO3, CO4, CO5, CO6, CO7: Knowledge of treatment and diagnostics contributes moderately to understanding social health challenges and public health implications, with drug resistance and diagnostics having higher relevance.

PO4: Research-related Skills and Scientific Temper

- CO1, CO2: Researching chemotherapy and antimicrobial mechanisms supports scientific inquiry.
- CO3, CO4, CO6, CO7: In-depth understanding of drug resistance, pathogen identification, and diagnostics is critical for research.

PO5: Trans-disciplinary Knowledge

- CO1, CO2, CO3, CO4, CO5, CO6, CO7: The study of chemotherapy, antimicrobials, and pathogen diagnostics requires integrating knowledge from biochemistry, pharmacology, and clinical sciences.

PO6: Personal and Professional Competence

- CO1, CO2: Understanding and applying knowledge in professional contexts builds competence.
- CO3, CO4, CO6, CO7: Diagnostic skills, drug resistance knowledge, and treatment recommendations are crucial for professional practice.

PO7: Effective Citizenship and Ethics

- CO1, CO3, CO6, CO7: Knowledge of chemotherapy, drug resistance, and diagnostics contributes to ethical medical practice and public health.

PO8: Environment and Sustainability

- CO1, CO2, CO3, CO4, CO5, CO6, CO7: While not a primary focus, understanding pathogen life cycles and treatment implications can have a minimal impact on environmental considerations in medical practices.

PO9: Self-directed and Life-long Learning

- CO1, CO2: Keeping updated on chemotherapy and antimicrobial resistance requires ongoing learning. Weightage: 2
- CO3, CO4, CO6, CO7: The rapidly evolving field of diagnostics and pathogen treatment demands continuous education.

SYLLABUS (CBCS) FOR T.Y.B.Sc. Microbiology (2022 Pattern)
(w. e. from Nov, 2024)

Name of the Programme	**: B.Sc. Microbiology**
Programme Code	**: USMB**
Class	**: T.Y.B.Sc.**
Semester	**: VI**
Course Type	**: Theory**
Course Name	**: Genetics and Molecular Biology – II**
Course Code	**: USMB362**
No. of Credits	**: 03**
No. of Lectures	**: 48**

Course Objective:

1. Explore the discovery and mechanisms of natural transformation in both Gram-positive bacteria (e.g., *Streptococcus pneumoniae*) and Gram-negative bacteria (e.g., *Haemophilus influenzae*), as well as artificial transformation techniques.
2. Study the discovery of transduction, including generalized transduction (e.g., P22) and specialized transduction (e.g., Lambda phage), to understand how bacterial DNA is transferred between cells.
3. Examine the discovery of conjugation, the role of the F plasmid, and the processes involved in the formation and crossing of $F^+ \times F^-$ and $HFr \times F^-$ cells, including the formation of F' cells.
4. Gain knowledge about recombination, including mapping techniques such as map units, recombination frequency, co-transformation, co-transduction, conjugation (interrupted mating experiment), and tetrad analysis.
5. Learn about Mendel's laws, the eukaryotic cell cycle, mitosis, meiosis, and how tetrad analysis in *Neurospora crassa* is used for gene mapping.
6. Explore various types of restriction enzymes, their nomenclature, and the techniques for cutting DNA. Understand vectors (plasmid, lambda phage, cosmid, phagemid), DNA joining methods, and the process of transferring recombinant DNA into host cells.
7. Study methods for screening recombinant DNA, including insertional inactivation and blue-white assays, to identify successful transformation and recombination.

Course Outcome:

CO1. Students will be able to describe the mechanisms of natural and artificial transformation in both Gram-positive and Gram-negative bacteria.
CO2. Students will understand and explain the principles of generalized and specialized transduction, including the role of phages in bacterial DNA transfer.
CO3. Students will be able to explain the mechanisms of conjugation, including the roles of the F plasmid and the processes leading to the formation of HFr and F' cells.
CO4. Students will be able to define recombination and perform various mapping techniques, including co-transformation, co-transduction, conjugation, and tetrad analysis.
CO5. Students will apply their knowledge of Mendelian genetics, cell cycle, mitosis, and meiosis to perform gene mapping using tetrad analysis in *Neurospora crassa*.
CO6. Students will gain practical skills in using restriction enzymes, vectors, and techniques for cutting and joining DNA, as well as transferring recombinant DNA into host cells.
CO7. Students will be able to perform and interpret screening methods for recombinant DNA, including insertional inactivation and blue-white assays, to identify successful genetic modifications.

Credits	Unit	Topic	No. of Lectures
I	1	**Gene Transfer** **Transformation** a) Discovery of natural transformation b) Natural transformation in Gram positive bacteria (*Streptococcus pneumoniae*) c) Natural transformation in Gram negative bacteria (*Haemophilus influenzae*) d) Artificial transformation	 5
	2	**Transduction** a) Discovery of transduction b) Generalized transduction (P22) c) Specialized transduction (Lambda phage)	5
	3	**Conjugation** a) Discovery of conjugation b) F plasmid c) Cross $F^+ \times F^-$ d) Formation of HFr cell e) Cross HFr × F^- f) Formation of F’	6
II	1	**Recombination mapping** a) Definition of Recombination b) Recombination mapping: Map unit and Recombination frequency c) Mapping by co-transformation d) Mapping by co-transduction e) Mapping by conjugation (Interrupted mating experiment) f) Mapping by Tetrad analysis: 1. Mendel’s laws 2. Eukaryotic cell cycle 3. Mitosis 4. Meiosis 5. Gene mapping by Tetrad analysis in *Neurospora crassa*	 1 1 2 2 2 8
III	1	**Recombinant DNA Technology** a. Types of restriction enzyme b. Nomenclature of restriction enzyme c. Cutting of DNA using restriction enzyme d. Vectors: Plasmid, lambda phage, Cosmid and Phagemid e. Joining of DNA: ligase, linker, adapter, Homopolymer tailing f. Transfer of recombinant DNA in to host cell g. Screening of recombinant DNA: Insertional inactivation and Blue white assay	 1 1 1 6 4 1 2

References:

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2. Gardner E. J., Simmons M. J. and Snustad D. P. (2006). Principles of Genetics. 8thedition. John Wiley and Sons Publication. ISBN-13: 9788126510436 3. Lewin's GENES X (2011).
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Mapping of Program Outcomes with Course Outcomes

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	3	2		2	2			2	2
CO 2	3	2		2	2			2	2
CO 3	3	2		2	2			2	2
CO 4	3	3		3	2			2	2
CO 5	3	3		3	2			2	2
CO 6	3	3		3	2	2		2	2
CO 7	3	3		3	2	2		2	2

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Understanding natural and artificial transformation mechanisms in bacteria is fundamental to genetics and microbiology, reflecting a deep knowledge of these disciplines.

CO2: Principles of generalized and specialized transduction and the role of phages are key topics in microbiology and genetic research.

CO3: Mechanisms of conjugation and the roles of plasmids are essential knowledge in bacterial genetics and molecular biology.

CO4: Defining recombination and mapping techniques are central to understanding genetic processes and methodologies in genetics.

CO5: Application of Mendelian genetics and gene mapping techniques in Neurospora crassa is fundamental to genetic research and practical application.

CO6: Practical skills in DNA manipulation techniques such as restriction enzymes and vectors are essential knowledge in molecular genetics and biotechnology.

CO7: Performing and interpreting screening methods for recombinant DNA involves deep knowledge and practical skills in genetic engineering.

PO2: Critical Thinking and Problem Solving

CO1: Understanding transformation mechanisms involves analyzing and solving problems related to bacterial genetics and transformation processes.

CO2: Explaining transduction and phage roles requires critical thinking to understand complex genetic transfer mechanisms.
CO3: Mechanisms of conjugation involve problem-solving skills related to genetic transfer and plasmid interactions.
CO4: Recombination and mapping techniques require significant problem-solving and critical thinking skills to analyze genetic data and relationships.
CO5: Gene mapping and analysis using tetrad analysis involve complex problem-solving and critical thinking related to genetic inheritance patterns.
CO6: Practical skills in DNA manipulation and recombinant DNA techniques involve designing and solving experimental problems.
CO7: Interpreting screening methods for recombinant DNA requires critical analysis and problem-solving to identify successful genetic modifications.

PO4: Research-Related Skills and Scientific Temper
CO1: Knowledge of bacterial transformation mechanisms involves understanding experimental techniques and scientific principles.
CO2: Principles of transduction involve experimental methods and scientific inquiry.
CO3: Mechanisms of conjugation and plasmid roles involve practical research skills and scientific techniques.
CO4: Performing genetic mapping techniques requires application of research methods, hypothesis testing, and scientific inquiry.
CO5: Gene mapping using tetrad analysis involves practical research skills and an understanding of experimental techniques.
CO6: Practical skills in DNA cutting, joining, and transferring involve direct application of research techniques and scientific methods.
CO7: Performing and interpreting screening methods for recombinant DNA involves applying research skills to evaluate genetic modifications.

PO5: Trans-disciplinary Knowledge
CO1: Understanding transformation mechanisms integrates knowledge from microbiology and genetics.
CO2: Transduction involves both virology and genetics, demonstrating interdisciplinary integration.
CO3: Conjugation mechanisms involve knowledge from microbiology and molecular genetics.
CO4: Recombination and mapping techniques integrate genetic principles with experimental methodologies.
CO5: Gene mapping using tetrad analysis spans genetics and experimental biology.
CO6: Practical skills in DNA manipulation involve both molecular biology and biotechnology.
CO7: Screening methods for recombinant DNA involve integration of genetic engineering and molecular biology.

PO6: Personal and Professional Competence
CO6: Practical skills in DNA manipulation require attention to detail and professional competency in laboratory settings.
CO7: Interpreting screening methods for recombinant DNA involves practical skills and professional judgment.

PO8: Environment and Sustainability
CO1: Knowledge of bacterial transformation mechanisms can impact environmental and sustainability studies, particularly in genetic engineering applications.
CO2: Understanding transduction principles can be relevant for environmental applications involving genetic modifications.
CO3: Conjugation mechanisms can influence environmental biotechnology and sustainability studies.

CO4: Recombination and mapping techniques can be relevant for environmental and sustainable genetic engineering practices.
CO5: Gene mapping techniques can be applied in environmental contexts to study genetic variations and their impacts.
CO6: DNA manipulation techniques have implications for environmental applications and sustainability in genetic engineering.
CO7: Screening methods for recombinant DNA can be relevant to environmental and sustainability considerations in genetic modifications.

PO9: Self-directed and Life-long Learning
CO1: Understanding bacterial transformation mechanisms encourages ongoing learning and adaptation in genetics and microbiology.
CO2: Principles of transduction and their applications support continuous learning in genetic research.
CO3: Knowledge of conjugation mechanisms promotes self-directed learning in molecular genetics.
CO4: Recombination and mapping techniques involve learning and applying advanced genetic methods.
CO5: Gene mapping in Neurospora crassa fosters ongoing learning in genetics and experimental techniques.
CO6: Practical skills in DNA manipulation require continual learning and adaptation to new techniques.
CO7: Interpreting screening methods for recombinant DNA encourages life-long learning in genetic engineering and biotechnology.

SYLLABUS (CBCS) FOR T.Y.B.Sc. Microbiology (2022 Pattern)
(w. e. from Nov, 2024)

Name of the Programme : B.Sc. Microbiology
Programme Code : USMB
Class : T.Y.B.Sc.
Semester : VI
Course Type : Theory
Course Name : Metabolism
Course Code : USMB363
No. of Credits : 03
No. of Lectures : 48

Course Objective:

1. Gain a comprehensive understanding of cell membrane composition, architecture, and the various transport mechanisms, including passive transport (diffusion, osmosis, facilitated transport) and active transport systems in bacteria.
2. Explore the mechanisms of active transport, focusing on bacterial systems and group translocation of sugars, as well as the role of ionophores in membrane transport.
3. Learn about the habitat and examples of photosynthetic bacteria, the structure and function of the photosynthetic apparatus, and the differences between oxygenic and anoxygenic photosynthesis mechanisms.
4. Understand the Calvin cycle in bacterial photosynthesis, including its regulation and the role it plays in carbon fixation and energy storage.
5. Explore the laws of thermodynamics, the concepts of free energy and entropy, and the roles of high-energy compounds (e.g., pyrophosphate, enolic phosphates) in biological systems.
6. Gain knowledge about the components of the mitochondrial ETC, their arrangement in the inner membrane, the structure and function of ATP synthase, and the impact of inhibitors and uncouplers on the ETC.
7. Understand the chemistry and polymerization of macromolecules (polysaccharides, lipids), and learn about their degradation pathways, including polysaccharides (starch, glycogen), lipids (fatty acid oxidation), and proteins (urea cycle).

Course Outcome:

CO1. Students will be able to describe the composition and architecture of cell membranes and explain various membrane transport mechanisms, including passive and active transport.
CO2. Students will understand the principles of active transport in bacteria, including group translocation and the role of ionophores in facilitating transport across membranes.
CO3. Students will be able to identify the habitats and examples of photosynthetic bacteria, describe the photosynthetic apparatus, and differentiate between oxygenic and anoxygenic photosynthesis.
CO4. Students will understand the Calvin cycle, its role in bacterial photosynthesis, and its regulation mechanisms, including the integration of carbon fixation.
CO5. Students will be able to apply the laws of thermodynamics to biological systems, understand concepts of free energy and entropy, and explain the roles of high-energy compounds in cellular energy processes.
CO6. Students will be able to describe the components and arrangement of the mitochondrial electron transport chain, the function of ATP synthase, and the effects of ETC inhibitors and uncouplers on oxidative phosphorylation.

CO7. Students will be proficient in describing the chemistry and polymerization of macromolecules, and explain the pathways for their degradation, including starch and glycogen breakdown, fatty acid oxidation, and protein metabolism through the urea cycle.

Credits	Unit	Topic	No. of Lectures
I	1	**Membrane transport mechanisms:**	
		Composition and Architecture of cell Membrane	1
		Passive transport - Diffusion, Osmosis, Facilitated transport	3
		Active transport - Active transport systems in bacteria	2
		Group translocation of sugars in bacteria	1
		Ionophores: Mechanism and examples	1
	2	**Bacterial Photosynthesis:**	
		Habitat and examples of photosynthetic bacteria	2
		Photosynthetic apparatus	2
		Oxygenic and Anoxygenic mechanisms	2
		Calvin cycle and its regulation	2
II	1	**Bioenergetics:**	
		Laws of thermodynamics	1
		Concepts of free energy, entropy	2
		High energy compounds: Pyrophosphate, enolic phosphates, acyl phosphates, thioester compounds, and guanidinium compounds	5
	2	**Mitochondrial electron transport chain:**	
		Components of ETC	1
		Arrangement of different components in the inner membrane	2
		Structure and function of ATP synthase	1
		Inhibitors and uncouplers of ETC	1
		Oxidative phosphorylation	2
		Energetics of electron transport chain	1
III	1	**Biosynthesis**	
		Chemistry, concept of polymerization of Macromolecules:	
		Polysaccharides (Starch, Glycogen)	4
		Lipids (Fatty acids, triglycerides and phospholipids)	4
	2	**Degradation of macromolecules:**	
		Polysaccharides (starch, glycogen)	4
		Lipids (fatty acids oxidation)	2
		Proteins (urea cycle)	2

References:

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7. White David (2000) Physiology and Biochemistry of Prokaryotes. 2nd Ed. Oxford University Press, New York.
8. David A. Hall & Krishna Rao (1999) Photosynthesis (Studies in Biology) 6th Edition, Cambridge University Press, London

Mapping of Program Outcomes with Course Outcomes

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	3	3		2	2			2	2
CO 2	3	3		2	2			2	2
CO 3	3	3		2	2			2	2
CO 4	3	3		2	2			2	2
CO 5	3	3		2	2			2	2
CO 6	3	3		2	2			2	2
CO 7	3	3		2	2			2	2

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Understanding cell membrane composition and transport mechanisms is fundamental to biological sciences, reflecting a comprehensive knowledge of cell biology, which is central to the graduate program.

CO2: Knowledge of active transport in bacteria and ionophores is an advanced concept in microbiology and biochemistry, demonstrating strong theoretical and practical understanding.

CO3: Identifying habitats and mechanisms of photosynthetic bacteria involves detailed disciplinary knowledge in microbiology and biochemistry.

CO4: Understanding the Calvin cycle and its regulation is crucial for comprehending bacterial photosynthesis, which is key to the graduate program.

CO5: Application of thermodynamics laws to biological systems is fundamental to biochemistry, showing deep disciplinary knowledge.

CO6: Describing the mitochondrial electron transport chain and ATP synthase is central to cellular energy processes and reflects comprehensive knowledge in biochemistry.

CO7: Proficiency in macromolecule chemistry and metabolism is essential for understanding complex biological processes, demonstrating strong disciplinary knowledge.

PO2: Critical Thinking and Problem Solving

CO1: Explaining membrane transport mechanisms requires critical analysis and problem-solving skills to understand complex biological systems.

CO2: Understanding and analyzing active transport in bacteria involves critical thinking about complex mechanisms.

CO3: Differentiating between oxygenic and anoxygenic photosynthesis involves critical thinking about metabolic pathways.

CO4: Understanding the Calvin cycle and its regulation involves problem-solving skills to integrate and analyze various components of bacterial photosynthesis.

CO5: Applying laws of thermodynamics and understanding free energy and entropy involve complex problem-solving in biochemistry.

CO6: Analyzing the mitochondrial electron transport chain and its effects requires problem-solving skills related to energy production.

CO7: Understanding macromolecule chemistry and metabolism involves critical analysis and problem-solving to grasp complex biochemical processes.

PO4: Research-Related Skills and Scientific Temper

CO1: Understanding membrane transport mechanisms involves experimental techniques and scientific thinking.

CO2: Active transport in bacteria includes knowledge of experimental techniques and scientific inquiry.
CO3: Identifying and describing photosynthetic bacteria involves scientific observation and experimentation.
CO4: Understanding the Calvin cycle involves knowledge of experimental methods in research.
CO5: Applying thermodynamic laws to biological systems involves scientific principles and experimentation.
CO6: Describing the mitochondrial electron transport chain and ATP synthase requires an understanding of experimental methods in biochemistry.
CO7: Understanding macromolecule chemistry and metabolism involves knowledge of experimental techniques and research methods.

PO5: Trans-disciplinary Knowledge
CO1: Understanding membrane transport mechanisms requires integration of biology and biochemistry.
CO2: Knowledge of active transport integrates microbiology with biochemistry.
CO3: Photosynthesis knowledge involves integration of microbiology and biochemistry.
CO4: The Calvin cycle connects biochemistry and microbiology.
CO5: Application of thermodynamic laws spans both chemistry and biology.
CO6: The mitochondrial electron transport chain links biochemistry with broader biological systems.
CO7: Understanding macromolecules integrates knowledge from different biochemical and biological areas.

PO8: Environment and Sustainability
CO1: Understanding membrane transport mechanisms can relate to environmental impacts if applied to ecological contexts.
CO2: Knowledge of bacterial transport can be relevant to environmental sustainability in terms of microbial processes.
CO3: Photosynthetic bacteria have direct environmental implications and sustainability relevance.
CO4: The Calvin cycle's role in photosynthesis impacts environmental processes and sustainability.
CO5: Understanding thermodynamics in biological systems can be relevant to environmental and sustainability studies.
CO6: Mitochondrial processes have implications for understanding energy use and sustainability.
CO7: Understanding macromolecule metabolism can relate to environmental impact and sustainability.

PO9: Self-directed and Life-long Learning
CO1: Understanding membrane transport mechanisms encourages ongoing learning and adaptation in cell biology.
CO2: Active transport knowledge requires continual learning about evolving research and techniques.
CO3: Knowledge of photosynthetic bacteria fosters self-directed learning in microbiology and related fields.
CO4: Understanding the Calvin cycle supports ongoing learning in plant biology and biochemistry.
CO5: Application of thermodynamic principles encourages life-long learning in biochemistry and related disciplines.
CO6: Analyzing mitochondrial processes supports continuous learning in cellular biology and biochemistry.
CO7: Understanding macromolecule chemistry and metabolism encourages ongoing education in biochemistry.

SYLLABUS (CBCS) FOR T.Y.B.Sc. Microbiology(2022 Pattern)

(w. e. from Nov, 2024)

Name of the Programme : B.Sc. Microbiology
Program Code : USMB
Class : T.Y.B.Sc.
Semester : VI
Course Type : Theory
Course Name : IMMUNOLOGY – II
Course Code : USMB364
No. of Credits : 03
No. of Lectures : 48

Learning Objectives:

1. Students will gain knowledge of antibody affinity, avidity, and the kinetics of antigen-antibody reactions.
2. Students will learn about various techniques such as precipitation reactions, agglutination, immunofluorescence, ELISA, and RIA.
3. Students will study MHC structure, polymorphism, and antigen typing methods.
4. Students will learn about the types, characteristics, and functions of key cytokines like interferons, interleukins, and TNFs.
5. Students will cover blood group antigens, ABO and Rh systems, blood typing methods, and medico-legal applications.
6. Students will learn about different types of vaccines, current perspectives, and immunization schedules.
7. Students will study hypersensitivity reactions, autoimmune diseases, and hybridoma technology for monoclonal antibody production.

Course outcomes:

On completion of the course, the students will be able to:

1. Students will be able to explain the principles of antigen-antibody interactions.
2. Students will be proficient in various techniques for visualizing antigen-antibody complexes.
3. Students will be able to describe the structure and function of MHC molecules and perform MHC antigen typing.
4. Students will be able to evaluate vaccines, immunization schedules, and their relevance to public health.
5. Students will be knowledgeable about immunohematology, including blood group systems and blood typing techniques.
6. Students will be able to evaluate vaccines, immunization schedules, and their relevance to public health.
7. Students will be capable of discussing hypersensitivity reactions, autoimmune diseases, and the use of hybridoma technology.

Credits	Unit	Topic	No. of Lectures
I	**1**	**Antigen-Antibody Interactions -** **Principles of interactions:** Antibody affinity and avidity, ratio of antigen antibody, lattice hypothesis and two stage theory, antigen-antibody reaction kinetics (dialysis equilibrium experiment) **Visualization of antigen antibody complexes:** a. Precipitation reactions: in fluid and in gel,	8

		immunoelectrophoresis b. Agglutination reactions: hemagglutination, bacterial agglutination, passive agglutination and agglutination-inhibition c. Immunofluorescence techniques: direct and indirect, FACS d. ELISA, biotin-avidin system e. RIA f. Jerne's hemolytic plaque assay	
	2	**Major Histocompatibility Complex -** a. Structure of MHC in man and mouse b. Structure and functions of MHC class–I and class–II molecules c. Polymorphism of MHC molecules d.MHC antigen typing (microcytoxicity and mixed lymphocyte reaction)	5
	3	**Cytokines -** Types, General characters and role in immune activation - Interferons, Interleukins and TNFs	3
II	**4**	**Immunohematology -** a. Systems of blood group antigens b. ABO system - Biochemistry of blood group substances, Bombay blood group, Inheritance of ABH antigens c. Rh system d. Laboratory methods of blood group typing, Coomb's test e. Medico-legal applications of blood groups f. Blood banking practices, transfusion reactions	10
	5	**Public Health Immunology -** a. Types of vaccines and Antisera b. Current perspective of vaccines. B .Immunization schedules: principles, schedules in developing and developed countries	6
III	**6**	**Hypersensitivity -** a. Immediate and delayed type hypersensitivity b. Gell and Coomb's classification of hypersensitivity – mechanism with examples for type I, II, III and IV	6
	7	**Autoimmunity and Autoimmune diseases-** a. Immunological tolerance b. Types of autoimmune diseases c. Factors contributing development of autoimmune diseases d. Immunopathological mechanisms e. Diagnosis and treatment of autoimmune diseases: Myasthenia gravis and Rheumatoid arthritis f. Therapeutic immunosuppression for autoimmunity	7
	8	**Hybridoma Technology -** a. Preparation, HAT selection and propagation of hybridomas secreting monoclonal antibodies b. Applications of monoclonal antibodies	3

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Mapping of Program Outcomes with Course Outcomes

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	3	3	3		3				2
CO 2	2	3		2		2			2
CO 3	3			3					
CO 4		2	3		3				
CO 5	3			2			3		
CO 6			3				3		
CO 7	3	2		2	3				

Justification for the mapping

PO1: Disciplinary Knowledge

CO1, CO2, CO3, CO5, CO7 these Cos understanding the antigen-antibody interactions is a core aspect of disciplinary knowledge in immunology & understanding hypersensitivity, autoimmunity, and hybridoma technology is key disciplinary knowledge.

PO2: Critical Thinking and Problem Solving

CO1, CO2, CO4, CO7 these Cos explaining principles requires critical analysis of how antigen-antibody interactions work & discussing these complex topics involves critical analysis and problem-solving capabilities.

PO3: Social Competence

CO1, CO4, CO6 these Cos evaluating vaccines and immunization schedules involves understanding their societal impact and relevance.

PO4: Research-Related Skills and Scientific Temper

CO2, CO3, CO5, CO7 these Cos mastery of techniques like ELISA and immunofluorescence involves hands-on research skills and scientific rigor & understanding and applying typing techniques involves scientific accuracy and research skills.

PO5: Trans-disciplinary Knowledge

CO1, CO4, CO7 these Cos Application of these topics can span across various fields, including biotechnology and clinical research.

PO6: Personal and Professional Competence

CO2: Effective self-management is crucial for keeping up with coursework, understanding intricate immunological concepts, and completing laboratory work accurately. The syllabus should encourage students to develop these skills by including deadlines, practical assignments, and structured study plans.

PO7: Effective Citizenship and Ethics

CO5, CO6, these Cos This ensures that students are aware of and can navigate the ethical challenges they might encounter in their research careers. Immunology research often involves sensitive topics such as human and animal subjects, genetic information, and potentially hazardous pathogens.

PO9: Self-directed and Life-long Learning

CO1, CO2 these cos Incorporating independent research projects or thesis work in the syllabus helps students practice and enhance their research skills, preparing them for future academic or professional research roles.

SYLLABUS (CBCS) FOR T.Y.B.Sc. Microbiology(2022 Pattern)

(w. e. from Nov, 2024)

Name of the Programme	**: B.Sc. Microbiology**
Program Code	**: USMB**
Class	**: T.Y.B.Sc.**
Semester	**: VI**
Course Type	**: Theory**
Course Name	**: Fermentation Technology -II**
Course Code	**: USMB365**
No. of Credits	**: 03**
No. of Lectures	**: 48**

Course Objectives:

1 To cater the needs of students for building up their careers in pharmaceutical and fermentation industries.
2 To understand the types of fermentations.
3 To understand the typical fermentations with respect to production of primary metabolites.
4 To understand the typical fermentations with respect to production of secondary metabolites.
5 To understand the typical fermentations with respect to production of fermented food products.
6 To understand the typical fermentations with respect to production of animal cell products.
7 To understand the opportunities towards entrepreneurship.

Course Outcome:

CO1 Theoretical understanding of principles and basic methods of industrial fermentations.
CO2 Students will be able to understand the importance of production of industrially important microorganisms and products with respect to primary metabolites.
CO3 Students will be able to understand the importance of production of industrially important microorganisms and products with respect to secondary metabolites.
CO4 Students will be able to understand and advanced techniques of production of fermented food products.
CO5 Students will be able to understand the importance of production of industrially important microorganisms and products with respect to animal cell products.
CO6 Students will be able to understand the difference between fermentation and transformation.
CO7 Establishment and development as an entrepreneur.

Credit No.	Topic	Lectures
I	**Unit 1: Introduction to Solid state fermentation and Submerged fermentation**	**2**
	Unit 2: Uses of following primary metabolites and their large scale production (with respect to microbial producers, production process & recovery, and flowsheet):	**4**
	a. Vitamins (B12 & Riboflavin)	**4**
	b. Amino acids (Glutamic acid & Lysine)	**6**
	c. Organic acids (Citric acid, Acetic acid & Lactic acid)	
II	**Unit 1: Uses of following secondary metabolites and their large scale production (with respect to microbial producers, production process & recovery, and flowsheet):**	
	i. Ethanol	**2**
	ii. Alcoholic beverages (Beer & Wine)	**4**
	iii. Antibiotics (Penicillin & Streptomycin)	**5**
	Unit 2: Uses of the following enzymes and their large scale production (with respect to microbial producers, production process & recovery, and flowsheet):	**2**
	a. Amylase	**2**
	b. Protease	**1**
	c. Esterase	
III	**Unit 1: Uses of the following fermentation products and their large scale production (with respect to microbes involved, production process, and flowsheet):**	
	a. Baker's and Distiller's yeast	**2**
	b. Edible mushroom	**2**
	c. Dairy products:	
	i. Cheese (Cheddar & Swiss)	**2**
	ii. Yoghurt	**1**
	Unit 2: Large scale production of the following:	
	a. Viral vaccines (Polio, Rabies)	**3**
	b. Bacterial vaccine (Tetanus toxoid)	**1**
	c. Immune Sera	**2**
	Unit 3: Steroid transformation by microbes	**3**

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Mapping of course outcomes and programme outcomes:

Weightage: 1= weak or low relation, 2= Moderate or partial relation, 3= Strong or direct relation

	Programme Outcomes (POs)								
Course outcomes (COs)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3			3		2			3
CO2	3			3					
CO3	3			3					
CO4	3					2			2
CO5	3								
CO6	3	2							
CO7	3					2	2		2

PO1	**Disciplinary Knowledge:** CO1: The students will understand the basic methods of fermentation processes. CO2: The students shall learn about the methods of production of primary metabolites. CO3: The students shall be able to understand the production methods of secondary metabolites. CO4: Students shall learn about the different strategies of production of fermented food products CO5: The students shall acquire knowledge about the animal cell products. CO6: Students shall come to know about the difference between fermentation and transformation. CO7: The students shall gain knowledge about the entrepreneurship development.
PO2	**Critical Thinking and Problem Solving:** CO6: The students shall be able to perform the calculations in relation to yields and productivity.
PO4	**Research-related skills and Scientific temper:** CO1: The students will understand the basic protocols for production of primary metabolites. CO2: The students will understand the basic protocols for production of secondary metabolites. CO3: The students will understand the basic protocols for production of animal cell products.

PO6	**Personal and professional competence** CO1: The students will be able to learn basic protocols used in fermentation industries. CO4: Students shall understand different production techniques important for professional development. CO7: Students shall acquire knowledge about the different opportunities in business establishment.
PO7	**Effective citizenship Ethics** CO7: As an entrepreneur, students may learn the citizenship ethics.
PO9	**Self directed and life long learning** CO1: The students will understand the basic methods of fermentations used in industries. CO4: Students shall understand different fermentations in relation to fermented foods. CO7: Students shall acquire knowledge about the basic requirements needed for business establishment in relation to fermentation.

SYLLABUS (CBCS) FOR T.Y.B.Sc. Microbiology(2022 Pattern)

(w. e. from Nov, 2024)

Name of the Programme	**: T.Y.B.Sc. Microbiology**
Program Code	**: USMB**
Class	**: T.Y.B.Sc.**
Semester	**: VI**
Course Type	**: Elective Theory**
Course Name	**: Agricultural and Environmental Microbiology**
Course Code	**: USMB366A**
No. of Credits	**:03**
No. of Lectures	**:48**

Course Objectives:

1. To explore various methods of enhancing plant growth with a focus on disease resistance and environmental tolerance.
2. To learn about chemical, biological, and integrated pest management techniques for controlling plant diseases.
3. To introduce modern technologies like BT crops, antisense RNA, and RNA interference for plant disease management.
4. To study the mechanisms of nitrogen fixation, phosphate solubilization, potassium mobilization, and iron chelation in biofertilizers.
5. To understand the production methods, application techniques, and uses of various biofertilizers.
6. To provide an overview of biopesticides, including their types and advantages over chemical pesticides.
7. To explore the role of microorganisms in bioremediation, bioaugmentation, and bioleaching, with a focus on environmental sustainability.

Course Outcomes:

CO1: Students will be able to describe the methods used to enhance plant growth by improving disease resistance and environmental tolerance.

CO2: Students will develop an understanding of the various techniques for controlling plant diseases, including chemical, biological, and integrated pest management.

CO3: Students will be able to explain the application of BT crops, antisense RNA, and RNAi technology in plant disease control.

CO4: Students will understand the mechanisms behind the role of biofertilizers in promoting plant growth, including nitrogen fixation and phosphate solubilization.

CO5: Students will be able to outline the production processes, application methods, and practical uses of different biofertilizers.

CO6: Students will gain knowledge of the types and advantages of biopesticides, distinguishing them from traditional chemical pesticides.

CO7: Students will develop an understanding of the role of microbes in environmental processes such as bioremediation, bioaugmentation, and bioleaching, and their applications in environmental microbiology.

Credit No.	Unit No.	Topic	Lectures
I	**Unit 1**	**Plant growth and plant disease control**	**16**
		Plant growth improvement with respect to: a. Disease resistance b. Environmental tolerance	**4**
		Methods of plant disease control a. Chemical control b. Eradication c. Biological control (employing bacterial and fungal cultures) d. Integrated pest management e. Application of viral proteins in controlling plant viral diseases f. Mycoviruses acting against fungal plant pathogens	**6**
	Unit 2	**Tools and techniques in Agricultural Technology** a. Development of insect resistant plants (BT crops) b. Antisense RNA technology in plant disease control c. RNA interference (RNAi) technology in controlling plant pathogens	**6**
II	**Unit 1**	**Biofertilizers**	**16**
		Mechanism of: a. Nitrogen Fixation b. Phosphate solubilization c. Potassium mobilization d. Iron chelation	**08**
		Production, Methods of application and Uses of following biofertilizers: *a. Azotobacter* *b. Rhizobium* *c. Azospirillum* d. Blue green algae e. Phosphate solubilizing microorganisms	**05**
	Unit 2	**Biopesticides** a. Introduction b. Types of biopesticide c. Advantages	**03**
III	**Unit 1**	**Environmental microbiology**	**16**
		Bioremediation: a. Definition b. Role of plants & Microbes in Bioremediation of: Xenobiotics and Hydrocarbons c. Genetically Modified Microorganisms in Bioremediation	**06**
		Bioaugmentation: a. Definition b. Use of microbial cultures and enzymes for bioaugmentation Application	**04**
		Bioleaching: a. Microorganisms used b. Bioleaching process c. Bioleaching of – Copper & Gold d. Advantages of Bioleaching	**06**

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Mapping of course outcomes and programme outcomes:

Weightage: 1= weak or low relation, 2= Moderate or partial relation, 3= Strong or direct relation

Course outcomes (COs)	Programme Outcomes								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	1	1	1	1	1	1	1	1
CO2	3	1	1	1	3	1	1	1	1
CO3	3	1	1	3	1	1	1	1	3
CO4	3	3	1	1	3	1	1	1	1
CO5	3	1	1	3	1	3	1	1	1
CO6	3	1	1	1	1	1	1	1	1
CO7	3	1	1	1	1	1	3	1	1

Justification for the mapping

PO1 Disciplinary knowledge

All Cos contribute to disciplinary knowledge by covering various critical aspects of microbiology, such as plant growth, disease control, biofertilizers, biopesticides, and environmental microbiology. This foundational knowledge is essential for students to become proficient in their field.

PO2 Critical thinking and problem solving

Each CO involves applying critical thinking to understand and solve problems, whether it's improving plant growth (CO1), controlling diseases (CO2, CO3), or applying biofertilizers and biopesticides (CO4, CO5, CO6). Students must analyze situations and apply appropriate microbiological solutions.

PO3 Social competence

CO6 involves understanding biopesticides and their advantages, which includes considering ethical implications and social responsibilities. The responsible use of biopesticides relates to public health and safety, requiring social competence.

PO4 Research related skills and scientific temper

CO2 and CO3 involve understanding and applying advanced techniques like RNAi and BT crops, which require a scientific temper and research skills. CO7 involves applying

microbes in environmental processes, often requiring research to optimize and understand these applications.

PO5 Trans-disciplinary knowledge

CO3 (BT crops, RNAi technology) and CO7 (microbial applications in environmental processes) involve the integration of microbiology with biotechnology, genetics, and environmental science, making them trans-disciplinary in nature.

PO6 Personal and professional competence

CO5 and CO6, which cover biofertilizers and biopesticides, help students develop practical skills and professional competencies that are vital for careers in microbiology, agriculture, and environmental management.

PO7 Effective Citizenship and ethics

CO6, which deals with biopesticides, includes understanding their ethical use and environmental impact. This CO promotes effective citizenship by encouraging the use of safe, ethical alternatives to chemical pesticides.

PO8 Environment and sustainability

These Cos are directly related to environmental sustainability. CO1 and CO4 focus on plant growth and biofertilizers, CO5 on production processes, CO6 on biopesticides, and CO7 on microbial applications in environmental processes, all promoting sustainable practices.

PO9 Self-directed and life-long learning

While no CO is directly mapped to PO9, the content covered in all Cos encourages continuous learning. Understanding advanced and ever-evolving topics like biotechnology, environmental microbiology, and plant disease management requires students to engage in lifelong learning to stay updated with the latest advancements in the field

SYLLABUS (CBCS) FOR T.Y.B.Sc. Microbiology(2022 Pattern)

(w. e. from Nov, 2024)

Name of the Programme : T.Y.B.Sc. Microbiology
Program Code : USMB
Class : T.Y.B.Sc.
Semester : VI
Course Type : Elective Theory
Course Name : Nanobiotechnology
Course Code : USMB366B
No. of Credits : 03
No. of Lectures :48

Course Objectives:

1. Understanding Microbial Nanoparticle Synthesis: To provide students with a comprehensive understanding of the fundamental concepts, history, and biological methods involved in the microbial synthesis of nanoparticles.

2. Exploring Microorganisms in Nanotechnology: To examine the role of various microorganisms, including bacteria, fungi, and Actinomycetes, in synthesizing nanoparticles, with a special focus on magnetotactic bacteria for natural magnetic nanoparticle production.

3. Analyzing Synthesis Methods: To delve into the various methods of microbial-mediated metallic nanoparticle synthesis, distinguishing between top-down and bottom-up approaches.

4. Characterization Techniques Proficiency: To equip students with the knowledge and skills to use different techniques for characterizing nanoparticles, such as optical spectroscopy, UV-visual spectroscopy, FTIR, SEM, TEM, XRF, and XRD.

5. Applications of Nanoparticles: To explore the diverse applications of nanoparticles in various fields, including agriculture, medicine, environmental remediation, textile nanofibre production, and the food industry.

6. Critical Thinking and Problem Solving: To develop students' critical thinking and problem-solving skills in applying nanotechnology techniques to real-world scenarios in diverse industries.

7. Research and Development: To encourage students to engage in research and development, promoting the innovative application of microbial synthesis methods and nanotechnology in solving global challenges.

Course Outcomes:

CO1 Comprehensive Understanding: Students will be able to demonstrate a thorough understanding of the history, definition, and biological methods involved in the microbial synthesis of nanoparticles.

CO2 Microbial Role in Nanotechnology: Students will be able to explain the role of different microorganisms, including bacteria, fungi, and Actinomycetes, in synthesizing nanoparticles and describe specific examples like magnetotactic bacteria for magnetic nanoparticle production.

CO3 Methodology Proficiency: Students will gain proficiency in distinguishing between top-down

and bottom-up approaches for microbial-mediated metallic nanoparticle synthesis and understanding their practical applications

CO4 Technical Expertise: Students will be able to utilize and interpret data from various nanoparticle characterization techniques such as optical spectroscopy, SEM, TEM, and XRD.

CO5 Application Awareness: Students will be able to identify and explain the applications of nanoparticles across multiple industries, including agriculture, medicine, environment, textiles, and food.

CO6 Problem-Solving: Students will develop the ability to apply nanotechnology concepts to solve practical problems in industry, healthcare, and environmental sectors.

CO7 Research Skills: Students will be able to design and execute research projects related to microbial nanoparticle synthesis and its applications, contributing to advancements in nanotechnology

Credit No.	Topic	Lectures
I	**Introduction and microbial synthesis of nanoparticles:**	
	UNIT 1.Introduction and microbial synthesis: a) Definition, history, time-line b) Biological Methods of Synthesis c) Use of microorganisms for nanoparticle synthesis - bacteria, fungi, Actinomycetes d) Magnetotactic bacteria for natural synthesis of magnetic nanoparticles **e)** Microbial synthesis of**:** Gold nanoparticles (AuNPs), Silver nanoparticles (AgNPs)	**1** **1** **2** **2** **2**
	UNIT 2. Microbial mediated metallic nanoparticles synthesis methods: a) Top-down: Ball milling, Plasma arching, Laser sputtering, Vapour deposition b) Bottoms-up: Sol-gel, Colloidal, Electrodeposition, Solution phase reductions	**4** **4**
II	**Techniques in nanotechnology**	
	UNIT 1. Techniques of characterization of nanoparticles a. Optical spectroscopy b. UV-visual spectroscopy, c. Fourier transform infrared (FTIR), d. Scanning electron microscopy (SEM), e. Transmission electron microscopy (TEM) f. X-ray Fluorescence (XRF) g. X-ray diffraction (XRD**)**	**2** **2** **3** **2** **2** **2** **3**
III	**Applications of nanoparticles**	
	UNIT1. Applications of nanoparticles in following fields: 1. Agricultural 2. Medicine and health care	**3** **3** **4**

	3. Environment remediation 4. Textile –Nanofibre production 5. Food Industry	**3** **3**

References:

1. Characterization of Nanophase materials – Z.L Wang (ed), Wiley-VCH, New York 2000.
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7. Nanochemistry by Sergeev G.B., Elseiver publication,2006.
8. Nanostructures and Nanomaterials, synthesis, properties and applications by Guozhong Cao, Imperial College Press, 2004.
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Mapping of Program Outcomes with Course Outcomes

Weightage:1=weak or low relation, 2=moderate or partial relation, 3=strong or direct relation

	Program Outcomes								
Course Outcomes (COs)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	2	1	2	2	2	2	3	1
CO2	3	2	2	3	2	2	2	3	1
CO3	3	3	2	3	3	2	2	2	3
CO4	3	3	2	3	3	2	2	2	3
CO5	3	3	2	3	3	2	2	2	2
CO6	3	3	2	3	3	3	2	2	3
CO7	2	3	2	3	3	2	3	3	2

Justification for the Mapping

PO1: Disciplinary Knowledge

CO1, CO2, CO3, CO4, CO5, CO6, CO7: All COs contribute strongly to PO1 as they cover the essential aspects of microbial nanoparticle synthesis, characterization techniques, and applications, which are fundamental to the field of nanotechnology.

PO2: Critical Thinking and Problem Solving

CO1, CO2: Understanding the history, methods, and microbial roles in nanoparticle synthesis fosters critical thinking.

CO3, CO4, CO6: Distinguishing synthesis approaches, characterizing nanoparticles, and applying nanotechnology to solve real-world problems directly involve problem-solving skills.

CO5: Understanding the applications across industries also involves critical thinking.
CO7: Designing research projects requires significant problem-solving abilities.

PO3: Social Competence

CO2, CO3: The role of microorganisms in nanotechnology and the application of synthesis methods have social relevance, particularly in healthcare and environmental sectors.

CO5, CO6: Application awareness and problem-solving skills have implications for societal benefits, particularly in medicine and environmental sustainability.

PO4: Research-related Skills and Scientific Temper

CO1, CO2: Understanding microbial synthesis methods contributes to scientific inquiry.

CO3, CO4: Mastery of synthesis approaches and characterization techniques is crucial for research.

CO7: Conducting research projects on microbial nanoparticle synthesis directly contributes to research-related skills.

PO5: Trans-disciplinary Knowledge

CO1, CO2, CO3, CO5, CO6, CO7: The study of microbial nanoparticle synthesis and its applications requires integrating knowledge from microbiology, chemistry, materials science, and engineering.

PO6: Personal and Professional Competence

CO1, CO3, CO4: Gaining technical expertise and methodological proficiency enhances both personal and professional competence.

CO6, CO7: Applying nanotechnology concepts and conducting research projects is essential for professional growth in the field.

PO7: Effective Citizenship and Ethics

CO5, CO6, CO7: Understanding and applying nanotechnology in a socially responsible and ethical manner, particularly in healthcare and environmental sectors, contributes to effective citizenship.

PO8: Environment and Sustainability

CO5, CO6: Application awareness and problem-solving skills in environmental sectors have a direct impact on sustainability.

CO1, CO2, CO3: Understanding microbial synthesis methods contributes minimally to environmental sustainability.

PO9: Self-directed and Life-long Learning

CO1, CO2, CO3, CO4: Keeping updated on synthesis methods and characterization techniques requires ongoing learning.

CO5, CO6, CO7: The fast-evolving field of nanotechnology necessitates continuous self-directed learning and adaptability.

SYLLABUS (CBCS) FOR T.Y.B.Sc. Microbiology (2022 Pattern)
(w. e. from Nov, 2024)

Name of the Programme	**: B.Sc. Microbiology**
Programme Code	**: USMB**
Class	**: T.Y.B.Sc.**
Semester	**: VI**
Course Type	**: Practical**
Course Name	**: Biochemistry and Molecular biology**
Course Code	**: USMB367**
No. of Credits	**: 02**
No. of Lectures	**: 60**

Course Objective:

1. Acquire skills in enzyme purification methods, focusing on the precipitation of amylase from fermentation broth, dialysis, and the determination of specific activity to establish a purification chart.
2. Study the techniques and principles behind the immobilization of enzymes, specifically invertase, to explore its applications and advantages in biochemical processes.
3. Gain practical experience in isolating and enumerating bacteriophages and studying their morphology to understand their role and application in molecular biology.
4. Learn methods for the isolation and estimation of bacterial genomic DNA, including techniques for analyzing DNA quantity and quality.
5. Develop proficiency in transforming E. coli cells and selecting recombinant colonies to study gene insertion and expression.
6. Visit a research laboratory or industry to observe real-world applications of biochemistry and molecular biology techniques, gaining insights into their practical uses and current research trends.
7. Learn how to establish purification charts by determining the specific activity of both crude and purified enzymes, and apply this knowledge to optimize enzyme purification processes.

Course Outcome:

CO1. Students will be able to execute enzyme purification techniques, including precipitation and dialysis, and accurately determine the specific activity of enzymes to create a detailed purification chart.
CO2. Students will be capable of describing and implementing enzyme immobilization techniques, particularly for invertase, and understanding its benefits in various applications.
CO3. Students will be able to isolate and enumerate bacteriophages, identify their morphology, and understand their significance in molecular biology and biotechnology.
CO4. Students will demonstrate the ability to isolate and estimate bacterial genomic DNA, ensuring its quality and suitability for further molecular analyses.
CO5. Students will effectively perform bacterial transformation of E. coli, select for recombinants, and interpret the results to understand gene expression and manipulation.
CO6. Students will gain practical insights from visiting a research laboratory or industry, observing the application of biochemistry and molecular biology techniques in real-world settings.
CO7. Students will apply their knowledge to establish and interpret purification charts, effectively analyzing the specific activity of enzymes in both crude and purified forms to optimize enzyme purification processes.

Credit No.	Topic	No. of Practical
I	Biochemistry	
	Enzyme Purification:	
	Precipitation of amylase from fermentation broth	1
	Dialysis	1
	Determination of specific activity of crude and purified amylase and establishment of Purification chart	2
	Effect of pH on enzyme activity	1
	Effect of Temperature on enzyme activity	1
	Immobilization of Invertase	1
II	Molecular biology	
	Isolation and enumeration of bacteriophages and study of phage morphology	2
	Genomic (bacterial) DNA isolation and estimation.	2
	Transformation of *E. coli* and selection of transformants	2
	Isolation of mutant strain using replica plate technique	1
	Visit to Research laboratory/Industry	1

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2. Johnson, M. C., & Davis, P. Q. (2019). Practical Enzymology: A Comprehensive Guide. Academic Press.
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5. Smith, J. K., & Brown, L. M. (2016). Enzyme Purification Techniques: A Practical Approach. Oxford University Press.
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Mapping of Program Outcomes with Course Outcomes

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	3	2		3	2	2			2
CO 2	3	2		3	2	2			2
CO 3	3	2	2	3	2	2			2
CO 4	3	2		3	2	2			2
CO 5	3	3	2	3	2	3			3
CO 6	2	2	3	2	2	2	2	2	2
CO 7	3	2		3	2	2			2

Justification for the mapping

PO1: Disciplinary Knowledge

CO1 (3): Strong relation as it requires a thorough understanding of enzyme purification techniques and practical knowledge to create purification charts.
CO2 (3): Strong relation due to the necessity of comprehensive knowledge of enzyme immobilization techniques and their applications.
CO3 (3): Strong relation as it involves detailed understanding and practical skills in isolating and enumerating bacteriophages.
CO4 (3): Strong relation since it requires in-depth knowledge of bacterial genomic DNA isolation and estimation techniques.
CO5 (3): Strong relation as it involves extensive knowledge of bacterial transformation processes and gene manipulation techniques.
CO6 (2): Moderate relation; while the visit enhances practical understanding, it is less directly related to theoretical knowledge.
CO7 (3): Strong relation due to the application of knowledge to establish and interpret purification charts effectively.

PO2: Critical Thinking and Problem Solving

CO1 (2): Moderate relation; requires problem-solving skills to optimize purification processes and analyze enzyme activity.
CO2 (2): Moderate relation as it involves designing and implementing enzyme immobilization techniques, which requires problem-solving.
CO3 (2): Moderate relation; isolation and enumeration of bacteriophages involve analytical skills to interpret results.
CO4 (2): Moderate relation due to the need to critically analyze and ensure the quality of isolated bacterial DNA.
CO5 (3): Strong relation as it involves significant problem-solving skills in performing transformations, selecting recombinants, and interpreting results.
CO6 (2): Moderate relation; the visit can enhance problem-solving by observing real-world applications but is not directly involved in problem-solving activities.
CO7 (2): Moderate relation as it involves analyzing data to create and interpret purification charts.

PO3: Social Competence

CO3 (2): Moderate relation; involves presenting findings and understanding bacteriophages, which may require effective communication.
CO5 (2): Moderate relation; communication skills are important for presenting transformation results and findings.
CO6 (3): Strong relation; visiting a research laboratory or industry provides valuable experience in social interaction and effective communication.

PO4: Research-related Skills and Scientific Temper

CO1 (3): Strong relation as it involves using laboratory techniques and scientific inquiry to purify enzymes and analyze results.
CO2 (3): Strong relation; implementing enzyme immobilization requires hands-on application of scientific methods and techniques.
CO3 (3): Strong relation due to the necessity of applying laboratory techniques and scientific methods to isolate and study bacteriophages.
CO4 (3): Strong relation as it involves using molecular biology techniques and scientific temper to isolate and estimate DNA.
CO5 (3): Strong relation; performing bacterial transformation involves research skills, including experiment design and result interpretation.

CO6 (2): Moderate relation; while the visit enhances understanding, it provides observational rather than hands-on research experience.
CO7 (3): Strong relation due to the application of knowledge in a practical context to analyze and interpret purification data.

PO5: Trans-disciplinary Knowledge
CO1 (2): Moderate relation; involves applying knowledge from biochemistry to enzyme purification, integrating various techniques.
CO2 (2): Moderate relation; understanding enzyme immobilization integrates knowledge from different biochemical fields.
CO3 (2): Moderate relation; requires knowledge from microbiology and virology, showing some integration of disciplines.
CO4 (2): Moderate relation; involves molecular biology techniques with knowledge from genetics.
CO5 (2): Moderate relation; transformation involves integration of genetic engineering and microbiology knowledge.
CO6 (2): Moderate relation; visiting industry/research labs shows integration of practical applications with theoretical knowledge.
CO7 (2): Moderate relation; application of enzyme purification techniques can involve integrating knowledge from various areas.

PO6: Personal and Professional Competence
CO1 (2): Moderate relation; requires individual responsibility and teamwork for effective enzyme purification.
CO2 (2): Moderate relation; involves individual skills and collaborative efforts in implementing enzyme immobilization.
CO3 (2): Moderate relation; working with bacteriophages requires both individual and collaborative skills in a lab setting.
CO4 (2): Moderate relation; involves personal competence in handling DNA isolation and estimation tasks.
CO5 (3): Strong relation; performing transformations and selecting recombinants involves teamwork and personal skills in a lab environment.
CO6 (2): Moderate relation; the visit emphasizes professional competence and provides insights into industry practices.
CO7 (2): Moderate relation; analyzing and interpreting purification charts involves personal competence and potential teamwork.

PO7: Effective Citizenship and Ethics
CO6 (2): Moderate relation; the visit may provide insights into ethical practices in research and industry.

PO8: Environment and Sustainability
CO6 (2): Moderate relation; industry visits may highlight sustainable practices and their importance.

PO9: Self-directed and Life-long Learning
CO1 (2): Moderate relation; involves learning and adapting enzyme purification techniques, relevant for ongoing development.
CO2 (2): Moderate relation; understanding and applying enzyme immobilization techniques encourages continuous learning.
CO3 (2): Moderate relation; handling bacteriophages involves learning and adapting new techniques.
CO4 (2): Moderate relation; isolating and estimating DNA requires continual learning in molecular techniques.
CO5 (3): Strong relation; performing bacterial transformations involves staying updated with genetic engineering techniques.

CO6 (2): Moderate relation; the visit provides context for ongoing learning and adaptation in real-world applications.
CO7 (2): Moderate relation; establishing and interpreting purification charts involves continual learning and adaptation in enzyme purification.

SYLLABUS (CBCS) FOR T.Y.B.Sc. Microbiology (2022 Pattern)
(w. e. from Nov, 2024)

Name of the Programme : T.Y.B.Sc. Microbiology
Program Code : USMB
Class : T.Y.B.Sc.
Semester : VI
Course Type : Practical
Course Name : Hematology and Diagnostic Immunology
Course Code : USMB368
No. of Credits : 02
No. of Lectures : 60

Course Objective:

1 To enrich the students knowledge about hematology.
2 To develop expertise in Diagnostic practices.
3 To enrich student's knowledge and train them in hematology and Immunology.
4 To understand the scientific responsibilities while working in medical field.
5 To develop opportunities in entrepreneurships
6 To enrich students' knowledge in hematology.
7 To understand developments in the field of hematology

Course Outcomes:

On completion of the course, the students will be able to

CO1 Practical understanding of basic hematology and Immunology.
CO2 Understand different practices in hematology and Immunology.
CO3 Apply this Practical knowledge to society for human welfare.
CO4 Establishment and development as an entrepreneur**.**
CO5 Expertise the basic knowledge of hematology and Immunology.
CO6 Enrich the practices of hematology and Immunology.
CO7 Aware the society about hematology and Immunology.

Credits	Sr. No.	Practical Titles	No. of Practicals
I and II	**1**	**Study of permanent slides of following microbial pathogens:** *a. Entamoeba histolytica* *b. Giardia* spp. *c. Plasmodium* spp. *d. Mycobacterium* (tuberculosis and leprae)	1

	2	**Immunohematology**: a. Peripheral Blood Smear (differential WBC count) b. Blood Grouping c. Cross-matching (Major and Minor) d. Estimation of Hemoglobin by acid hematin and cyanmet haemoglobin method e. Detrermination of ESR	1 1 1 2 1
	3	**Immunochromatographic tests** a. The qualitative differential detection of IgM and IgG antibodies to Dengue virus in Human serum /Plasma. b. Qualitative detection of Hepatitis B surface Antigen (Rapid card test)	2
	4	**Antigen-Antibody Interaction:** **a.** Immunoprecipitation: Double Diffusion (Ouchterlony) Technique. **b.** Agglutination: Widal Test (Rapid) **c.** Indirect Coomb's Test	1 1 1
	5	**Cell counting Using Counting Chambers.** **a.** Total RBC Count By Neubauer's Haemocytometer. **b.** Total WBC Count By Neubauer's Haemocytometer.	1 1
	6	**c.** Blood Bank / Diagnostic lab visit	1

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6. Maheshwari N. (2017). Clinical Pathology Hematology and Blood Banking (For Dmlt Students). 3rd edition. Jaypee Brothers Medical Publishers. ISBN-13: 978- 9386261182
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9. Talib V. H. (2019). Handbook Medical Laboratory Technology. 2nd edition. CBS, Publishers and Distributors Pvt. Ltd. ISBN-13: 978-8123906775

Mapping of course outcomes and programme outcomes:

Weightage: 1= weak or low relation, 2= Moderate or partial relation, 3= Strong or direct relation

	Programme Outcomes (POs)								
Course outcomes (COs)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	2		3		2		3	
CO2	3			2	3		3		3
CO3	3	2	3	3				2	
CO4	3		2						
CO5	3			2					2
CO6	3					3			
CO7	3				2		2		2

Justification for the mapping

PO1

Disciplinary Knowledge:

CO1: Develop a solid foundation in the principles and concepts of Hematology and Immunology.

CO2: Acquire a diverse set of skills and practices within the fields of Hematology and Immunology

CO3: Apply acquired knowledge to address societal needs and contribute to human welfare, particularly in the context of healthcare...

CO4: Develop skills and knowledge necessary for career advancement, including entrepreneurship or leadership roles.

CO5: Attain expertise in fundamental and advanced aspects of Hematology and Immunology

CO6: Contribute to the advancement and enrichment of practices within the fields through innovation, research, or improved methodologies

CO7: Raise awareness and educate the broader community about the significance of Hematology and Immunology, particularly in the context of healthcare...

PO2 **Critical Thinking and Problem Solving:**

CO2: development of a comprehensive understanding of diverse practices within hematology and immunology..

CO4: It might not directly align with critical thinking but could indirectly contribute to problem-solving skills in a professional context.

PO3 **Social Competence:**

CO3: It is related to the application of knowledge for the benefit of society, emphasizing practical and real-world applications...

CO4: Being able to apply practical knowledge for human welfare, establishing oneself as an entrepreneur, and raising awareness in society about hematology and immunology require strong social competence.

PO4 **Research-related skills and Scientific temper:**

CO1: Providing students with a practical understanding that forms the basis for further research.

CO2: Understanding different practices requires a research-oriented approach, contributing to the development of research-related skills.

CO3: The application of practical knowledge for human welfare involves a scientific temper, emphasizing the societal impact of scientific practices.

CO5: Developing expertise involves an in-depth understanding that is often gained through research, contributing to research-related skills...

PO5 **Trans-disciplinary knowledge:**

CO1: Foundational knowledge in both Hematology and Immunology can contribute to a trans-disciplinary understanding, as these fields often intersect with other disciplines such as pathology, genetics, and biochemistry.

CO6: Enriching practices may involve incorporating insights from other disciplines.

PO6 **Personal and professional competence:**

CO1: Provides the groundwork for personal and professional competence in the specific field of Hematology and Immunology.

CO6: Contributing to the enrichment of practices showcases professional competence..

PO7 **Effective Citizenship and Ethics:**

CO2: Awareness of diverse practices includes ethical considerations in research and healthcare practices

CO7: Creating awareness should align with ethical principles and contribute positively to effective citizenship.

PO8 **Environment and Sustainability:**

CO1 Understanding the environmental impact of laboratory practices and healthcare procedures is essential for sustainable practices.

CO3: The application of knowledge for human welfare should align with environmental and sustainable considerations...

PO9 **Self-directed and Life-long learning:**

CO2: Exposure to diverse practices fosters a mindset of continuous learning and adaptation..

CO5: Developing expertise is an ongoing process, requiring a commitment to lifelong learning.

CO7: Developing expertise is an ongoing process, requiring a commitment to lifelong learning.

SYLLABUS (CBCS) FOR T.Y.B.Sc. Microbiology (2022 Pattern)
(w. e. from Nov, 2024)

Name of the Programme : T.Y.B.Sc. Microbiology
Program Code : USMB
Class : T.Y.B.Sc.
Semester : VI
Course Type : Practical
Course Name : Project
Course Code : USMB369
No. of Credits : 02
No. of Lectures : 60

Course objective:

1. Define the scope and objectives of a research project in the field of biotechnology.
2. Develop skills in project planning, organization, and management, including setting clear objectives and timelines.
3. Foster collaboration by working effectively in a group of maximum four students on a research project.
4. Acquire knowledge under the guidance of a supervisor, demonstrating the ability to seek guidance and work independently.
5. Implement and understand the significance of continuous project evaluation throughout the semester to ensure progress and quality.
6. Develop proficiency in scientific writing by preparing a comprehensive project report at the end of the semester.
7. Apply research methodologies in practice, including data collection, analysis, and interpretation, to achieve the project's objectives.

Course Outcome:

CO1	Formulate a clear and concise project proposal, outlining the research questions, objectives, and methodology.
CO2	Demonstrate effective teamwork and communication skills within a group setting while working on the project.
CO3	Develop and enhance research skills, including literature review, experimental design, and data collection techniques.
CO4	Experience and benefit from guided supervision, gaining insights into the importance of mentorship in research projects.
CO5	Enhance critical thinking skills and problem-solving abilities by addressing challenges encountered during the research process
CO6	Implement continuous monitoring and evaluation strategies to track project progress and make informed adjustments as necessary..
CO7	Communicate research findings effectively through the preparation and submission of a comprehensive project report, adhering to scientific writing standards.

Credits: 2 Credit

- The students must complete a project/dissertation work.
- Students may undertake the projects with maximum three to four objectives.
- A group of maximum four students may undertake one project.
- Each group will be supervised by a Guide.
- There will be continuous evaluation of the project during the tenure of semester VI.

- Evaluation will be done at the end of the semester VI for which students must submit a project report.

- Survey reports shall not be considered for this credit.

Mapping of course outcomes and programme outcomes:

Weightage: 1= weak or low relation, 2= Moderate or partial relation, 3= Strong or direct relation

	Programme Outcomes (POs)								
Course outcomes (COs)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3			3				3	
CO2	3		3			2			
CO3	3			3					
CO4	3								3
CO5	3	2							
CO6	3						3		
CO7	3					3			

PO1 **Disciplinary Knowledge:**

CO1: This outcome suggests that students will develop the ability to articulate research questions, objectives, and methodologies.
CO2: This outcome is more about soft skills, these skills are crucial for sharing disciplinary knowledge within a team setting. Collaborative efforts often lead to a richer understanding of disciplinary content.
CO3: The ability to conduct a literature review, design experiments, and collect data contributes to the acquisition of in-depth knowledge within a specific discipline.
CO4: Guided supervision is a form of mentorship, providing insights into the discipline.
CO5: Critical thinking and problem-solving are generic skills, but they are crucial for disciplinary knowledge.
CO6: Monitoring and evaluation help in maintaining the integrity and quality of the research.
CO7: Effective communication of research findings

PO2 **Critical Thinking and Problem Solving:**

CO5: Addressing challenges in a research context requires analytical thinking, problem-solving strategies, and the application of critical thought

PO3 **Social Competence:**

CO2: The course outcome directly aligns with the program outcome by emphasizing effective teamwork and communication within a group setting

PO4 **Research-related skills and Scientific temper:**

CO1he course outcomes are inherently focused on developing and enhancing research-related skills
CO3: Additionally, developing research skills includes literature review, experimental design, and data collection techniques.

PO6 **Personal and professional competence:**

CO2: Effective teamwork, critical thinking, problem-solving, and communication skills are essential components of both personal and professional competence.

CO7: Preparing and submitting a comprehensive project report adhering to scientific writing standards reflects a level of professional competence.

PO7 **Effective Citizenship and Ethics:**

CO6: Implementing continuous monitoring and evaluation strategies reflects a responsible and accountable approach to project work, which aligns with the principles of effective citizenship.

PO8 **Environment and Sustainability:**

CO1The research projects involve topics related to the environment, sustainability, or societal impact, incorporating explicit outcomes related to these areas could enhance the course's relevance to broader global challenges.

PO9 **Self-directed and Life-long learning:**

CO4: Engaging in research projects, benefiting from guided supervision, implementing continuous monitoring, and effectively communicating findings all contribute to a learning process that extends beyond the immediate course duration.
CO7: The research experience and skills gained are applicable to future learning endeavors