PERIYAR UNIVERSITY

Salem-636011

(NAAC 'A++' Grade - State University - NIRF Rank 94)

DEPARTMENT OF MICROBIOLOGY

M.Sc., DEGREE

[Choice Based Credit System (CBCS)]

OBE Based Curriculum

(Effective from the academic year 2026-2027 and thereafter)

M.Sc., Microbiology

OBE BASED SYLLABUS

(With effect from the academic year 2026-2027 onwards)

Preamble

Post graduate Microbiology is a course focus on microbiology and its complete diversity exploring their relationship with various environments. Curriculum includes Foundation of Microbiology and Microbial Diversity, Cell Biology and Microbial Physiology, Microbial Genetics and Molecular Biology, Immunology and Vaccinology, Medical Bacteriology and Mycology, Medical Virology and Parasitology, Industrial Microbiology and Fermentation Technology, Research Methodology and Biostatistics, Food and Dairy Microbiology and Computational Microbiology and Artificial Intelligence. M.Sc., Microbiology program designed by integrating the knowledge of cutting-edge technologies like omics technologies and recombinant technologies for the heterologous expression allowing the generation of new and improved products and services in microbiology. It is envisaged to produce competitive graduates with a great spectrum of proficiency, interdisciplinary focus at par with international qualification. The detailed syllabus for each paper is constructed to inculcate the graduate with outcome-based education pattern which provide space forRemember, Understand, Application, Analysize, Evaluate and Synthesis.

THE LEARNING OUTCOMES

LO1: Disciplinary knowledge:

Capable of demonstrating comprehensive knowledge and understanding of one or more disciplines that form a part of an undergraduate programme of study.

LO2: Communication Skills:

Ability to express thoughts and ideas effectively in writing and orally; Communicate with others using appropriate media, confidently share one's views and express herself himself; demonstrate the ability to listen carefully, read and write analytically, and present complex information in a clear and concise manner to different groups.

LO3: Critical thinking:

Capability to apply analytic thought to a body of knowledge; analyse and evaluate evidence, arguments, claims, beliefs on the basis of empirical evidence; identify relevant

assumptions or implications; formulate coherent arguments; critically evaluate practices, policies and theories by following scientific approach to knowledge development.

LO4: Problem solving:

Capacity to extrapolate from what one has learned and apply their competencies to solve different kinds of non-familiar problems, rather than replicate curriculum content knowledge; and apply one's learning to real life situations.

LOS: Analytical reasoning:

Ability to evaluate the reliability and relevance of evidence; identify logical flaws and holes in the arguments of others; analyse and synthesise data from a variety of sources; draw valid conclusions and support them with evidence and examples, and addressing opposing viewpoints.

LO6: Research-related skills:

A sense of inquiry and capability for asking relevant/ appropriate questions, problematising, synthesising and articulating: Ability to recognise cause-and-effect relationships, define problems, formulate hypotheses, test hypotheses, analyse, interpret and draw conclusions from data, establish hypotheses, predict cause-and-effect relationships; ability to plan, execute and report the results of an experiment or investigation.

LO7: Cooperation/Team work:

Ability to work effectively and respectfully with diverse teams; facilitate cooperative or coordinated effort on the part of a group, and act together as a group or a team in the interests of a common cause and work efficiently as a member of a team.

LOS: Scientific reasoning:

Ability to analyse, interpret and draw conclusions from quantitative/qualitative data; and critically evaluate ideas, evidence and experiences from an open-minded and reasoned perspective.

LO9: Reflective thinking:

Critical sensibility to lived experiences, with self-awareness and reflexivity of both self and society.

LO10: Information/digital literacy:

Capability to use ICT in a variety of learning situations, demonstrate ability to access, evaluate, and use a variety of relevant information sources, and use appropriate software for analysis of data.

LO11: Self-directed learning:

Ability to work independently, identify appropriate resources required for a project, and manage a project through to completion.

LO12: Multicultural competence:

Possess knowledge of the values and beliefs of multiple cultures and a global perspective; and capability to effectively engage in a multicultural society and interact respectfully with diverse groups.

LO13: Moral and ethical awareness/reasoning:

Ability to embrace moral/ethical values in conducting one's life, formulate a position/argument about an ethical issue from multiple perspectives, and use ethical practices in all work. Capable of demonstrating the ability to identify ethical issues related to one's work, avoid unethical behaviour such as fabrication, falsification or misrepresentation of data or committing plagiarism, not adhering to intellectual property rights; appreciating environmental and sustainability issues; and adopting objective, unbiased and truthful actions in all aspects of work.

LO14: Leadership readiness/qualities:

Capability for mapping out the tasks of a team or an organization, and setting direction, formulating an inspiring vision, building a team who can help achieve the vision, motivating and inspiring team members to engage with that vision, and using management skills to guide people to the right destination, in a smooth and efficient way.

LO15: Lifelong learning:

Ability to acquire knowledge and skills, including "learning how to learn', that are necessary for participating in learning activities throughout life, through self-paced and self-directed learning aimed at personal development, meeting economic, social and cultural objectives, and adapting to changing trades and demands of work place through knowledge/skill development/reskilling

II. COURSE OUTCOMES

The Learning Outcomes are achieved through different Course outcomes framed for the courses in the programme that deals with all levels (K1 –K6) of Bloom's Taxonomy.

- ❖ Remember (K1),
- ❖ Understand (K2),
- ❖ Apply(K3),
- ❖ Analyze (K4),
- ❖ Evaluate(K5) and
- ❖ Create (K6).

III. ABOUT THE PROGRAM

1. **Candidate's eligibility for admission**

   Candidate who has passed the B.Sc. degree in any Life Sciences [Microbiology/ Industrial Microbiology/ Botany/ Zoology/ Biochemistry/ Bioinformatics/ Medical Lab Technology/ Agriculture / Biotechnology/FoodScience/MolecularBiology/MedicalMicrobiology/Biology/Chemistry with Botany& Zoology as Allied Subjects] of this university or an examination of any other university accepted by the syndicate as equivalent thereto shall be eligible for admission to M.Sc. Degree Course in Microbiology.

2. **Duration of the programme**

   The duration of the course is for two academic years consisting of four semesters.

3. **CBCS - Structure of the programme**

Course Component	**No. of courses**	**Hours of Learning per week**	**Marks/ Paper**	**Credits**	**Total Credits**
Core Papers	10	5	100	4	40
Core Practical	06	6	100	4	24
Elective papers	3	3	100	3	09
Supportive paper	1	2	100	3	02
Project	1	24	100	12	12
Credit seminar	1	1	100	2	02
Internship	1	2 Wks Total	100	2	02
Online courses	1	-	100	2	02
Value education	1	-	100	2	02
Total	**24**				**95**

Curriculum structure

	Paper Code	Title of the Paper	Hrs/ Week	Credits	Marks		
					CIA	EA	Total
I	26UPMBC1C01	Core I – Foundation of Microbiology and Microbial Diversity	5	4	25	75	100
	26UPMBC1C02	Core II –Cell Biology and Microbial Genetics	5	4	25	75	100
	26UPMBC1C03	Core III –Molecular Biology and rDNA Technology	5	4	25	75	100
	26UPMBC1E**	Elective -1	3	3	25	75	100
	26UPMBC1P01	Core Practical I – Basic Techniques in Microbiology	6	4	40	60	100
	26UPMBC1P02	Core Practical Il – Microbial genetics, and Molecular Biology	6	4	40	60	100
		Swayam / Mooc Course	-	2	-	-	-
				25			
II	26UPMBC1C04	Core IV – Immunology and Vaccinology	5	4	25	75	100
	26UPMBC1C05	Core V - Medical Bacteriology and Mycology	5	4	25	75	100
	26UPMBC1C06	Core VI - Medical Virology and Parasitology	5	4	25	75	100
	26UPMBC1E**	Elective - 2	3	3	25	75	100
	26UPMBC1P03	Core Practical III – Bacteriology and Mycology	6	4	40	60	100
	26UPMBC1P04	Core Practical IV – Immunology, Virology and Parasitology	6	4	40	60	100
		Value Education	-	2	25	75	100
				25			
III	26UPMBC1C07	Core VII – Industrial Microbiology and Fermentation Technology	5	4	25	75	100
	26UPMBC1C08	Core VIII – Food and Dairy Microbiology	5	4	25	75	100
	26UPMBC1C09	Core IX – Soil and Environmental Microbiology	5	4	25	75	100
	26UPMBC1E**	Elective – 3	3	3	25	75	100
	26UPMBC1S**	Supportive – 1	2	2	25	75	100
	26UPMBC1P05	Core Practical V: Industrial and Food Microbiology	5	4	40	60	100
	26UPMBC1P06	Core Practical VI: Soil and Environmental Microbiology	5	4	40	60	100
	26UPMBC1I01	Internship	2 wks	2	40	60	100
				27			
IV	26UPMBC1C10	Core X– Research Methodology and Biostatistics	5	4	25	75	100
	26UPMBC1CS01	Credit Seminar	1	2	40	60	100
	26UPMBC1PR01	Project	24	12	40	60	100
				18			
		Total		**95**	735	1665	2400

Elective courses 1

1. Biofertilizers and Biocontrol Agents (26UPMBC1E01)
2. IPR, Biosafety and Bioethics (26UPMBC1E02)
3. Entrepreneurship in Microbiology (26UPMBC1E03)

Elective courses 2

4. Health and Hygiene (26UPMBC1E04)
5. Bioprocess of Mushroom and Single Cell Protein (26UPMBC1E05)
6. Eye Microbiome and Infectious Diseases (26UPMBC1E06)

Elective courses 3

7. Computational Microbiology and Artificial Intelligence (26UPMBC1E07)
8. Microbial Bio-prospecting in Blue Economy (26UPMBC1E08)
9. Quality Control in Industries (26UPMBC1E09)

Supportive courses for other departments

1. Entrepreneurship in Microbiology (26UPMBC1S01)
2. Microbiology (26UPMBC1S02)
3. Medical Laboratory Technology (26UPMBC1S03)
4. Health Science Management (26UPMBC1S04)

4. **Credit Calculation**

Method of teaching	**Hours**	**Credits**
Lecture Core	1.25	1
Lecture Elective	1	1
Lecture Supportive	1.5	1
Practical/Internship/Self-Learning	1.5	1

5. **Examinations**

There shall be four semester examinations: first semester examinations at the middle of the first academic year and the second semester examination at the end of the first academic year. Similarly, the third and fourth semester examinations shall be held at the middle and end of the second academic year, respectively.

6. **Scheme for Evaluation and Attainment Rubrics**

Evaluation will be done on a continuous basis and will be evaluated four times during the course work. The first evaluation will be in the 7^{th} week, the second in the 11^{th} week, third in the 16^{th} week and the end- semester examination in the 19^{th} week. Evaluation may be by objective type questions, short answers and essays. The end semester examination is a university theory examination with prescribed question paper pattern.

ATTAINMENT RUBRICS FOR THEORY COURSES

University Exam : 75 Marks

Internal Marks : 25 Marks

Total : 100 Marks

Question Paper Pattern (Theory Internals – 50 Mark, Time Duration – 2 Hrs)

Section	Approaches	Mark Pattern	K Level	LOs coverage
A	One word (Answer all questions)	20 x 1=20 (Multiple choice questions)	Remember/ Understand	LO1
B	100 to 200 words (Answer any two questions among the options given)	2 x 5=10 (Paragraphs, Brief summary)	Apply	LO4
C	500 to 1000 words (Answer any two of the 'either or' type questions from the options given)	2 x 10=20 (Essays)	Analyze or Design	LO5 & LO11

Question Pattern – University Theory Exam: (75 Marks)

Part A: 20 nos. Objective type, one mark each (10 marks - recall, 10 marks - understand)

Part B: Any three questions from the options given, each 5 marks (3 x 5 = 15 marks) (Apply, Problem solving)

Part C: Answer All questions, each 8 marks (5 X 8 = 40 marks) (Analyze, Design/Create)

ATTAINMENT OF RUBRICS FOR LAB COURSES:

Practical: Internal Assessment ------ 40 Marks

University Practicals ------ 60 Marks

Question Pattern – Practical Exam (60 marks)

Part A: Major Experiment (25 marks: theory, observation, practical skills and result reporting)

Part B: Minor Experiment (15 marks: theory, observation, practical skills and result reporting)

Part C: Spotters 5 nos, each 2 marks (2 X 5 = 10 marks)

Part D: Record and Viva (5 + 5=10 marks)

ATTAINMENT RUBRICS FOR RESEARCH PROJECT:

Internal Assessment : 40 marks

External Assessment : 60 marks

Total Marks : 100 marks

7. **Grading System**

Evaluation of performance of students is based on ten-point scale grading system as given below.

Range of Marks	Grade Points	Letter Grade	Description
90 – 100	9.0 – 10.0	O	Outstanding
80 – 89	8.0 – 8.9	D+	Excellent
75 – 79	7.5 – 7.9	D	Distinction
70 – 74	7.0 – 7.4	A+	Very Good
60 – 69	6.0 – 6.9	A	Good
50 – 59	5.0 – 5.9	B	Average
00 – 49	0.0	U	Re-Appear
ABSENT	0.0	AAA	Absent

8. **Classification of Final Result**

CGPA	Grade	Classification of Final Result
9.5 – 10.0	O+	First Class with Exemplary*
9.0 and above but below 9.5	O	
8.5 and above but below 9.0	D++	First Class with Distinction*
8.0 and above but below 8.5	D+	
7.5 and above but below 8.0	D	
7.0 and above but below 7.5	A++	First Class
6.5 and above but below 7.0	A+	
6.0 and above but below 6.5	A	
5.5 and above but below 6.0	B+	Second Class
5.0 and above but below 5.5	B	
0.0 and above but below 5.0	U	Re-Appear

* The candidates who have passed in the first appearance and within the prescribed semester of the PG Program are eligible.

SEMESTER-I

Core Paper I – Foundation of Microbiology and Microbial Diversity

(Paper Code: 26UPMBC1C01)

Course Objectives

The course contents are designed to establish a foundational knowledge of the development of microbiology and explain the structural and morphological diversity of microorganisms. Students will be become proficient in able to provide technical laboratory skills, describe the principles of systematic microbial taxonomy and use modern molecular methodologies for analyzing microbial diversity.

Course Outcome

Upon successful completion of this course, students will be able to:

CO1 Remember	Identify the historical contributions of pioneers such as Pasteur, Koch, Beijerinck, Winogradsky, Waksman., List the nomenclature rules, hierarchical organization levels used in systematic microbiology and recall different morphological types, including bacteria, fungi, cyanobacteria, and yeast.	LO1, LO2
CO2 Understand	Explain the transition from theories of spontaneous generation to biogenesis, describe the "One Health" concept and the significance of the human microbiome and summarize the principles and resolving powers of various microscopes viz. light, electron (SEM/TEM), and confocal microscopy.	LO1, LO2, LO3, LO8, LO9,
CO3 Apply	Demonstrate various staining techniques (simple, differential, and special), sterilization methods, implement pure culture techniques, preservation methods and Use Bergey's Manual of Systematic Bacteriology to assist in the identification and classification of microbes.	LO1, LO2, LO4, LO6, LO11,
CO4 Analyze	Compare major classification systems, including Haeckel's three kingdoms, Whittaker's five kingdoms, Woese domain system, compare between the ecological niches and specific adaptations of various extremophiles (thermophiles, halophiles, methanogens), traditional (e.g., API System, VITEK 2) and modern molecular approaches (MALDI-TOF and 16s rRNA gene sequencing) for identification.	LO1, LO2 LO3, LO4, LO5, LO11,
CO5 Evaluate	Assess the suitability of different types of media (basal, enriched, selective, or enrichment) for the cultivation of specific microorganisms, evaluate the effectiveness of physical and chemical disinfection and sterilization methods.	LO1, LO3, LO5, LO11,
CO6 Create	Create a comprehensive workflow for analyzing complex microbial communities using advanced methodologies like Next Generation Sequencing (NGS) or Whole Genome Sequencing and Design appropriate cultivation and preservation strategies for newly isolated aerobic and anaerobic organism.	LO3, LO4, LO6, LO8

Unit I: Introduction to Microbiology

Development of microbiology and the early discoveries – Spontaneous generation *vs* biogenesis. Contribution of pioneers in microbiology; Development of the field of soil microbiology- Contributions of Martinus W. Beijerinck, Sergei N. Winogradsky, Selman A.Waksman,Paul Ehrlich and Elie Metchnikoff etc. Modern Microbiology.Introduction to microbiomes -human. Concept of One Health (human–animal–environment)

Unit II: Microscopy& Morphological types

Morphological types – bacteria, fungi, cyanobacteria, yeast. Structural diversity- Biofilms, Cell surface diversity - capsules, S-layers. Microscopy- Visualization of cells and subcellular components by light microscopy, resolving powers of different microscopes, scanning and transmission microscopes, different fixation and staining techniques for EM, image processing methods in microscopy. Confocal microscopy, Live-cell imaging

Unit III: Media and Staining

Media Preparation: Preparation of liquid, solid and semisolid media. Types of media and uses- Basal, Enriched, Selective, Enrichment media and Biochemical test media. Sterilization and disinfection – physical and chemical methods for controlling microorganism.Staining- Simple, differential and special staining.Pure culture techniques- Cultivation of Aerobic & Anaerobic organisms.Microbial culture collections.Preservation methods of microbes- Routine methods, liquid nitrogen preservation & freeze-drying (lyophilization).

Unit IV: Microbial taxonomy

Microbial taxonomy: Definition, systematics, Nomenclature rules and identification, Hierarchical organization and the position of microbes in the living world, Haeckel's three kingdom classification; Whittaker's five kingdom approach; Woese domain system; Major characteristics used in taxonomy: Morphological, physiological and metabolic, genetic and molecular taxonomy. Operational taxonomic units – OTUs. Bergey's Manual of Systematic Bacteriology.

Unit V: Microbial Diversity

Introduction to Microbial diversity- ecological niche-Types- Bacterial, Archaea and Eucarya. Archaea types - habitat, classification, adaptations, and applications- Thermophiles, Halophiles, Acidophiles, Alkaliphiles and Methanogens. Microbial diversity analysis methods- key approaches API System, VITEK 2 - 16s rRNA gene, Whole Genome Sequencing and MALDI-TOF Mass Spectrometry. Advanced methods - next generation sequencing (NGS).

Textbooks

1. Tortora, G.J., Funke, B.R. and Case, C.L. (2016) *Microbiology: An Introduction*, 11th Edition, Pearson Education, India.
2. Madigan, T.M., Martinko, M.J., Bender, S.K., Buckley, H.D., Stahl, A.D. and Brock, T. (2020) *Brock Biology of Microorganisms*. 16th Edition, Licensing agency, UK.
3. Kathleen Park Talaro, Barry Chess. (2014) Foundations in Microbiology, McGraw-Hill Education publication.
4. Dr. Prasanna V Dharani Aiyer. (2018) Introduction to Microbiology and Microbial Diversity, Publisher, Idea Publishing.
5. Srilekha Raha and Arindam Mitra (2023) Foundations of Microbiology, Academic Publishers.

6. Afroz Aslam (2024) Foundations of Microbiology, Algology, Mycology and Plant Pathology (2 Volumes), publisher: IBP Books.

Web References

1. www.life.umd.edu/classroom/bsci424/BSCI223WebSiteFiles/LectureList.htm
2. www.microbiologyonline.org.uk
3. www.cambridge.org › Home › Academic › Life science › Microbiology and Immunology.
4. https://open.umn.edu/opentextbooks/BookDetail.aspx?bookId=404
5. https://www.boundless.com/microbiology
6. www.ebooks.cambridge.org/ebook.jsf?bid=CBO9781139170635
7. www.grsmu.by/files/file/university/cafedry/.../files/essential_microbiology.pdf
8. https://microbiologyinfo.com/top-and-best-microbiology-books/

Internal Assessment Matrix for the defined COs

CO	Test 1	Test 2	Quiz	Assignment	Seminar	Percentage allocation	Mapping Strength
CO1	6	6	1			13	2
CO2	6	6	1			13	2
CO3	6	6	2	7		21	3
CO4	12		1	8	5	21	3
CO5		12				12	2
CO6				10	10	20	2
Marks	30	30	5	25 (Assignment, Group discussion, etc.,)	10 (Seminar)	100	

Course Articulation Matrix for defined COs

CO	Learning Outcomes														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	√	√													
CO2	√	√	√					√	√						
CO3	√	√		√		√					√				
CO4	√	√	√	√	√						√				
CO5	√		√		√						√				
CO6			√	√		√		√							
	5	4	**4**	**3**	**2**	**2**	**-**	**2**	**1**	**-**	**3**	-	-	-	-

Core Paper II: Cell Biology and Microbial Genetics

(Paper Code: 26UPMBC1C02)

Course Objective

The primary objectives of the course is to uncover the structural-functional mechanisms of life at the micro-scale and decode how genetic information is stored, regulated, and transferred. The course helps in exploring cellular organization and focusing how organisms pass on and modify genetic traits and examining mutation types and their roles in microbial evolution and adaptability.

At the end of the course the students will have the ability to

CO1 Recall	Recall the tenets of cell theory, Cell structure. Explain active/passive transport, basic concepts of energy production. Outline mitotic and meiotic phases. Describe the differences in DNA replication models. Define mutation and list the mutagen types.	LO1, LO4
CO2 Understand	Identify and list the functions of cell organelles. Differentiate - active/passive transport, *mitochondria and chloroplast PMFs.* Summarize replication and Compare mutation types	LO1, LO4
CO3 Apply	Explain how specialized structures apply for their functions.Predict the direction of solute movement. Calculate generation times and growth rate constants.Assess the phenotypic outcomes of mutagen treatments.	LO1, LO4, LO5, LO8, LO9, LO11,
CO4 Analyze	Demonstrate how checkpoint failures lead to uncontrolled cell division. Deconstruct the biochemical pathways of glycolysis and the electron transport chain. EvaluateMeselson-Stahl experiment in proving/disproving replication models.	LO1, LO4, LO5, LO8, LO9, LO11,
CO5 Design	Evaluate the impact of a mutation in cell-cycle checkpoints. Justify the claim for methanogen's survival in anaerobiosis. Apply the knowledge to predict DNA strand densities when replacing the nitrogen type in medium. Propose an experimental setup to check the mutagenicity of a chemical.	LO1, LO4, LO5, LO8, LO9, LO11,
CO6 Evaluate, Critical & Reflective thinking, Self directed Life-long learning etc.	With self-directed learning, students build higher cognitive skills and gain the abilities of critical thinking, scientific reasoning and reflective thinking to make effective seminars, group discussions and other assignments.	LO2, LO3, LO8, LO9, LO10, LO11, LO15

Unit I: Cell Ultra structure and Function

Discovery of cells, Cell Theory.Origin of eukaryotic cells; Differentiating Prokaryotic and Eukaryotic cells; Cell wall composition, synthesis and its inhibition. Ultra structure and function of, cytoskeleton, ribosomes, inclusion bodies, cellular organelles – golgi bodies, mitochondria, chloroplast, endoplasmic reticulum, centrioles, vacuoles. Membrane model. Membrane Transport systems: Passive Transport – Simple diffusion, Osmosis, Facilitated diffusion. Primary active Transport via Sodium Potassium Pumps, Secondary Active Transport using electro chemical gradient through Co-tranporters, Bulk/Vescicular Transport – exocytosis & endocytosis.

Unit II: Cell locomotion, division and Signaling

Locomotory organelles – Flagella and cilia, Structural organization and function. Types of flagella, Bacterial groupings based of flagella types. Binary fission in bacteria, Budding in Yeast, Mitotic division – Prophase, Metaphase, Anaphase, Telophase and Cytokinesis. Key phases during gametogenesis in Eukaryotes - I and II Meiotic divisions, Cell Cycle. Bacterial growth curve and Generation time calculation. Cell signaling and Quorum sensing.

Unit III: Microbial Physiology and Bioenergetics

Nutritional grouping of Microorganisms - Phototrophs, Chemotrophs, Autotrophs, Heterotrophs, Lithotrophs and Organotrophs Photosynthesis Carbohydrate metabolism – EMP, HMP and ED pathway – Kreb's Cycle – Glyoxylate cycle – Aerobic respiration – Substrate level and Oxidative phosphorylation – ATP generation. Electron transport system.Lipid catabolism – β-oxidation. Anaerobic respiration – Sulphur compounds– Nitrate and Carbon -di -oxide as electron acceptors. Fermentation – Mixed and Homo fermentatitive reactions. Oxygenic photosynthesis (Light dependent and Light Independent reactions), Anoxygenic photosynthesis.

Unit IV: Genome Organization and Replication

Nucleic acids as genetic material –Discovery of genetic material- Avery , Mc Cleod and Griffith experiment, Models of Replication – Dispersive, Conservative and Semiconservative-Meselson Stahl experiment. Genome organization – nucleoid, nucleosomes, chromatin/solenoid fibres, kinetochores, centromeres, Chromosomes, Euchromatin, Heterochromatin, allele, loci, gene.Molecular structure of nucleic acids.Nucleosides, Nucleotides.DNA helix & Positive/Negative supercoilings and their importance.Types of DNA conformations **(A, B, Z)**.DNA replication in prokaryotes, Theta mode of Replication and Rolling circle replication. Mechanism and enzymology of replication.Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication.

Unit V: DNA damages and Mutation

Mutant types – germinal verses somatic mutants, Spontaneous Vs induced, insertional mutagenesis, Deletions, inversions and duplications, Point and Frame-shift mutations, Mis sense, Non sense, Reversion vs Suppression, Conditional, Biochemical, Loss of function, Gain of function and Lethal mutations. Causes – Physical and Chemical mutagens, Ionizing and Non-ionizing Radiations, Free radicals, Alkylating agents, Nitrosamines, Hydroxylating agents, Intercalating agents, Base analogs, Tautomerism.

Text Books:

1. Caldwell D.R. (1995) Microbial Physiology and Metabolism. Brown Publishers.
2. Moat A.G., Foster J. W Spector M. P. (2002) Microbial Physiology John Wiley& Sons.
3. Rose Ah Advances in Microbial Physiology. Vol. 36, Academic Press Newyork.
4. Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M., & Stahl, D. A. (2021). Brock Biology of Microorganisms (16th Edition). Pearson.
5. Sanjay Kumar Sharma (2012) Cell Biology Physiology And Mycology. Ist Edition. Pragun Publications.
6. Dubey R.C. and Maheshwari D. K. (2009). Textbook of Microbiology. S. Chand, Limited.
7. Gardner E. J. Simmons M. J. and Snusted D.P. (2006). Principles of Genetics. (8th Edition). Wiley India Pvt. Ltd.
8. Verma P.S. and Agarwal V.K. (2004). Cell biology, Genetics, Molecular Biology, Evolution and Ecology. (2nd Edition). S Chand publication.
9. Tamarin, R., 1991, Principles of Genetics, 3rd edition.
10. De Robertis, E.D.P. and Robertis, E.M.F. 1991. Cell and molecular biology. Lea and Febiger Celis, J.E. (1998)

Reference Book

1) White, D., Drummond, J., & Fuqua, C. (2012). The Physiology and Biochemistry of Prokaryotes (4th Edition). Oxford University Press
2) Poole, R. K., & Kelly, D. J. (Eds.). (2021). Advances in Microbial Physiology, Volume 78. Academic Press
3) Shapiro, L., McAdams, H. H., &Losick, R. (Eds.). (2009). Bacterial Cell Biology. Cold Spring Harbor Laboratory Press.
4) Pontarotti P. (2018). Origin and Evolution of biodiversity. (1st Edition). Springer

   McGraw Hill.
5) Kim, B. H., & Gadd, G. M. (2019). Bacterial Physiology and Metabolism. Cambridge University Press.
6) Willey, J., Sandman, K., & Wood, D. (2022). Prescott's Microbiology (12th Edition).

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1) https://pmc.ncbi.nlm.nih.gov/articles/PMC12579171/
2) https://scispace.com/pdf/the-bacterial-cell-envelope-o3k9u4ycci.pdf
3) https://bio.libretexts.org/Bookshelves/Microbiology/Microbiology_(Boundless)/05%3A_Microbial_Metabolism
4) https://www.nature.com/scitable/topicpage/operons-and-prokaryotic-gene-regulation-992/
5) https://www.mdpi.com/2311-5637/11/7/410.

Internal Assessment Matrix for the defined COs

CO	Test 1	Test 2	Quiz	Assignment	Seminar	Percentage allocation	Mapping Strength
CO1	6	6	1			13	2
CO2	6	6	1			13	2
CO3	6	6	2	7		21	3
CO4	12		1	8	5	21	3
CO5		12				12	2
CO6				10	10	20	2
Marks	30	30	5	25 (Assignment, Group discussion, Model making etc.)	10 (Seminar)	100	

Strength = 3 (if percentage > 20%); Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage < 10%)

Course Articulation Matrix for defined COs

CO	Learning Outcomes														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	√			√											
CO2	√			√											
CO3	√			√	√			√	√		√				
CO4	√			√	√			√	√		√				
CO5	√			√	√			√	√		√				
CO6		√	√					√	√	√	√				√
	5	**1**	**1**	**5**	**3**	**-**	**-**	**4**	**4**	**1**	**4**	**-**	-	**-**	**1**

Core Paper III: Molecular Biology and rDNA Technology

(Paper Code: 26UPMBC1C03)

Course Objective

The course is designed to provide comprehensive knowledge of molecular mechanisms gene transfer methods, expression, regulation and gene manipulation. The course enables students to understand bacterial genetic recombination, transcription, translation, DNA repair mechanisms, recombinant DNA technology, molecular cloning, sequencing technologies and modern genome editing approaches. It also develops analytical, problem-solving and research skills required for molecular biology, biotechnology and biomedical sciences.

Course Outcome

At the end of the course the students will have the ability to :

CO1 Recall	Recall the mechanisms of homologous and non-homologous recombination, conjugation, transformation, transduction, transposable elements, transcription, translation, DNA repair pathways, cloning vectors, sequencing methods and PCR techniques.	LO1, LO4
CO2 Understand	Understand bacterial gene transfer mechanisms, transcriptional and translational regulation, operon models, DNA repair systems, recombinant DNA methodologies, cloning vectors and sequencing technologies.	LO1, LO4
CO3 Apply	Apply molecular biology principles to predict gene transfer events, select appropriate cloning vectors, interpret electrophoretic profiles, design PCR strategies, analyse gene expression and recommend suitable sequencing methods for research applications.	LO1, LO4, LO5, LO8, LO9, LO11,
CO4 Analyze	Analyse transcriptional regulation, translational mechanisms, DNA repair pathways, recombinant protein expression systems, cloning strategies, restriction maps, sequencing data and CRISPR-based genome editing approaches.	LO1, LO4, LO5, LO8, LO9, LO11
CO5 Design	Design cloning strategies, recombinant DNA experiments, PCR-based diagnostics, genome editing workflows, gene expression studies and molecular approaches for therapeutic and industrial applications.	LO1, LO4, LO5, LO8, LO9, LO11
CO6 Self-directed Life long learning etc.	Demonstrate independent learning by critically evaluating current molecular biology research, recombinant DNA technologies, genome engineering strategies and their ethical, biomedical and industrial applications through seminars, discussions and scientific assignments.	LO2, LO3, LO8, LO9, LO10, LO11, LO15

Unit I: Recombination in Bacteria

Homologous and non-homologous recombination. Natural methods of genetic transfers - Conjugation: self-transmissible plasmids, F factor, tra genes, oriT, F' Sexduction and Hfrstrains, Transposable elements – Class I and Class II – Enzymes involved, Retrotransposons, DNA Trasposons. Transduction types – General and Specialized transductions, **T**ransformation and DNA uptake – Artificial transformation techniques-electroporation, microinjection, protoplast fusion and microparticle bombardment.

Unit II: Transcription and Gene Regulation

Molecular mechanism and Enzymology of Transcription and Translation in prokaryotes – Structure and function of different RNA types – rRNA, m RNA, t RNA, micro RNA, Sn RNA. Transcription factors and machinery, formation of initiation complex, RNA polymerases, capping, elongation, and termination, RNA processing, RNA editing, splicing, RNA transport and polyadenylation, post-transcriptional modifications, Transcriptional inhibitors. Operon concept – lac, trp and ara operon. Transcription activator and Repressor, role of chromatin in gene expression and gene silencing.

Unit III: Translation Process and DNA repair mechanism

Protein synthesis – Ribosome units, formation of initiation complex, initiation factors and elongation factors, tRNA identity, Amino-acylation of tRNA, amino acyl tRNA synthetase, and translational proof-reading, translation termination.Translational inhibitors, post-translational modification of proteins and their detection.Genetic code and Wobble's Hypothesis. DNA Repair mechanisms – Base Excision repair, Nucleotide repair mechanism, Mismatch repair mechanism, SOS repair.

Unit IV: Recombinant DNA methods

Analysis of RNA, DNA and proteins by one- and two-dimensional gel electrophoresis, Isoelectric focusing gels.. Gene cloning vectors - pBR322 and derivatives, pUC vectors and pGEM3Z - Phage Vectors (M13 and Lambda), cosmids, phasmids, phagemids, BACs and YACs. Expression of recombinant proteins using bacterial, animal and plant vectors. Methods for analysis of gene expression at RNA and protein level, large scale expression. Genes knock out in bacterial and eukaryotic organisms. In vitro mutagenesis and deletion techniques, Ames Test.

Unit V: Molecular Sequencing, cloning and their applications

Isolation of specific nucleic acid sequences. DNA sequencing methods - Primer walking, Sanger's method and automated sequencing methods. Pyrosequencing – DNA chips and micro array. Next generation sequencing.Generation of genomic and cDNA libraries Protein sequencing methods. Molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems. Characterization of cloned DNA: Hybrid arrested translation (HAT) - Restriction mapping - restriction fragment length polymorphism (RFLP) – RAPD. Polymerase chain reaction (PCR) – types and their applications.CRISPR-cas9 technique and their applications. Gene Therapy.

Text Books

1. Malacinski G.M. (2008). Freifelder's Essentials of Molecular Biology. (4th Edition). Narosa Publishing House, New Delhi.
2. Dubey R.C. and Maheshwari D. K. (2009).Textbook of Microbiology. S. Chand, Limited.
3. Gardner E. J. Simmons M. J. and Snusted D.P. (2006). Principles of Genetics.(8th Edition).Wiley India Pvt. Ltd.
4. Verma P.S. and Agarwal V.K. (2004).Cell biology, Genetics, Molecular Biology, Evolution and Ecology.(2nd Edition).S Chand publication.
5. Cooper & Hausman .2004. The Cell – A Molecular Approach
6. Tamarin, R., 1991, Principles of Genetics, 3rd edition.
7. De Robertis, E.D.P. and Robertis, E.M.F. 1991. Cell and molecular biology. Lea and Febiger Celis, J.E. (1998)
8. Dale J. W., Schantz M.V. and Plant N. (2012). From Gene to Genomes – Concepts and Applications of DNA Technology.(3rd Edition).John Wileys and Sons Ltd.
9. Primrose S.B. and Twyman R. M. (2006). Principles of Gene Manipulation and Genomics.(7th Edition).Blackwell Publishing.
10. Snusted D.P. and Simmons M. J. (2019). Principles of Genetics.(7th Edition).John Wiley and Soms, Inc.

Reference Books

1.White D. Drummond J. and Fuqua C. (2011). The Physiology and Biochemistry of Prokaryotes, Oxford University Press, Oxford, New York.

2. Pontarotti P. (2018). Origin and Evolution of biodiversity.(1st Edition). Springer

3. Russell P.J. (2010). Genetics - A Molecular Approach.(3rd Edition).Pearson New International Edition.

4. Glick B. R. and Patten C.L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA.(5th Edition).ASM Press.

Web Resources

https://courses.lumenlearning.com/boundless-biology/chapter/dna-replication/

https://www.sciencedirect.com/topics/biochemistry-genetics-andmolecular- biology

https://www.kopykitab.com/Methods-In-Biology-Life-Science-Study-Material-For-CSIR NET-Exam-by-Panel-Of-Experts

Internal Assessment Matrix for the Defined COs:

CO	Test1	Test2	Quiz	Assignment	Seminar	Percentage allocation	Mapping Strength
CO1	6	6	1	-	-	13	2
CO2	6	6	1	-	-	13	2
CO3	6	6	2	7	-	21	3
CO4	12	-	1	8	5	21	3
CO5	-	12	-	-	-	12	2
CO6	-	-	-	10	5	20	2
Marks	30	30	5	25	10	100	

Strength = 3 (if percentage > 20%); Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage < 10%)

Course Articulation Matrix for defined COs

CO	Learning Outcomes														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	√			√											
CO2	√			√											
CO3	√			√	√			√	√		√				
CO4	√			√	√			√	√		√				
CO5	√			√	√			√	√		√				
CO6		√	√					√	√	√	√				√
	5	**1**	**1**	**5**	**3**	**-**	**-**	**4**	**4**	**1**	**4**	**-**	-	**-**	**1**

Core Practical I – Basic Techniques in Microbiology

(Paper Code: 26UPMBC1P01)

Course Objective

The objective of this course is to provide hands-on training in the quantification of microorganisms from environmental samples, develop technical proficiency in various staining methodologies to visualize cell morphology, subcellular structures and establish expertise through wide array of tests.

Course Outcome

At the end of the course, learners will be able to

CO1 Remember	Learn to prepare specific dyes, reagents, media components required for staining, biochemical testing, recall the procedural steps for determining bacterial motility using the hanging drop method.	LO1, LO3
CO2 Understand	Explain the underlying principles of differential staining, biological basis for various enzyme hydrolysis tests like,describe the different phases of a microbial growth curve and the significance of pure culture techniques.	LO1, LO3, LO6
CO3 Apply	Apply diverse staining techniques (Simple, Gram, Capsule, Spore, Acid-fast, LPCB),demonstrate the isolation and cultivation of algae and anaerobic bacteria, from various samples, perform IMViC series and TSI agar tests etc. to characterize bacterial traits.	LO4, LO6, LO8
CO4 Analyze	Compare the results of biochemical and fermentation tests for species level identification, analyze the specific growth rate, generation time from experimental growth curve data.	LO5, LO6, LO7
CO5 Evaluate	Assess the purity and density of microbial populations through enumeration techniques and staining procedures.	LO4, LO6
CO6 Create	Develop a systematic identification workflow for an unknown bacterial isolate based on morphological, cultural and biochemical characteristics. Design appropriate cultivation strategies for specific microbial growth.	LO3, LO4, LO6, LO14

List of Experiments

1. Isolation and Enumeration of Bacteria & Fungi from Soil Sample.
2. Staining Methods- Simple, Grams, Capsule, Spore Staining& Acid-fast staining.
3. Direct Microscopic observation of fungi- Lactophenol Cotton Blue Staining (LPCB).

4. Identification of Non sporulating fungi- Fungal Slide Culture.
5. Determination of Bacterial Motility- Hanging Drop Method.
6. Biochemical Test- Catalase, Oxidase, Triple Sugar Ion Agar Test & UreaseTest.
7. IMVIC tests.
8. Carbohydrate fermentation.
9. Enzyme Hydrolysis test-Casein, Starch, Gelatin and Lipid.
10. Growth Curve- Growth rate and Generation Time.
11. Isolation and cultivation of Algae.

Textbooks

1. Dhiraj.B.Shekhawat.(2021) Basics in Microbiology and Haematology. Neeraj Publishing House.
2. Anamika Vyas and Sheethal S (2026) Concise Workbook in Practical Microbiology. Jaypee Brothers Medical Publishers
3. A.S. Karwa, M.K. Rai & H.B. Singh. (2021) Handbook of Techniques in Microbiology - A Laboratory Guide to Microbes, Scientific Publishers.
4. S.M. Reddy & S. Ram Reddy. (2026) Microbiology: a laboratory manual 4th Edition, Scientific publisher.
5. Philip L.R. Bonner, Alan J. Hargreaves. (2022) Basic Bioscience Laboratory Techniques: A Pocket Guide, 2nd Edition, Wiley-Blackwell. Publisher.
6. Salvatore Hopkins. (2022) Laboratory Techniques in Microbiology, Kaufman press.

Web References

1. http://www.microbiologyonline.org.uk/media/.../sgm_basic_practical_microbiology_2.pdf
2. http:/www.faculty.washington.edukorshin/Class486/MicrobiolTechniques.pdf
3. http://www.pdfsdocuments.com/cp-baveja-microbiology.pdf
4. http://www.cmu.edu.cn/jc_sys1/upl_files/200858184159474.pdf
5. http:// www vlab.amrita.edu/?sub=3&brch=69&sim=192&cnt=1
6. http:// www homepage.usask.ca/~jrg426/manualtoc.html
7. http:// www.asmscience.org/content/book/10.1128/9781555815905
8. http://www.pleasanton.k12.ca.us/avhsweb/thiel/apbio/labs/Lab_Topic19.pdf

Internal Assessment Matrix for the defined COs

CO	Practical Class Performance	Model Exam	Percentage allocation	Mapping Strength
CO1	-	10 (spotters)	10	2
CO2	10	-	10	2
CO3	08	15	23	3
CO4	12	10	22	3
CO5	10	15	25	3
CO6	-	10 (record + viva)	10	2
Marks	40	60	100	-

Strength = 3 (if percentage > 20%); Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage < 10%)

Course Articulation Matrix for defined COs

CO	Learning Outcomes														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	√		√												
CO2	√		√			√									
CO3				√		√		√							
CO4					√	√	√								
CO5				√		√									
CO6			√	√		√								√	
	2	-	**3**	**3**	**1**	**5**	**1**	**1**	**-**	**-**	**-**	-	-	**1**	-

Core Practical Il: Microbial genetics and Molecular Biology

(Paper Code: 26UPMBC1P02)

Course objectives

This laboratory course objective is to provide hands-on experience in microbial genetics and molecular biology techniques. Students will learn to isolate and analyze DNA, RNA, and proteins, study microbial mutagenesis, and perform gene amplification and transfer methods like PCR and transformation. Simultaneously students gain research related skills and also develop cooperation and team work qualities and acquire leadership skills.

Course Outcomes

CO1 Recall & Understand	Understand the principles and techniques used to isolate and quantify nucleic acids and proteins.	LO1
CO2 Critical thinking	Gain practical skills in microbial genetics, including mutation, isolation and screening. Capable to apply analytical thought to identify relevant assumptions or implications by following scientific approach for knowledge development	LO3
CO3 Apply	Learn core molecular techniques and apply them for individual experiments like Nucleic acid and Protein isolation, Quantification, PCR, bacterial transformation, and DNA blotting.	LO4
CO4 Cooperation and team work	Students while working in teams during practical hours, learn to coordinate with each other for accomplishment of the group tasks. With each individual, assigned of some in-charge duty or function, has to perform his role satisfactorily, to prove himself or herself, as a reliable person with leadership qualities for directing or guiding the team work successfully to the satisfaction of evaluators	LO7
CO5 Research related skills	Students develop the ability to plan, execute, collect data, analyze, interpret and draw conclusions from data.	LO6
CO6 Leadership readiness and Communication	Capable of mapping out the group task of a team, set direction, help, guide, inspire and motivate the members towards the task, to achieve it in a smooth and efficient way. Able to communicate the results in a clear way orally and as write up .	LO14, LO2

List of Experiments:

1. Isolation of genomic DNA from Gram Positive and Gram Negative bacteria
2. Estimation of DNA using colorimeter (Diphenylamine reagent)
3. Isolation of Plasmid DNA
4. Separation of proteins by polyacrylamide gel electrophoresis (SDS-PAGE)
5. Isolation of RNA
6. RNA estimation by Orcinol method.
7. Isolation of Antibiotic-resistant mutants using gradient plate technique.
8. Screening of auxotrophic mutants using replica plating technique (Spontaneous vs induced).
9. Artificial Transformation - CaCl2
10. Amplification of DNA by PCR.
11. Southern blotting – Demonstration

Text Books

1. Russell P. J. (2019). Genetics – A Molecular Approach (3rd Edition). Pearson Education, Inc.
2. Glick B. R. and Patten C. L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA (5th Edition).ASM Press.
3. Gunasekaran P. (2007). Laboratory Manual in Microbiology.New Age International.
4. James G Cappucino. and Natalie Sherman. (2016). Microbiology – A laboratory manual.(5th Edition).The Benjamin publishing company. New York.
5. Hurst, C.J., Crawford R.L., Garland J.L., Lipson D.A., Mills A.L. and Stetzenbach L.D. (2007). Manual of Environmental Microbiology.(3rd Edition).American Society for Microbiology.

References Books

1. Sambrook J. and Russell D.W. (2001). Molecular Cloning: A Laboratory Manual. (7th Edition). Cold Spring Harbor, N.Y: Cold Spring Harbor Laboratory Press.
2. Brown T.A. (2016). Gene Cloning and DNA Analysis.(7th Edition).John Wiley and Jones, Ltd.
3. Dale J. W., Schantz M. V. and Plant N. (2012). From Gene to Genomes – Concepts and Applications of DNA Technology.(3rd Edition).John Wileys and Sons Ltd.
4. Pepper I., Gerba C. and Brendecke J. (2004). Environmental Microbiology - A Laboratory Manual.(2nd Edition). Academic Press, Elsevier.

Web Resources

https://microbenotes.com/gene-cloning-requirements-principle-steps-applications/

INTERNAL ASSESSMENT MATRIX FOR THE DEFINED COs:

CO	**Practical Class Performance**	**Model Exam**	**Percentage allocation**	**Mapping Strength**
CO1-Recall & Understand	-	10 (spotters)	10	2
CO2-Critical thinking	10	-	10	2
CO3-Apply	08	15	23	3
CO4-Cooperation and team work	12	10	22	3
CO5-Research related skills	10	15	25	3
CO6-Leadership readiness and Communication	-	10 (record + viva)	10	2
Marks	40	60	100	-

Strength = 3 (if percentage > 20%); Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage < 10%)

COURSE ARTICULATION MATRIX FOR DEFINED COs

CO	**Learning Outcomes**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	√														
CO2			√												
CO3				√											
CO4							√								
CO5						√									
CO6		√												√	
	1	**1**	1	**1**	**-**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	-	**1**	**-**

SEMESTER – II

Core Paper IV – Immunology and Vaccinology

Course Objective

This course provides a comprehensive evaluation of the mechanisms governing the human immune system and the industrial frameworks of modern vaccinology. Students will explore cell differentiation, lymphoid structural biology, antigen-antibody kinetics, clinical immunity pathologies, global vaccine manufacture and its regulatory compliance.

At the end of the course the students will have the ability to

CO1	Analyze Immune Component Development, Differentiate the origin, differentiation pathways, and functional roles of diverse immune cells and receptors	LO1, LO3, LO4, LO5, LO8, LO11
CO2	Evaluate Immune Response Mechanisms, Explain the structural organization of primary and secondary lymphoid organs, the mechanisms of T and B cell activation, and the role of Major Histocompatibility Complex (MHC)	LO1, LO4, LO5, LO8, LO9, LO11,
CO3	Execute Immunological Diagnostic Assays,Select and justify appropriate antigen-antibody interaction principles to accurately diagnose specific viral, bacterial, or blood-group antigens.	LO1, LO2, LO4, LO5, LO6, LO10 LO11,
CO4	Analyze Pathological and Clinical Immune Phenomena, Assess the underlying molecular mechanisms of hypersensitivity reactions, transplantation tissue typing (HLA), and tumor antigen expressions	LO1, LO3, LO4, LO5, LO13, LO11,
CO5	Design and Assess Vaccine Frameworks, Evaluate the design, manufacturing constraints, safety profiles, and regulatory compliance of diverse vaccine types	LO1, LO4, LO5, LO12 LO11, LO14, LO15

Unit I: Immunity & Cells of Immune system

History and scope of immunology; Types of immunity - Innate and acquired, active and passive, Cell mediated immunity and Humoral immunity, Hematopoiesis. Ontogeny, origin, development and differentiation of immune cells. Toll – like receptors Antigen presenting cells. T-helper and T-cytotoxic cells, Natural killer cells, Dendritic cells, Langerhan cells, Macrophages, Microphages.

Unit II: Organs of the Immune system and Immune response

Lymphoid tissues and organs - Primary lymphoid organs - Thymus, Bone marrow: Secondary lymphoid organ - Lymph node, spleen, MALT and GALT. Phagocytosis process.Clonal selection theory.B-lymphocytes and their activation, mechanism of T-cell activation. Thymus derived lymphocytes, Major histocompatibility complex. Structure and functions of Class I and II molecules.

Unit III: Antigens and Ag – Ab reaction

Antigenicity: factors governing antigenicity. Antigen types, haptens, epitopes, adjuvants, carriers, bacterial, viral and tumour antigens, autoantigens, blood group antigens, T

dependent, T independent antigens.Antibody – types and functions; Kinetics of antibody production - primary and secondary antibody response.Generation of antibody diversity.Organisation and expression of immunoglobulin genes. Antigen antibody reactions-precipitation, agglutination, immunofluorescence, haemagglutination, RIA, ELISA. Factors governing antigen-antibody interactions: Affinity, avidity, valency, cross reactivity.

Unit IV: Hypersensitivity, Transplantation and Tumour Immunology

The complement systems, Hypersensitivity reactions - types and mechanisms, Hybridoma and monoclonals. Transplantation immunity - Organ transplantation and HLA tissue typing.Tumour Immunology-Genetics of neoplastic cell antigens expression of tumor antigens. Immuno therapy for cancer

Unit V: Vaccinology

Introduction to Vaccines - Types of vaccines – Recombinant vector vaccines, DNA vaccines, Vaccines against AIDS and Tropical Infectious Diseases. The vaccine industry, Vaccine manufacturing, Vaccine additives and manufacturing residuals, World Health Organization (WHO) guidelines, Regulation and testing of vaccines, Vaccine safety, Limitations of vaccines.

Text Books

1. Rao, C.V. (2012) *An Introduction to Immunology*. 2nd Edition, Narosa Publishing House.

2. Richard M. Hyde (1995) Immunology, 3rd Edition, Willams and Wilkins Publishing
3. Joshi, K.R., Osama, N.O. (2012) *Immunology*, 5th Edition, Agrobios Ltd, India.

Reference Books:

1.Coico, R. and Sunshine, G. (2015) *Immunology: A Short Course*, 7th Edition, John Wiley & Sons, 432 pages.

2.William E. Paul (2018) *Fundamental Immunology*, 8th Edition, Willams and Wilkins Publishing.

3.Cruse, J., Lewis, R. and Wang, H. (2004) *Immunology Guidebook,* Academic Press.

4.Abbas, A.K., Litchman, A.H., Pober. J.S. (2017) *Cellular and Molecular Immunology*, 9th Edition, W.B.Saunders, USA.

5.Golds, R.A., Kindt T.J., Osborne B.A. (2005) *Immunology,* 5th Edition, Freeman and Company, New York.

6.Ivan M. Roitt and Peter J. Delves (2016) *Essential Immunology*, 13th Edition, Blackwell Science Ltd. Oxford.

7. Janeway, C.A., Travers, P., Walport, M. and Shlomchik, M.J. (2001) *Immunobiology: The Immune System in Health and Disease*, 5th Edition, Garland Publishing, USA.

8. Peter Wood (2006) *Understanding Immunology University of Manchester*, 2nd Edition, Pearson Education Lts, Essex.

9. Stefan H.E. Kaufmann, Sher, A., Ahmed, R. (2002) *Immunology of Infectious diseases*, ASM Press, USA.

10.Benjamini E, Coico R and SunskiseG,;Immunology – A short course, Wiley – Liss Publication, NY. Ed.4; 2000.

Web References

1.http://www.hhmi.org/biointeractive/immunology/lectures.html/

2.http://bitesized.immunology.org/what-is-immunology/

3.http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1365-2567

4.http://www.helmberg.at/immunology.pdf

5.http://www.mednotes.net/notes/immunology/

Internal Assessment Matrix for the defined COs

CO	Test 1	Test 2	Quiz	Assignment	Seminar	Percentage allocation	Mapping Strength
CO1	6	6	1			13	2
CO2	6	6	1			13	2
CO3	6	6	2	7		21	3
CO4	12		1	8	5	21	3
CO5		12				12	2
CO6				10	10	20	2
Marks	30	30	5	25 (Assignment, Group discussions, Problem solving)	10 (Seminar)	100	

Strength = 3 (if percentage > 20%); Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage < 10%)

Course Articulation Matrix for defined COs

CO	Learning Outcomes														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	√		√	√	√			√			√				
CO2	√			√	√			√	√		√				
CO3	√	√		√	√	√				√	√				
CO4	√		√	√	√						√		√		
CO5	√			√	√						√	√		√	√
	5	1	1	**5**	**5**	**1**	**-**	**2**	**1**	**1**	**5**	**1**	1	**1**	**1**

Core Paper V - Medical Bacteriology and Mycology

(Paper Code: 26UPMBC1C05)

Course Objective

The content of the course provides the protocols for managing clinical specimens explaining the relationship between indigenous normal flora and pathogenesis of human diseases. This paper provides a comprehensive understanding of fungal taxonomy with details of the epidemiological patterns and diagnostic methods for various types of mycoses.

Course Outcome

At the end of the course, learners will be able to

CO1 Remember	Recall critical medical terminologies such as infectious dose, epidemic, pandemic, sporadic, endemic, Identify the morphological characteristics and typical causative agents for major bacterial, fungal infections and List the various Biosafety Level requirements for bio-medical waste management.	LO1
CO2 Understand	Explain the importance of indigenous normal microbial flora in the human system, summarize the milestones in the history of mycology, the functions of fungal cell membranes and describe the mechanisms of nosocomial infections and the strategies used to combat ESKAPE pathogens.	LO3, LO4
CO3 Apply	Implement standardized procedures for the collection, transport and examination of clinical specimens apply antimicrobial susceptibility testing methods, (Kirby Bauer method and MIC). Use conventional and non-conventional diagnostic methods to identify specific mycoses like Candidiasis and Mucoromycosis.	LO4, LO6, LO13
CO4 Analyze	Analyze various pathogenic virulence factors, differentiate superficial, cutaneous, subcutaneous, systemic, and opportunistic mycoses and analyze the epidemiology and pathogenesis of zoonotic infections like *Bacillus anthracis* and *Listeria monocytogenes*.	LO3, LO4,
CO5 Evaluate	Assess the effectiveness of different classes of antifungals (E-test, agar/broth dilution), justify the advantages and limitations of automated identification systems (MALDI-TOF MS) and evaluate the role and functions of ethical committees in medical laboratory practice.	LO3, LO4, LO6, LO13
CO6 Create	Develop a diagnostic and treatment plan for clinical bacterial infections based on laboratory findings, plan a management strategy using appropriate biosafety levels for biomedical waste disposal.	LO4, LO6, LO7

Unit I: Introduction to Bacteriology

Medical Terminologies associated with Bacterial infections- Infectious dose, Epidemic, Pandemic, Sporadic, and Endemic. Collection, transport and microbiological examination of clinical specimens – Urine, Sputum, CSF, Blood, Pus and Stool.Antimicrobial susceptibility testing-Kirby Bauer method and Minimal Inhibitory concentration (MIC).Safety in Medical laboratory- Biosafety Levels and its importance.Management of Bio-medical Waste and Ethical Committee-Structure and functions.

Unit II: Normal flora and Diseases

Indigenous normal microbial flora of the human system and their importance. Virulence factors of pathogenic bacteria – Adherence, Invasion, Toxins and Enzymes. Morphology, pathogenesis, laboratory diagnosis and treatment of diseases caused by species of *Staphylococci, Streptococci, Pneumococci,Corynebacteria, Mycobacteria and Clostridium*. Nosocomial Infections- types, causes and prevention.

Unit III: Medical Bacteriology

Morphology, pathogenesis, laboratory diagnosis and treatment of diseases caused by species of Enterobacteriaceae members- *E.coli,Salmonella,Shigella, Pseudomonas, Vibrio,Helicobacter, Bordetella,* Spirochetes- *Leptospira* and *Treponem*a. Zoonotic infections-*Bacillus anthracis, Listeria monocytogenes* and *Erysipelothrix*.Medically important disease- Scrub typhus.

Unit IV: Medical Mycology

Introduction-Historical Perspectives and Miles stones in Mycology, Fungal Taxonomy-Binomial nomenclature, Fungi: Cell wall - membranes and their functions. Classification of Antifungals, Antifungal Susceptibility testing- E test, Agar dilution & Broth dilution.Diagnosis of Fungal infections- Conventional and Non-conventional methods**.** Automated Microbial identification system-MALDI-TOF MS -Advantages and limitations.

Unit V: Mycosis

Causative agent, Epidemiology, Pathogenesis, Laboratory diagnosis and treatment of Superficial mycosis - Tinea, Cutaneous mycosis - Dermatophytosis. Subcutaneous mycosis - Mycetoma, Systemic mycosis- Histoplasmosis.Opportunistic mycosis - Candidiasis, and Mucoromycosis, Oculomycosis-Fungal Keratitis and Endophthalmitis.

Textbooks

1. Barer M R. (2019) Medical Microbiology A Guide To Microbial Infections. Pathogenesis Immunity Laboratory Investigation and Control, Publisher: Elsevier.
2. Vasant Baradkar , Ajit Damle , Simit Kumar. (2025) Essentials in Medical Mycology for Postgraduates, Jaypee Brothers Medical Publishers Pvt Ltd.
3. MV Pravin Charles , Arunava Kali.(2025) Textbook of Clinical Microbiology (2nd Edition), Paras Medical Publisher.
4. Patrick R. Murray (2020) Medical Microbiology 9th Edition, Publisher : Elsevier.
5. Ananthanarayan and Paniker (2013) *Textbook of Microbiology,* 8th Edition. University Press.
6. Jegadish Chander (2018) *A Text Book of Medical Mycology*. 4th Edition, Jaypee Brothers Medical Publishers, Interprint, New Delhi.

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2. http:// www.bact.wise.edu/microtextbook.
3. http://dmoz.org/Science/Biology/Microbiology/.
4. http://microbiology.mtsinai.on.ca/manual/default.asp.

Internal Assessment Matrix for the defined COs

CO	Test 1	Test 2	Quiz	Assignment	Seminar	Percentage allocation	Mapping Strength
CO1	6	6	1			13	2
CO2	6	6	1			13	2
CO3	6	6	2	7		21	3
CO4	12		1	8	5	21	3
CO5		12				12	2
CO6				10	10	20	2
Marks	30	30	5	25 (Assignment, Group discussion, etc.,)	10 (Seminar)	100	

Course Articulation Matrix for defined COs

CO	Learning Outcomes														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	√														
CO2			√	√											
CO3				√		√							√		
CO4			√	√											
CO5			√	√		√							√		
CO6				√		√	√								
	1	-	**3**	**5**	**-**	**3**	**1**	**-**	**-**	**-**	**-**	-	**2**	-	-

Core Paper VI - Medical Virology and Parasitology

(Paper Code: 26UPMBC1C06)

Course Objective

The course is designed to provide comprehensive knowledge of medically important viruses and parasites, their classification, structure, life cycles, pathogenesis, epidemiology, laboratory diagnosis, prevention, and treatment. The course enables students to understand host–pathogen interactions, viral cultivation, emerging and re-emerging viral diseases, bacteriophages, protozoan and helminthic infections, and modern approaches for diagnosis, disease control, and public health management.

CO1 Recall	Recall the general properties, classification, morphology and cultivation of viruses, transmission mechanisms, host immune responses, medically important DNA and RNA viruses, bacteriophage biology, protozoan and helminth classification, life cycles, laboratory diagnostic methods and antiparasitic drugs.	LO1, LO4
CO2 Understand	Understand viral replication strategies, pathogenic mechanisms, epidemiology of viral diseases, mechanisms of antiviral agents, bacteriophage life cycles, host–parasite relationships, pathogenicity of protozoa and helminths, laboratory diagnosis and treatment of medically important viral and parasitic infections.	LO1, LO4
CO3 Apply	Apply laboratory techniques for viral cultivation, specimen collection, laboratory diagnosis of viral and parasitic diseases, identification of bacteriophages, microscopic identification of protozoa and helminths, interpretation of clinical findings, and selection of appropriate therapeutic and preventive measures.	LO1, LO4, LO5, LO8, LO9, LO11,
CO4 Analyze	Analyze viral epidemiology, compare DNA and RNA viruses, differentiate lytic and lysogenic bacteriophage cycles, evaluate emerging and re-emerging viral diseases, analyze parasite life cycles and transmission routes, interpret laboratory reports, and investigate disease outbreaks using microbiological evidence.	LO1, LO4, LO5, LO8, LO9, LO11
CO5 Design	Design diagnostic algorithms for viral and parasitic diseases, formulate infection prevention and control strategies, develop surveillance programmes for emerging viral infections, propose laboratory workflows for parasitological diagnosis, and recommend public health interventions for disease prevention and control.	LO1, LO4, LO5, LO8, LO9, LO11
CO6 Self-directed Lifelong learning.	Develop self-directed learning throughseminars, case discussions, disease surveillance reports and literature review. Critically evaluate antiviral therapies, vaccination strategies, parasite control programmes, diagnostic technologies and global public health responses while demonstrating scientific reasoning and lifelong learning skills.	LO2, LO3, LO8, LO9, LO10, LO11, LO15

Unit I

General properties of viruses - Structure and symmetry of viruses - viroids, prions, satellite RNAs and virusoids. Baltimore system of Classification - Cultivation of viruses - embryonated eggs, experimental animals and cell cultures. Different modes of Transmission and Virus Entry into host - Host Defenses Against Viral Infections.

Unit II

Epidemiology, pathogenic mechanisms, Pathogenesis, laboratory diagnosis, treatment for the following viruses: DNA Viruses- Pox, Herpesvirus, RNA Viruses- Picorna, Rhabdo virus. Emerging and re-emerging viral infections – Influenza, HIV, Dengue, Chikungunya, Ebola, Corona virus.Antiviral agents and their mechanism of action.

Unit III

Life cycle and phage production - Lytic and Lysogenic life cycle, Different stages of lytic cycle.Prophage. Structural organization, life cycle and Importance of M13 Bacteriophage, Structural organization and Importance of T4 Bacteriophage, P1 virus - adsorption, injection, protection of DNA, replication, terminal redundancy, headful packaging P1 transducing particle.Bacteriophage typing and applications.

Unit IV

Introduction to Medical Parasitology – Classification, host-parasite relationships. Epidemiology, life cycle, pathogenic mechanisms, laboratory diagnosis, treatment for the following: Protozoa causing human infections – *Entamoeba histolytica, Giardia, Plasmodiumvivax, and Leishmania donovani.*

Unit V

Classification, life cycle, pathogenicity, laboratory diagnosis and treatment for parasites – Helminthes - Cestodes –*Taenia Solium, Echinococcus*. Trematodes – Liver fluke: *Fasciola Hepatica,* Intestinal fluke:*Fasciolopsisbuski,* Lung fluke:*Paragonimus,* Blood fluke: *Schistosomes*. Nematodes - *Ascaris, Ansyklostoma*, *Trichinella, Strongyloides*and *Wuchereria*

Text Books

1. Kanunga R. (2017). Ananthanarayanan and Panicker's Text book of Microbiology. (10th Edition). Universities Press (India) Pvt. Ltd.
2. Dubey, R.C. and Maheshwari D.K. (2010). A Text Book of Microbiology. S. Chand & Co.
3. Rajan S. (2007). Medical Microbiology.MJP publisher.
4. Paniker J. (2006). Text Book of Parasitology.Jay Pee Brothers, NewDelhi.
5. Arora, D. R. and Arora B. B. (2020). Medical Parasitology.(5thEdition). CBS Publishers & Distributors Pvt. Ltd. New Delhi.

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1. Carter J. (2001). Virology: Principles and Applications (1st Edition). Wiley Publications.
2.. Willey J., Sandman K. and Wood D. Prescott's Microbiology. (11th Edition).McGraw Hill Book.
3. Jawetz E., Melnick J. L. and Adelberg E. A. (2000). Review of Medical Microbiology.(19th Edition).Lange Medical Publications, U.S.A.
4. Finegold S.M. (2000). Diagnostic Microbiology.(10th Edition). C.V. Mosby Company, St. Louis.

5. Levanthal R. and Cheadle R. S. (2012). Medical Parasitology.(6th Edition).S.A. Davies Co. Philadelphia.

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2. https://academic.oup.com/femsre/article/30/3/321/546048
3. https://www.sciencedirect.com/science/article/pii/S0042682215000859
4. https://nptel.ac.in/courses/102/103/102103039/
5. https://www.healthline.com/health/viral-diseases#contagiousness

Internal Assessment Matrix for the defined COs

CO	Test1	Test2	Quiz	Assignment	Seminar	Percentage allocation	Mapping Strength
CO1	6	6	1	-	-	13	2
CO2	6	6	1	-	-	13	2
CO3	6	6	2	7	-	21	3
CO4	12	-	1	8	5	21	3
CO5	-	12	-	-	-	12	2
CO6	-	-	-	10	5	20	2
Marks	30	30	5	25	10	100	

Strength = 3 (if percentage > 20%); Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage < 10%)

Course Articulation Matrix for defined COs

CO	Learning Outcomes														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	√			√											
CO2	√			√											
CO3	√			√	√			√	√		√				
CO4	√			√	√			√	√		√				
CO5	√			√	√			√	√		√				
CO6		√	√					√	√	√	√				√
	5	**1**	**1**	**5**	**3**	**-**	**-**	**4**	**4**	**1**	**4**	**-**	**-**	**-**	**1**

Core Practical III – Bacteriology and Mycology

(Paper Code: 26UPMBC1P03)

Course Objective

The course contents are designed to provide students to establish proficiency in clinical specimen management, specialized media preparation, develop technical skills for pathogen isolation from clinical sites,and equip the students with diagnostic techniques and standardized protocols of susceptibility testing.

Course Outcome

At the end of the course, learners will be able to

CO1 Remember	Identify the appropriate transport media for diverse clinical specimens, recall the specific formulations and purposes of specialized media used in diagnostics.	LO1
CO2 Understand	Explain the biological principles behind differential, selective media used to isolate specific pathogens, describe the mechanism of the germ tube method and sugar assimilation tests used for C*andida* species identification.	LO3, LO6
CO3 Apply	Demonstrate the collection, transport of clinical specimens following established medical protocols, assess the resistance patterns of clinical isolates by Kirby Bauer method, apply LPCB mounts and slide cultures to visualize fungi.	LO4, LO6, LO13
CO4 Analyze	Analyze the bacterial pathogens from complex clinical samples,differentiate between various *Candida* species by analyzing results from germ tube tests, sugar fermentation, and growth on chromogenic media.	LO5, LO6
CO5 Evaluate	Evaluate the MIC and MBC to study the effectiveness of antimicrobial agents against specific isolates, assess non-sporulating fungi by agar-based methods.	LO4, LO6
CO6 Create	Design a complete diagnostic workflow for an unknown clinical sample, integrating specimen processing, pathogen isolation, identification, and susceptibility testing to develo potential treatment options.	LO4, LO6, LO7

List of Experiments

1. Collection and transport of clinical specimens for microbiological examinations.
2. Cultivation of Microbes- Preparation of Basal, Differential and Selective media.
3. Isolation and identification of bacterial pathogens from clinical specimens
   (a) Throat swab (b) Pus (c) Urine (d) Sputum (e) Stool
4. Antimicrobial sensitivity testing by Kirby Bauer method.

5. Determination of Minimal Inhibitory Concentration (MIC).
6. Identification of fungi by Lactophenol cotton blue (LPCB) mount.
7. Identification of Non sporulating fungi- Slide culture method, Cornmeal/Tap water agar.
8. Identification of *Candida* species- Germ tube method.
9. Sugar assimilation/ fermentation test of Candida species.
10. Differentiation on Candida species on Hichrome agar.

Reference Books

1. Upasana Bhumbla. (2024) Competency Based Practical Manual for Microbiology, Jaypee brothers medical publishers pvt.ltd.
2. Lilly Bebora , Mahacla Odongo.(2020) Practical Bacteriology and Mycology Manual For Veterinary Students, Publisher : LAP Lambert Academic Publishing
3. Collee.(2025) Mackie and McCartney practical medical microbiology, Publisher Elsevier
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5. Singh S.(2022) Competency based practical manual of medical microbiology, CBS Publishers and Distributors Pvt. Ltd.

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2. http://www.yourarticlelibrary.com/experiments/experiment-to-cultivate-and identify-a-fungi-with-figure-micro-biology/26696/
3. http://www.dnatube.com/video/30156/Germ-Test-Tube--Identifying-Yeast
4. http://www.cdc.gov/dpdx/diagnosticprocedures/blood/specimenproc.html

Internal Assessment Matrix for the defined COs

CO	Test 1	Test 2	Quiz	Assignment	Seminar	Percentage allocation	Mapping Strength
CO1	6	6	1			13	2
CO2	6	6	1			13	2
CO3	6	6	2	7		21	3
CO4	12		1	8	5	21	3
CO5		12				12	2
CO6				10	10	20	2
Marks	30	30	5	25 (Assignment, Group discussion, etc.,)	10 (Seminar)	100	

Course Articulation Matrix for defined COs

CO	**Learning Outcomes**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	√														
CO2			√			√									
CO3				√		√							√		
CO4					√	√									
CO5				√		√									
CO6				√		√	√								
	1	-	1	**3**	**1**	**5**	**1**	**-**	**-**	**-**	**-**	-	1	-	-

Core Practical IV – Immunology, Virology and Parasitology

(Paper Code: 26UPMBC1P04)

Course Objectives

The students will develop practical skills in handling human blood samples and perform basic hematological and immunological techniques following biosafety and ethical practices. Acquire laboratory skills in virological techniques, including virus cultivation methods and identification of viral cytopathic effects. Identify medically important blood cells, parasites, and helminths using microscopic staining techniques and morphological characteristics and interpret laboratory results accurately. Apply quality control measures in clinical diagnostic procedures.

Course Outcomes

CO1	Collect, process, and handle human blood samples, prepare serum and plasma, perform blood grouping, and identify blood cells using appropriate staining techniques.	LO1, LO4, LO5, LO10, LO11
CO2	**:** Perform and interpret immunological and serological techniques such as Single Radial Immunodiffusion (SRID), Ouchterlony Double Immunodiffusion, Counterimmunoelectrophoresis, ELISA, Hemagglutination Inhibition Assay, and Western blotting for antigen and antibody detection	LO1, LO3, LO4, LO5, LO11
CO3	Conduct and interpret common clinical diagnostic tests including Rheumatoid Arthritis (RA), Anti-Streptolysin O (ASO), C-Reactive Protein (CRP), and Widal tests for the diagnosis of infectious and autoimmune diseases.	LO1, LO3, LO4, LO11
CO4	Demonstrate virological laboratory techniques including egg inoculation, recognize viral cytopathic effects (CPE), and understand their applications in virus isolation and identification.	LO1, LO3, LO4, LO5, LO7
CO5	Identify malarial parasites and medically important helminths through microscopic examination and morphological characteristics, while maintaining laboratory safety, quality assurance, and accurate documentation.	LO1, LO2, LO4, LO5, LO6,

List of Experiments

1. Collection of human peripheral blood.

2. Separation of serum and plasma from human blood,

3. Blood grouping Identification of various immune cells by morphology – Leishman staining, Giemsa staining

4. Single Radial Immuno Diffusion

5. Ouchterlony Double Immunodiffusion

6. Counter-immunoelectrophoresis

7. Rheumatoid Arthritis test

8. Anti Streptolysin O test

9. C-Reactive Protein test

10. WIDAL Test

11. Western Blotting – Demonstration

12. Hemaglutination Inhibition Assay (HAI).

13. Sandwich ELISA (Enzyme linked immunosorbent assay),

14. Egg inoculation technique

15. Viral Cytopathic effect (CPE) spotters

16. Blood smear examination for malarial parasite – Giemsa staining of thin blood smear

17. *Taenia solium-cephalex, Taenia saginata-cephalex, Schistosoma duodenale, Wucheririabankrofti*- adult worm -slide spotters

Text Books

1. Talwar, G.P. (1983) *A Hand Book of Practical Immunology*, Vikas Publishing House, India
2. Arthi, N. and Archana, A. (2008) Lab Manual in Biochemistry, Immunology and Biotechnology, McGraw-Hill Education
3. Celis, J.E. (1998) *Cell Biology: A Laboratory Handbook*, 2nd Edition, Immunocytochemistry, San Diego: Academic Press, pp 457-494
4. Weir, D.M. (1986) *Hand Book of Experimental Immunology* Vol I & II by Blackwell Scientific Company, Publication, Chicago.
5. Patrick Murray, R. and Ellen Jo Baron (2007) Manual of Clinical Microbiology, 9th Edition,Vol 1. ASM Press, Washington.
6. Patrick R. Murray, Ken S. Rosenthal, Micheal A. Pfaller (2005) *Medical Microbiology*, 5th Edition, Elsevier/Mosby, Philadelphia.
7. Brian WJ Mahy and Hillar O Kangro (1996) *Virology Methods Manual*, Academic Press
8. Chandrawathani P, Premalatha B, JAmnah Omar and Zaini Che Mamat (2019), *Manual on Parasitology*, Published by Department of Veterinary Science, Malaysia

Web References

1.http://cid.oxfordjournals.org/content/22/5/766.full.pdf

2. http://www.yourarticlelibrary.com/experiments/experiment-to-cultivate-and identify-a-fungi-with-figure-micro-biology/26696/

3.http://www.dnatube.com/video/30156/Germ-Test-Tube--Identifying-Yeast

4.http://www.cdc.gov/dpdx/diagnosticprocedures/blood/specimenproc.html

5.http://www.microbelibrary.org/library/laboratory-test/3107-egg-inoculation-for virus-cultivation

Internal Assessment Matrix for the defined COs

CO	**Practical Class Performance**	**Model Exam**	**Percentage allocation**	**Mapping Strength**
CO1-Recall & Understand	-	10 (spotters)	10	2
CO2-Critical thinking	10	-	10	2
CO3-Apply	08	15	23	3
CO4-Cooperation and team work	12	10	22	3
CO5-Research related skills	10	15	25	3
CO6-Leadership readiness and Communication	-	10 (record + viva)	10	2
Marks	40	60	100	-

Strength = 3 (if percentage > 20%); Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage < 10%)

Course Articulation Matrix for defined COs

CO	**Learning Outcomes**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	√			√	√					√	√				
CO2	√		√	√	√						√				
CO3	√		√	√							√				
CO4	√		√	√	√		√								
CO5	√	√		√	√	√									
	5	**1**	3	**5**	**4**	**1**	**1**	**-**	**-**	**1**	**3**	-	-	-	-

SEMESTER – III

Core Paper VII - Industrial Microbiology and Fermentation Technology

(Paper Code: 26UPMBC1C07)

Course Objectives

The students will understand the principles, history, scope, and industrial significance of fermentation technology. Explain the upstream and downstream processing steps. Understand the design, operation, control, and scale-up of fermenters used in industrial bioprocesses. Explore the industrial production and applications of microbial metabolites, recombinant products, fermented foods, and waste-based bioproducts.

Course Outcomes

CO1	Explain the fundamentals of fermentation technology, classify fermentation processes, and describe the isolation, screening, preservation, and improvement of industrial microorganisms.	LO1, LO3, LO4, LO5, LO6, LO8, LO10, LO11, LO15
CO2	Design and prepare suitable fermentation media, develop inoculum, and evaluate the use of agricultural, domestic, and industrial wastes as substrates for fermentation processes.	LO1, LO3, LO4, LO5, LO6, LO7, LO8, LO9, LO11, LO13
CO3	Describe the construction, operation, and control of fermenters, including sterilization, aeration, agitation, mass transfer, and scale-up/scale-down strategies for industrial fermentation.	LO1, LO2, LO3, LO4, LO5, LO6, LO8, LO10, LO11
CO4	Apply appropriate downstream processing techniques for the recovery, extraction, purification, concentration, and formulation of microbial products, including the management of fermentation wastewater.	LO1, LO3, LO4, LO5, LO6, LO7, LO8, LO10, LO11, LO13, LO15
CO5	Analyze the production processes and industrial applications of microbial products such as organic acids, amino acids, antibiotics, enzymes, vitamins, alcoholic beverages, fermented foods, recombinant proteins, and value-added products derived from natural wastes.	LO1, LO2, LO3, LO4, LO5, LO6, LO7, LO8, LO11, LO12, LO13, LO14, LO15

Unit I: Fermentation Process and Origin

Fermentation process - Definition, Scope and Chronological development. The range of fermentation process - Component parts of a fermentation process - Fermentation economics. Industrially important microorganisms - Isolation, screening, preservation and improvement of strains. Fermentation types - Submerged, solid state, batch and continuous fermentation.

Unit II: Upstream fermentation process

Media for industrial fermentation - Formulation and sterilization. Natural wastes used as Industrial fermentation Process. Classification and components in natural wastes.Biological wastes from domestic, agriculture and industries. Different kinds of wastes – Solid and Liquid wastes. Development of inoculum for various upstream processes - Shake flask, Pre-Seed fermentation and seed fermentation.

Unit III: Fermenter types and Design

Parts of a fermenter, body construction, Temperature control, gas liquid exchange, mass transfer - heat transfer, oxygen transfer, aeration and agitation. Scale up and scale down fermentation process. Control of temperature, pH, form pressure - Sterilization of bioreactors and nutrients.Computer application in fermentation technology.

Unit IV: Downstream Processing

Recovery of microbial products - Intracellular and extra cellular - Methods of recovery – Separation of Biomass by centrifugation, filtration, chemical and Electro flocculation.Cell disintegration - physical, chemical and enzymatic methods. Extraction - solvent, two phase, liquid extraction, whole broth, aqueous multiphase extraction. Purification by different methods, Concentration by precipitation, ultrafiltration, reverse osmosis.Drying and crystallization.Fermentation waste water and its characteristics.

Unit V: Microbial Products

Different kinds of Microbial Products - Organic acids - Amino acids, Antibiotics - Penicillin, Enzymes, Vitamins, Alcoholic beverages - wine and beer, Fermented foods - bread, cheese and soy sauce. Recombinant Products - insulin, interferon and growth hormone, Fermentation products from natural wastes - molasses, starch wastes and cellulosic wastes. Microbial transformations - steroids, sterols and non-steroid compounds - Antibiotics.

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1. Peter F. Stanbury, Allan Whitaker and Stephen J. Hall (2016) Principles of Fermentation Technology, 3rd Edition, IChemE, ISBN: 978-0-08-099953-1.
2. Kumar, Sachin, Sani, and Rajesh K (eds) (2018) Biorefining of Biomass to Biofuels, Springer Publisher, ISBN: 978-3-319-67678-4.
3. MejdiJeguirim and Lionel Limousy (Eds.) (2018) Biomass Chars: Elaboration, Characterization and Applications, MDPI Books Publisher, ISBN: 978-3-03842-690-5.
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6. Cassida, J.E. (1968). Industrial Microbiology, Willy Eastern.
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2. https://bmcenergy.biomedcentral.com/articles/10.1186/s42500-019-0004-7
3. https://www.biologydiscussion.com/fermentation/fermentation-technology-meaning-methodology-types-and-procedure/17492
4. https://www.omicsonline.org/enzyme-production-by-fermentation-technology-scholarly-open-access-journals.php
5. https://www.scientific.net/AMR.810.127
6. https://www.biologydiscussion.com/industrial-microbiology-2/fermentor-bioreactor-history-design-and-its-construction/55756
7. https://thebiologynotes.com/design-of-a-fermenter/
8. https://www.bioxcellence.com/our-business/upstream-downstream-processing

Internal Assessment Matrix for the defined COs

CO	Test 1	Test 2	Quiz	Assignment	Seminar	Percentage allocation	Mapping Strength
CO1	6	6	1			13	2
CO2	6	6	1			13	2
CO3	6	6	2	7		21	3
CO4	12		1	8	5	21	3
CO5		12				12	2
CO6				10	10	20	2
Marks	30	30	5	25 (Assignment, Group discussions, Problem solving)	10 (Seminar)	100	

Strength = 3 (if percentage > 20%); Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage < 10%)

Course Articulation Matrix for defined COs

CO	Learning Outcomes														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	√		√	√	√	√		√		√	√				√
CO2	√		√	√	√	√	√	√	√		√		√		
CO3	√	√	√	√	√	√		√		√	√				
CO4	√		√	√	√	√	√	√		√	√		√		√
CO5	√	√	√	√	√	√	√	√			√	√	√	√	√
	5	**1**	**5**	**5**	**5**	**5**	**3**	**5**	**1**	**3**	**5**	**1**	**3**	**1**	**3**

Core Paper VIII – Food and Dairy Microbiology

(Paper Code: 26UPMBC1C08)

Course Objective

The content of this course is to establish a foundational knowledge, explain the principles of food preservation and public health implications of food-borne infections. This course familiarizes students with comprehensive understanding of regulatory frameworks and quality assurance standards for food and dairy safety.

Course Outcome

At the end of the course, learners will be able to

CO1 Remember	Identify the common microorganisms associated with the spoilage of vegetables, fruits, meat, and canned foods, recall the names, roles of major regulatory bodies and policies. Lists of common food additives and chemical adulterants used in the food industry.	LO1, LO3
CO2 Understand	Explain the principles of food preservation techniques,describe the role of microbial metabolites in dairy spoilage. Summarize the health benefits and processing steps involved in producing fermented dairy products.	LO3, LO4
CO3 Apply	Demonstrate the bacteriological aspects of milk processing. Apply microbiological grading systems to raw milk to determine its quality and safety. Use specific starter cultures for the production and ripening of different types of cheese.	LO3, LO4, LO6
CO4 Analyze	Differentiate between bacterial and non-bacterial food-borne infection. Contrast international quality assessment standards with national standards. Analyze the natural antimicrobial systems present in raw milk and their impact on microbial growth.	LO4, LO6,LO8
CO5 Evaluate	Assess the effectiveness of sanitation protocols in dairy processing plants and the safety of dairy waste disposal methods. Evaluate food quality and detect potential hazards in food products.	LO4, LO5, LO6
CO6 Create	Develop a comprehensive quality assurance plan for a food production facility. Design optimized fermentation and ripening schedules for the production of novel or traditional fermented milk products.	LO4 ,LO6, LO7

Unit I: Microorganisms of food

Scope of food Microbiology.Contamination and spoilage of food –vegetables, fruits, poultry, fish, eggs, meat, meat products and canned foods. Food Preservation - Temperature (low and high), drying, radiation and chemicals.

Unit II: Food microbiology and public health

Food hazards.Food borne infections -*Bacillus cereus, Vibrio parahaemolyticus, Escherichia coli, Salmonella, Shigella, Yersinia enterocolitica*, *Listeria monocytogenes* and *Campylobacter jejuni*. Nonbacterial food borne illness - Helminthes, nematodes, protozoa, toxigenic fungi and food borne virus.

Unit III: Quality assurance of food

International aspects of Quality and safety assessment of foods.Microbiological quality standards for food.Government regulatory practices and policies - FDA, HACCP, BIS (IS), FSSAI-2014.Food adulteration and common food additives.

Unit IV: Introduction to Dairy microbiology

Dairy microbiology: Microorganisms associated with milk – Hygiene practices. Microbial metabolites and their role in spoilages- souring, curdling, gassiness, ropiness, proteolysis, lipolysis, abnormal flavour and colour. Microbiological grading of raw milk.Milk borne diseases and their control. Bacteriological aspects of milk processing – Thermization, pasteurization, boiling, sterilization, UHT, bactofugation, and membrane filtration. Antimicrobial systems in raw milk.

Unit-V: Microbiology of milk products

Microflora of milk products- Fermented dairy products- Starter culture, Cheese- Types, curdling, processing and ripening, other fermented dairy products- Yogurt, cultured Buttermilk, cream, acidophilus milk, Kefir- types, processing, production and health benefits. Sanitation of dairy processing plants, Disposal of dairy waste. Microbiological standards for Milk and Milk products- PFA BIS, Codex/ ISO

Reference Books

1. Adams M. R. and Moss M. O. (1996). Food Microbiology, New Age International (P) Limited Publishers, New Delhi.
2. Frazier W.C., Westhoff. D. C. and Vanitha K.N. (2013). Food Microbiology. (6th Edition). McGraw Hill Education.
3. Jay J.M., Loessner M.J. and Golden D.A. (2006). Modern Food Microbiology. (7th Edition). Springer.
4. Doyle M. P., Buchanan R. L. (2012). Food Microbiology: Fundamentals and Frontiers. (4th Edition). American Society for Microbiology Press.
5. Ray B. and Bhunia A. (2013). Fundamentals of Food Microbiology. (5th Edition). CRC Press.
6. Robinson R. K. (2000). Dairy Microbiology3rdedn, Elsevier Applied Science, London.
7. Adams M.R, and Moss M.D, (2005). Food Microbiology 4thedn, New Age International Pvt. Ltd., Publishers. First edition.
8. Banwarst. G.J. (2003). Basic Food Microbiology 2ndedn, CBS Publishers and distributors.
9. Hobbs, B.C. and Roberts, D, (1968), Food Poisoning and Food Hygiene 7thedn. Edward Arnold: London.

10. Vijaya R K, (2004). Food Microbiology 1stedn. MJP Publishers, Chennai.

Web Resources

1. https://www.fssai.gov.in
2. https://www.who.int/news-room/fact-sheets/detail/food-safety
3. https://www.fda.gov/food/hazard-analysis-critical-control-point-haccp/haccp-principles-application-guidelines

Internal Assessment Matrix for the defined COs

CO	Test 1	Test 2	Quiz	Assignment	Seminar	Percentage allocation	Mapping Strength
CO1	6	6	1			13	2
CO2	6	6	1			13	2
CO3	6	6	2	7		21	3
CO4	12		1	8	5	21	3
CO5		12				12	2
CO6				10	10	20	2
Marks	30	30	5	25 (Assignment, Group discussion, etc.,)	10 (Seminar)	100	

Course Articulation Matrix for defined COs

CO	Learning Outcomes														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	√		√												
CO2			√	√											
CO3			√	√		√									
CO4				√		√		√							
CO5				√	√	√									
CO6				√		√	√								
	1	-	3	**5**	**1**	**4**	**1**	**1**	**-**	**-**	**-**	-	-	-	-

Core Paper IX – Soil and Environmental Microbiology

(Paper Code: 26UPMBC1C09)

Course Objectives

The course aims to provide students with a comprehensive understanding of soil and environmental microbiology, emphasizing the role of microorganisms in soil fertility, plant health, and ecosystem sustainability. It introduces plant–microbe interactions, biofertilizers, biocontrol agents, environmental microbial processes, biogeochemical cycles, water quality assessment, waste management, biodegradation of pollutants, and environmental protection strategies for sustainable development.

Course Outcomes

CO1	Explain soil as a microbial habitat, microbial diversity, soil microbial processes, biological nitrogen fixation, and the role of microorganisms in maintaining soil fertility and plant health.	**LO1, LO4, LO5, LO8, LO11**
CO2	Describe microbial interactions, rhizosphere ecology, mycorrhizal associations, plant growth-promoting microorganisms, biofertilizers, biocontrol agents, and applications of GM crops.	**LO1, LO4, LO5,** LO7,**LO8, LO11, LO13**
CO3	Analyze the role of microorganisms in ecosystems, biogeochemical cycles, environmental diseases, water quality monitoring, and microbial research in extreme environments.	**LO1,** LO3,**LO4, LO5,** LO6,**LO8, LO11**
CO4	Apply microbial principles in waste management, industrial effluent treatment, bioconversion of wastes, composting, biogas production, and sustainable waste utilization.	**LO1, LO4, LO5, LO8,** LO10**, LO11, LO13**
CO5	Evaluate microbial degradation processes of pollutants, xenobiotics, hydrocarbons, synthetic compounds, and understand environmental laws and pollution control strategies.	**LO1,** LO3,**LO4, LO5, LO8,** LO11**, LO13, LO15**

Unit I:

Soil Microbiology – Soil as Microbial Habitat, Soil profile and properties, Soil formation, Diversity, and distribution of major group of microorganisms in soil. Quantification of soil microflora, role of microorganism in soil fertility.Mineralization of Organic & Inorganic Matter in Soil.Biological Nitrogen fixation. Phytopathology and Disease cycle of Plant pathogens - Tikka and Citrus canker, Types of plant diseases symptoms – Bacteria, Fungi, Viruses, Protozoa and Nematodes.

Unit II:

Microbial Interactions - Mutualism, Commensalism, Amensalism, Synergism, Competition, Rhizosphere- Rhizosphere effect, Mycorrhizae - Types, Mycorrhiza Helper Bacteria (MHBs). PGPR- Plant growth promoting bacteria– symbiotic (*Bradyrhizobium, Rhizobium*), Actinorhiza – *Frankia* sp. Cyanobacteria – Association with plants and fungi. Non-Symbiotic (*Azospirillum, Azotobacter*,Phosphate solubilizers), Biofertilizers and Biocontrol agents – Types, benefits and application. Genetically modified (GM) crops - Bt crops, golden rice.

Unit II:

Components of Environment: Hydrosphere, lithosphere, atmosphere, and biosphere – definitions with examples; Energy flow in the ecosystem- Carbon, Nitrogen, Sulfur and Phosphorous cycles. Physical factors affecting distribution of microorganisms in various environments. Predisposing factors for Environmental diseases – infectious (water and air borne) and pollution related, spread and control of these diseases. Treatment and safety of drinking (potable) water, methods to detect potability of water samples.Space microbiology - Microbiological research in space environment.

Unit IV:

Waste management – Solid waste - Types - management - Factors affecting solid waste generation rates.Industrial effluent treatment, primary, secondary, tertiary, and advanced treatment process.Quality assessment of decontaminated matters and other biological effluents.Biological reference standards. Solid Wastes to Valuable Products – Saccharification, Silage product, Pyrolysis, SCP, Composts, Vermicomposts, Bio manure and Biogas production. E waste management.

Unit V:

Degradation of organic matters - cellulose, hemicellulose, starch, lignin, pectin, common pesticides - herbicides (2,4-D) and pesticides (DDT), heavy metals. Biodegradation of Xenobiotics - Recalcitrant Halocarbons, Recalcitrant TNTs, PCBs and Synthetic polymers. Biodegradation of Hydrocarbons.Biodeterioration of Textiles and Leather.Pollution Control Bodies and Environmental laws in India.Environmental impact assessment, EIA guidelines, US Environment protection Agency norms.

Text Books

1. Subba Rao. N.S. (2017). Soil Microbiology. (5thEdition). MedTech Publishers.
2. Daniel. C.J. (2006). Environmental Aspects of Microbiology. (2nd Edition). Bright Sun Publications.
3. Rangaswami. G. and Mahadevan. A. (2006). Diseases of Crop Plants in India. (4th Edition). Prentice–Hall of India Pvt. Ltd.
4. Sharma P.D. (2010). Microbiology and Plant pathology. (2nd Edition). Rastogi Publications.
5. Subba Rao. N.S. (2005). Soil microorganisms and Plant Growth. (4th Edition). Oxford and IBH Publishing Pvt. Ltd.

Reference Books

1. Pepper I.L., Gerba C.P. and Gentry T.J. (2014). Environmental Microbiology (1st Edition). Academic Press, Elsevier.
2. Bitton, G. (2011). Wastewater Microbiology. (4thEdition). Wiley-Blackwell.
3. Bridgewater L. (2012). Standard Methods for the Examination of Water and Wastewater. American Public Health Association.
4. Shrivastava A.K. (2003). Environment Auditing. A.P.H. Publishing Corporation.
5. Tinsley, S. and Pillai, I. (2012). Environmental Management Systems – Understanding Organizational Drivers and Barriers. Earthscan.

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2. http://www.fao.org/3/t0551e/t0551e05.htm
3. www.environmentshumail.blogspot.in/
4. https://www.frontiersin.org/articles/10.3389/fpls.2017.01617/full
5. https://serc.carleton.edu/microbelife/index.html

Internal Assessment Matrix for the defined COs

CO	Test 1	Test 2	Quiz	Assignment	Seminar	Percentage allocation	Mapping Strength
CO1	6	6	1			13	2
CO2	6	6	1			13	2
CO3	6	6	2	7		21	3
CO4	12		1	8	5	21	3
CO5		12				12	2
CO6				10	10	20	2
Marks	30	30	5	25 (Assignment, Group discussions, Problem solving)	10 (Seminar)	100	

Strength = 3 (if percentage > 20%); Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage < 10%)

Course Articulation Matrix for defined COs

CO	Learning Outcomes														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	√			√	√			√			√				
CO2	√			√	√		√	√			√		√		
CO3	√		√	√	√	√		√			√				
CO4	√			√	√			√		√	√		√		
CO5	√		√	√	√			√			√		√		√
	5	-	**2**	**5**	**5**	**1**	**1**	**5**	**-**	**1**	**5**	-	**3**	-	**1**

Core Practical V: Industrial and Food Microbiology

(Paper Code: 26UPMBC1P05)

Course Objectives

The students will gain practical training in the isolation, screening, and characterization of industrially important microorganisms. Develop laboratory skills in fermentation processes, enzyme and metabolite production. Hands-on experience in downstream processing, purification, and characterization of industrial products. Familiarize the students with analytical techniques used in industrial microbiology and environmental monitoring. Apply industrial microbiology techniques for microbial product development and quality assessment.

Course Outcomes

CO1	Isolate, screen, and characterize industrially important microorganisms for the production of antibiotics, pigments, enzymes, and biofertilizers.Identify the plant pathogens related to specific diseases such as Red rot of sugarcane, citrus canker and leaf spot of mulberry.	LO1, LO4, LO5, LO6, LO8, LO11, LO15
CO2	Perform laboratory-scale fermentation processes for the production of industrial products such as enzymes, alcohol, wine, citric acid, and biosurfactants using conventional and waste substrates.Perform the isolation and characterisation of yeast and moulds from spoiled nuts, fruits and vegetables.	LO1, LO3, LO4, LO5, LO8, LO11, LO15
CO3	Apply downstream processing techniques including enzyme purification, immobilization, chromatographic separation, and characterization of microbial products.	LO1, LO3, LO4, LO5, LO11, LO15
CO4	Analyze the quality and physicochemical characteristics of fermentation products and evaluate environmental samples using standard microbiological and biochemical methods.Analyse the bacterial population on various food categories including dairy (curd, ice cream) and protein sources (raw meat, fish) by comprehensive bacteriological examinations.	LO1, LO3, LO4, LO5, LO8, LO11, LO13
CO5	Demonstrate competency in industrial microbiology laboratory practices, experimental design, data interpretation, safety procedures, and scientific reporting. Evaluate the milk quality by performing qualitative test and quantify the bacterial population using standard plate count technique.	LO1, LO4, LO5, , LO8, LO11, LO13

List of Experiments

1. Isolation and screening of antibiotic producing microbes
2. Screening of pigment producing microorganisms from soil.
3. Screening of enzyme producing organisms (e.g. Amylase and Cellulase).
4. Production of industrially important enzymes by Submerged and solid-state fermentation.

5. Production and Characterization of biosurfactants from natural wastes
6. Lab scale Production of alcohol from sugarcane molasses.
7. Lab scale Production of alcohol from beetroot wastes.
8. Microbial production of citric acid by using *Aspergillus*.
9. Synthesis and separation of bioactive compounds - TLC or Column Chromatography.
10. Immobilization of cells and enzymes.
11. Physical, chemical and. Colour, pH, alkalinity, acidity, COD, BOD, TS, TDS and TSS.
12. Quantification of microorganisms from air and water – Open plate technique and MPN test.
13. Determination of quality of milk sample by methylene blue reductase test by resazurin method.
14. Detection of number of bacteria in milk by standard plate count.
15. Isolation of yeast and molds from spoiled nuts, fruits and vegetables.
16. Bacteriological examination of specific food (a) Curd (b) Raw meat (c) Fish (d) Ice cream.
17. Isolation of plant pathogens - Study of the following diseases: Red root of sugarcane, Citrus cancer and Leaf spot of mulberry.

Reference Books

1. Hemen Sarma (Ed) and Majeti Narasimha Vara Prasad (Ed) (2021) Biosurfactants for a Sustainable Future: Production and Applications in the Environment and Biomedicine, Wiley Press, ISBN: 978-1119671008.
2. Basanta Kumar Rai and Dil Kumar Subba (2016) *Basic Practical Manual on Industrial Microbiology*, Dharan Multiple Campus, Nepal.
3. Kulandaivel and Janarthanan, S. (2012) *Practical Manual on Fermentation Technology*, ISBN: 9789381141809.
4. Mathur, N. and Singh, A. (2007) *Industrial Microbiology: A Laboratory Manual*, Pointer publishers.
5. Arnold L. Demain, Julian E. Davies, Ronald M. Atlas, Gerald Cohen, Charles L. Hershberger, Wei-Shou Hu, David H. Sherman, Richard C. Willson and David Wu, J.H. (1999) *Manual of Industrial Microbiology and Biotechnology*, 2nd Edition.
6. Dharmalingam, K. (1986) *Experiments with M13*. Macmilan India Ltd. Chennai.
7. Lorian, V. (1991) *Antibiotics in Laboratory Medicine*. Williams and Wilkins.
8. Willett, J.E. (1991) *Gas Chromatography*, John Wiley and Sons.
9. Sadasivam, S. and Manickam, A. (1996) *Biochemical Methods*. New Age International (P) Limited, Publishers.

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1. https://www.researchgate.net/publication/344465390_PRACTICAL_MANUAL_CUM_WORKBOOK_on_INDUSTRIAL_MICROBIOLOGY
2. https://cevre.erciyes.edu.tr/upload/M6Z30UUmicrobiology-laboratory-manual.pdf
3. https://www.ikbooks.com/openPdf/9789381141809
4. https://app.knovel.com/web/toc.v/cid:kpMIMBE006/viewerType:toc/
5. http://www.cuteri.eu/microbiologia/manuale_microbiologia_pratica.pdf

Internal Assessment Matrix for the defined COs

CO	Practical Class Performance	Model Exam	Percentage allocation	Mapping Strength
CO1-Recall & Understand	-	10 (spotters)	10	2
CO2-Critical thinking	10	-	10	2
CO3-Apply	08	15	23	3
CO4-Cooperation and team work	12	10	22	3
CO5-Research related skills	10	15	25	3
CO6-Leadership readiness and Communication	-	10 (record + viva)	10	2
Marks	40	60	100	-

Strength = 3 (if percentage > 20%); Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage < 10%)

Course Articulation Matrix for defined COs

CO	Learning Outcomes														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	√			√	√	√		√			√				√
CO2	√		√	√	√			√			√				√
CO3	√		√	√	√						√				√
CO4	√			√	√			√			√		√		
CO5	√			√	√	√		√			√		√		
	5	-	2	**5**	**5**	**2**	**-**	**4**	**-**	**-**	**5**	-	**2**	-	3

Core Practical VI: Soil and Environmental Microbiology

(Paper Code: 26UPMBC1P06)

Course Objectives

The course aims to develop practical skills in the microbiological and physicochemical assessment of soil, water and air. Students will learn the isolation, enumeration, and identification of beneficial and pathogenic microorganisms from environmental and plant samples. It provides hands-on experience in biosurfactant production, biofertilizer preparation, soil enzyme analysis, and isolation of agriculturally important microbes. Overall, the course promotes the application of soil and environmental microbiology for sustainable agriculture and environmental management.

Course Outcomes

CO1	Perform microbiological and physicochemical analysis of water, wastewater, and air using standard techniques and interpret basic environmental quality parameters.	LO1, LO5, LO8
CO2	Demonstrate practical skills in the production and characterization of biosurfactants, preparation and evaluation of biofertilizers, and estimation of soil enzymes such as urease and phosphatase.	LO1, LO4, LO5, LO8
CO3	Isolate, enumerate, and identify beneficial soil microorganisms, including nitrogen-fixing bacteria, *Rhizobium*, phosphate-solubilizing bacteria, cellulose- and starch-degrading bacteria, and VAM fungi.	LO1, LO3, LO5, LO6, LO8
CO4	Isolate and identify phylloplane microorganisms and plant pathogens, diagnose common plant diseases, and apply Koch's postulates to establish pathogenicity.	LO1, LO3, LO4, LO5, LO8
CO5	Apply microbiological techniques for Azolla cultivation, environmental and agricultural applications, plant disease documentation, and herbarium preparation, demonstrating laboratory safety and good microbiological practices.	LO1, LO3, LO6, LO8, LO13

Lists of Experiments

1. Microbiological analysis of water - Total Heterotrophic Count

2. Test for indicative organisms in water and waste water: 1) MPN 2) Membrane Filtration

3. Physical, chemical assessment of water: Color, pH, alkalinity, acidity, DO, BOD, COD, TS, TSS and TDS

4. Enumeration of bacteria and fungi from air: Open Plate Technique, Air sampler

5. Biosurfactant: Synthesis, Characterization and Environmental applications

6. Preparation of Biofertilizers and testing the efficiency of prepared biofertilizers

7. Estimation of soil enzymes- urease and phosphatase

8. Study of phylloplane microflora by leaf impression method

9. Isolation of cellulose and Starch degrading bacteria

10. Isolation of free-living nitrogen fixers from soil and *Rhizobium* from root nodules of leguminous plants.

11. Isolation and enumeration of phosphate-solubilizing bacteria from soil

12. Isolation of VAM fungi from soil

13. Isolation of plant pathogen - *Alternaria* &*Curvularia*spps species

14. Cultivation of *Azolla*

15. Visual examination, observation, and identification of some common plant infections.

16. To test Koch postulates using plant pathogens.

17. Collection of 5 herbarium specimens of infected leaves.

References

1. Russell P. J. (2019). Genetics – A Molecular Approach (3rd Edition). Pearson Education, Inc.
2. Glick B. R. and Patten C. L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA (5th Edition). ASM Press.
3. James G Cappucino. and Natalie Sherman. (2016). Microbiology – A laboratory manual. (5th Edition). The Benjamin publishing company. New York.
4. Hurst, C.J., Crawford R.L., Garland J.L., Lipson D.A., Mills A.L. and Stetzenbach L.D. (2007). Manual of Environmental Microbiology. (3rd Edition). American Society for Microbiology.
5. Sambrook J. and Russell D.W. (2001). Molecular Cloning: A Laboratory Manual. (7th Edition). Cold Spring Harbor, N.Y: Cold Spring Harbor Laboratory Press.
6. Brown T.A. (2016). Gene Cloning and DNA Analysis. (7th Edition). John Wiley and Jones, Ltd.
7. Dale J. W., Schantz M. V. and Plant N. (2012). From Gene to Genomes – Concepts and Applications of DNA Technology. (3rd Edition). John Wileys and Sons Ltd.
8. Pepper I., Gerba C. and Brendecke J. (2004). Environmental Microbiology - A Laboratory Manual. (2nd Edition). Academic Press, Elsevier
9. Yates M.V., Nakatsu C.H., Miller R.V. and Pillai, S.D. (2016). Manual of Environmental Microbiology. (4th Edition). Wiley.

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1. https://www.molbiotools.com/usefullinks.html
2. https://geneticgenie.org3.
3. https://currentprotocols.onlinelibrary.wiley.com/doi/pdf/10.1002/cpet.5
4. https://vlab.amrita.edu/index.php?sub=3&brch=272
5. https://nptel.ac.in/courses/102105087

Internal Assessment Matrix for the defined COs

CO	**Practical Class Performance**	**Model Exam**	**Percentage allocation**	**Mapping Strength**
CO1-Recall & Understand	-	10 (spotters)	10	2
CO2-Critical thinking	10	-	10	2
CO3-Apply	08	15	23	3
CO4-Cooperation and team work	12	10	22	3
CO5-Research related skills	10	15	25	3
CO6-Leadership readiness and Communication	-	10 (record + viva)	10	2
Marks	40	60	100	-

Strength = 3 (if percentage > 20%); Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage < 10%)

Course Articulation Matrix for defined COs

CO	**Learning Outcomes**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	√				√			√							
CO2	√			√	√			√							
CO3	√		√		√	√		√							
CO4	√		√	√	√			√							
CO5	√		√			√		√					√		
CO6															
	5	-	3	**2**	**4**	**2**	**-**	**5**	**-**	**-**	**-**	**-**	-	**-**	**-**

INTERNSHIP

(Paper Code: 26UPMBC1I01)

Course Objective:

Internship program help improve multicultural competency of students by providing real world exposure to diverse work styles, cross cultural communication and inclusive team works. Students develop critical sensibility to lived experiences, with self awareness with reflexivity of both self and society. They become aware of different values and beliefs prevailing in multicultural society and learn to be competent enough in such a societal environment.

Course Outcomes:

CO1-Reflective thinking and Problem solving skills	During internships students get chances to mingle with institutional employees, employers, other students and stakeholders by which they gain reflective thinking skills and Problem-solving skills	LO9, LO4
CO2-Multicultural competence	Students will possess knowledge of values and beliefs of multiple cultures with a global perspective and can effectively engage in multicultural society and interact respectfully with diverse groups	LO12
CO3-Communication skills	Daily workplace interactions help students practice active listening and clear communication across language and cultural barriers.	LO2
CO4-Analytical skills	Observing the work process and writing down the details in a clear way requires Analytical skills	LO5

Internal Assessment Matrix for the defined COs

CO	**Internal Performance**	**External Performance**	**Percentage allocation**	**Mapping Strength**
CO1-Reflective thinking and Problem solving skills	10	15	25	3
CO2-Multicultural competence	10	15	25	3
CO3-Communication skills	10	15	25	3
CO4-Analytical skills	10	15	25	3
Marks	40	60	100	-

Strength = 3 (if percentage > 20%); Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage < 10%)

Course Articulation Matrix for defined COs

CO	**Learning Outcomes**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1				√					√						
CO2												√			
CO3		√													
CO4					√										
	-	1	-	**1**	**1**	**-**	**-**	**-**	**1**	**-**	**-**	1	-	-	-

SEMESTER – IV

Core X– Research Methodology and Biostatistics

(Paper Code: 26UPMBC1C10)

Course Objectives

The course develops a set of transferable skills, including data handling, practical problem-solving, and the application of the scientific method. Learners develop relevant attitudes, such as concern for accuracy and precision, objectivity, integrity, inquiry, initiative, and inventiveness. They acquire the essential scientific skills required for progression to further studies or employment

Course Objectives

At the end of the course the students will have the ability to

CO1	Explain the qualities of a good researcher highlighting moral and ethical awareness in every phase of research. List the essential lab instruments, statistical tools and apply them for science research. Differentiate the distribution types. Perform the tests of significance and Interpret the results in statistical terms.	LO1, LO3, LO4, LO6, LO13
CO2	Explain the working principles of various analytical instruments. Develop SOPs for efficient lab functioning process. Formulate Hypothesis, test them experimentally and evaluate data statistically for scientific reasoning	LO1, LO4, LO5, LO6
CO3	Develop critical thinking and practical problem-solving skills through literature survey to solve theoretical and applied problems using scientific reasoning. Result analysis - ANOVAs, regression etc. **Identify Random vs. Systematic Error**	LO1, LO3, LO4, LO5, LO6, LO8, LO9
CO4	Demonstrate computational ability in solving a wide array of statistical problems. Communicate research outcomes and interpretations effectively through charts, bar graphs, pie diagrams etc.	LO1, LO2, LO4, LO5, LO6 LO8, LO9
CO5	Identify applications of statistics in other disciplines and in society.	LO1, LO4, LO5, LO6, LO8, LO9, LO12
CO6	Encountering different statistical tools for scientific data analysis sparks curiosity for lifelong learning and a drive to independently research complex global issues with inquiry driven mindset	LO3,LO6, LO8, LO11, LO15

Unit I

Introduction to Research Methodology - Meaning and importance.Statement, Constraints.Review of literature - Review and synopsis presentation. Types of research, Research tools, Methods and techniques of data collection - types of data, methods of primary data collection (observation/ experimentation/ questionnaire/ interviewing/ case/pilot study, methods), methods of secondary data collection.

Unit II

Research process. Research designs. Report writing types, guidelines for writing an article and report, Ethical issues related to publishing, Plagiarism and Self-Plagiarism. Salami-slicing. Bio instrumentation techniques**:** Chromatography, Spectrophotometer, Centrifugation, Atomic absorption spectroscopy, HPLC, GC-MS, LC-MS, Flow cytometry, Computer assisted statistical techniques – SPSS, RSM, R-Programme.

Unit III

Introduction to Biostatistics - Basic concepts, Population, Sample, Inferential and Descriptive statistics.Scales of Measurement - Nominal, Ordinal, Interval and Ratio. Sampling and Sampling frame, Sampling methods - simple random, systematic, sequential, stratified and cluster. Probability and Non probability sampling, Methods of Data presentation.Probability distributions.Difference between parametric and non-parametric statistics.

Unit IV

Measures of central tendency: Mean, Median, Mode. Variables – Independent, Dependent and Extraneous variables, discontinuous, continuous and derived variables. Measures of Dispersion - Range, Absolute mean deviation, Variance, Standard deviation, Z score calculation and its advantages, Standard error, Coefficient of variation. Point estimate and Interval estimate. Confidence Interval; Errors; Levels of significance; Hypothesis Testing - Type I and Type II errors. Chi-square test, Student's t- test – One sample t-test, Two sample t-test.

Unit V

Analysis of variance (ANOVA) - one way and two-way classification. Tests of significance – Duncan's Multiple Range Test (DMRT), Tukey's honest Significant difference (TSD). Correlation and regression - Positive, negative, calculation of Karl-Pearson's co-efficient of correlation. Linear regression and Line of best fit, Calculation of an unknown variable using regression. Basic introduction to Multivariate statistics.

Text Books

1. Bajpai P.K. (2010). Biological Instrumentation And Methodology, S. Chand and Company, New Delhi
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Internal Assessment Matrix for the defined COs

CO	Test 1	Test 2	Quiz	Assignment	Seminar	Percentage allocation	Mapping Strength
CO1	6	6	1			13	2
CO2	6	6	1			13	2
CO3	6	6	2	7		21	3
CO4	12		1	8	5	21	3
CO5		12				12	2
CO6				10	10	20	2
Marks	30	30	5	25 (Assignment, Group discussions, Problem solving)	10 (Seminar)	100	

Strength = 3 (if percentage > 20%); Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage < 10%)

Course Articulation Matrix for defined COs

CO	Learning Outcomes														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	√		√	√		√							√		
CO2	√			√	√	√									
CO3	√		√	√	√	√		√	√						
CO4	√	√		√	√	√		√	√						
CO5	√			√	√	√		√	√			√			
CO6			√			√		√			√				√
	5	1	**1**	**5**	**4**	**6**	**-**	**4**	**3**	**-**	**1**	**1**	1	**-**	**1**

PROJECT

(Paper Code: 26UPMBC1PR01)

Course objectives

During the PROJECT course, students get involved in self directed learning, acquire moral and ethical awareness with reasoning skills, and develop the ability to adopt Digital literacy and get self motivated for a life-long learning.

Course Outcomes

CO1 Self directed learning	Develop the ability to work independently, identify appropriate resources required for a project, and can manage a project through to completion	LO11
CO2 Moral ethical awareness and reasoning	Students embrace moral/ ethical values, formulate arguments from multiple perspectives using ethical practices. Students will appreciate the importance of adhering to intellectual property rights, have concern for environmental and sustainability issues.	LO13
CO3 Information and digital literacy	Ability to access, evaluate and use a variety of information resources, with the capability to use ICT in varied learning situations and use appropriate software tools for data analysis.	LO10
CO4 Research related skills	Students learn to identify and define problems, formulate hypothesis and test them. They develop the ability to plan, execute and report the results of an investigation. They can analyze, interpret and draw conclusions from data.	LO6
CO5 Life long learning	Ability to acquire research knowledge and skills. Learn, unlearn and relearn which are essential for life long learning and personal development for meeting, economic, social and cultural objectives	LO15

Internal Assessment Matrix for the defined Cos

CO	**Internal Performance**	**External Performance**	**Percentage allocation**	**Mapping Strength**
CO1-Self directed learning	10	12	22	3
CO2-Moral ethical awareness and reasoning	05	17	22	3
CO3-Information and digital literacy	10	12	22	3
CO4-Research related skills	10	12	22	3
CO5-Life-long learning	05	07	12	2
Marks	40	60	100	-

Strength = 3 (if percentage > 20%); Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage < 10%)

Course Articulation Matrix for defined Cos

CO	**Learning Outcomes**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1											√				
CO2													√		
CO3										√					
CO4						√									
CO5															√
	-	-	-	**-**	**-**	**1**	**-**	**-**	**-**	**1**	**1**	-	1	-	**1**

ELECTIVE COURSES

Elective Paper I: Biofertilizers and Biocontrol Agents

(Paper Code: 26UPMBC1E01)

Course Objective

The course aims to provide students with a comprehensive understanding of biofertilizers and biocontrol agents, emphasizing their role in sustainable agriculture and environmental conservation. It covers the principles, production, formulation, and application of microbial biofertilizers, organic manures, integrated nutrient management, biological pest control, integrated pest management, and the commercialization of biopesticides for enhancing crop productivity and soil health.

Upon successful completion of the course, students will be able to:

Course Outcome

CO1	Explain the classification, importance, and applications of biofertilizers, organic manures, and biological nutrient management in sustainable agriculture.	LO1, LO4, LO5, LO8, LO11, LO13, LO15
CO2	Demonstrate knowledge of cyanobacterial, bacterial, fungal, and actinobacterial biofertilizers, their production methods, and agricultural applications.	LO1, LO4, LO5, LO8, LO11, LO13, LO15
CO3	Apply the principles of biomanure technology, integrated nutrient management, and the use of biofertilizers and biostimulants for crop productivity.	LO1, LO2, LO3, LO4, LO5, LO6, LO8, LO10, LO11, LO15
CO4	Analyze the principles of biological pest control, integrated pest management (IPM), and the role of parasitoids, predators, and entomopathogens in sustainable agriculture.	LO1, LO3, LO4, LO5, LO6, LO7, LO8, LO11, LO13, LO15
CO5	Explain the production, formulation, quality control, field application, and advantages of biopesticides and biocontrol agents over chemical pesticides.	LO1, LO2, LO3, LO4, LO5, LO6, LO8, LO10, LO11, LO13, LO14, LO15

Unit I: Current status of fertilizer and biofertilizers

History, importance and present status of fertilizers and their application to crop plants. Biological nutrient management through applications of Organic manures, biocomposts, organic residues and biofertilizer soil amendments. Biological fixation of nitrogen. Cyanobacterial Biofertilizers and their Symbiotic association: *Nostoc*, *Anabaena* and *Scytonema*. Bacterial biofertilizers: Free living forms - *Azatobacter*, *Azospirillum*. Symbiotic forms: Rhizobium-Legume association. Ancient farming - Green manure, Crop rotation, Intercropping. Phosphate solubilization and mobilization.Mass production of bacterial biofertilizers.

Unit II:Fungal and actinobacterial Biofertilizers

Fungal biofertilizers: Mycorrhizal fungi as natural biofertilizers. Types - Ecto, endo and ect-endomycorrhiza. Structure and symbiotic nutrient exchange. Arbuscular mycorrizalassociation (AM) *Glomus* spp., Isolation and field enrichment of mycorrhiza.Agricultural applications. Actinomycetes as biofertilizers: History and biology of actinorhiza, Actinorhizal associations in higher plants, *Frankia* spp. - Isolation and culture methods.

Unit III:Biomanure Technology

A general account of manures. Major classes of organic manures - Animal manure, Composts, Vermi Compost, Farm yard manure, Plant manure, Moulds. Methods of its preparation. Oil seed cakes - Castor and neem, Green leaf manures, Agro-industrial wastes - Poultry manure and saw-dust. Application of biofertilizers and manures - A combination of biofertilizer and manure applications with reference to soil, seed and leaf sprays.

Unit IV:Introduction to biocontrol

Introduction to parasitoids, predators and pathogens.Important groups of parasitoids, predators and pathogens.Principles of classical biological control-importation, augmentation and conservation. Biology, adaptation, host seeking behaviour of predatory and parasitic groups of insects. Symptoms and their mode of action.Physical and biological pest control.Role of insects in biological pest control.

Unit V:Biocontrol agents

Definition and importance of biological pests and bio-pesticides in agriculture.Brief conception of Integrated Pest Management (IPM), Integrated Pest and Disease Management (IDPM). Biopesticides - Examples of biopesticides, *Bacillus thuringiensis* and its importance. Significance of biopesticides over chemical pesticides, Mass production of quality biocontrol agents - techniques, formulations, economics, field application and evaluation.

Reference Books

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Internal Assessment Matrix for the defined COs

CO	Test 1	Test 2	Quiz	Assignment	Seminar	Percentage allocation	Mapping Strength
CO1	6	6	1			13	2
CO2	6	6	1			13	2
CO3	6	6	2	7		21	3
CO4	12		1	8	5	21	3
CO5		12				12	2
CO6				10	10	20	2
Marks	30	30	5	25 (Assignment, Group discussions, Problem solving)	10 (Seminar)	100	

Strength = 3 (if percentage > 20%); Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage < 10%)

Course Articulation Matrix for defined COs

CO	Learning Outcomes														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	√			√	√			√			√		√		√
CO2	√			√	√			√			√				√
CO3	√	√	√	√	√	√		√		√	√				√
CO4	√		√	√	√	√	√	√			√		√		√
CO5	√	√	√	√	√	√		√		√	√		√	√	√

Elective Paper II: IPR, Biosafety and Bioethics (26UPMBC1E02)

Course Objectives

The students will understand the fundamental concepts of Intellectual Property Rights (IPR), their significance, and their application. Gain knowledge of national and international IPR laws, treaties, conventions, and patent filing procedures. Develop the ability to identify, protect, and commercialize intellectual property through patents, copyrights, trademarks. Understand the principles and regulations of biosafety and risk assessment associated with pathogens and genetically modified organisms. Appreciate the ethical, legal and social issues related to biomedical research.

Course Outcome

CO1	Explain the concepts, types, and significance of Intellectual Property Rights and their applications in Microbiology and Biotechnology.	LO1, LO4, LO5, LO8, LO10, LO11, LO13, LO15
CO2	Interpret national and international IPR laws, treaties, conventions, and patent regulations governing intellectual property protection	LO1, LO3, LO4, LO5, LO8, LO10, LO11, LO13, LO15
CO3	Apply the principles of patent search, patent filing, intellectual property registration, commercialization, and licensing in biotechnology-related innovations.	LO1, LO2, LO3, LO4, LO5, LO6, LO10, LO11, LO14, LO15
CO4	Demonstrate knowledge of biosafety principles, biosafety regulations, risk assessment, and regulatory frameworks governing GMOs and laboratory safety.	LO1, LO3, LO4, LO5, LO6, LO8, LO10, LO11, LO13, LO15
CO5	Analyze ethical, legal, and social issues related to biotechnology, including cloning, gene therapy, stem cell research, animal experimentation, and human subject research.	LO1, LO2, LO3, LO4, LO5, LO6, LO8, LO9, LO11, LO12, LO13, LO15

Unit I - Introduction to Intellectual Property

Introduction to IPRs, Basic concepts and need for Intellectual Property – Patents, Copyrights, Trademarks, Traditional Knowledge, Plant varieties, Trade Secrets, Geographical Indications, IPR in India and Abroad. IPR– Genesis and Development – the way from WTO to WIPO –TRIPS, Nature of Intellectual Property, Industrial Property, technological Research, Inventions and Innovations IPs of relevance to Microbiology / Biotechnology and few Case Studies.

Unit II - Agreements and Treaties

International Treaties and Conventions on IPRs History of GATT & TRIPS Agreement; Madrid Agreement; Hague Agreement; WIPO Treaties; Budapest Treaty; PCT; Patent Act of India, Patent Amendment Act, Paris Convention. Design Act, Trademark Act, Geographical Indication Act

Unit III - Basics of Patents and Concept of Prior Art

Introduction to Patents; Concept related to patents novelty, non-obviousness, utility, anticipation, etc. Types of patent applications: Practical aspects of registration of Copy

Rights, Trademarks, Patents, Geographical Indications, Trade Secrets and Industrial Design registration in India. International patent Databases; Country-wise patent searches (USPTO, esp@cenet (EPO), Patents scope (WIPO), IPO, EPO, etc.).National & Patent Cooperation treaty(PCT) filing procedure; Time frame and cost; Financial assistance for patenting - introduction to existing schemes Patent licensing and agreement Patent infringement-meaning, scope, litigation, case studies – Neem, Turmeric and Basmati rice, Commercialization and Licensing.

Unit IV – Biosafety

Introduction to Biosafety – General GLP, Biological Safety Cabinets – Biosafety level of specific microbes – Risk assessment - Primary Containment for Biohazards; Biosafety guidelines and regulations – International & National, Biosafety in relation to transgenic research, GMOs & LMOs – Concerns and Challenges, Role of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs – Risk analysis & assessment.

Unit V – Bioethics

Bioethics – Hstory and development, Definition, Ethical implications of cloning - Reproductive cloning & therapeutic cloning, ELSI of gene therapy, germ line, somatic, embryonic and adult stem cell research. Bioethics in animal research - Norms in India - Licensing of animal house - Bioethics – norms for conducting studies on human subjects. Human genome project and its ethical implications. Bioethics committees – IAEC, CPCSEA, etc.

Text Book

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6. http://www.cbd.int/biosafety/background.shtml
7. http://www.cdc.gov/OD/ohs/symp5/jyrtext.htm

Internal Assessment Matrix for the defined COs

CO	Test 1	Test 2	Quiz	Assignment	Seminar	Percentage allocation	Mapping Strength
CO1	6	6	1			13	2
CO2	6	6	1			13	2
CO3	6	6	2	7		21	3
CO4	12		1	8	5	21	3
CO5		12				12	2
CO6				10	10	20	2
Marks	30	30	5	25 (Assignment, Group discussions, Problem solving)	10 (Seminar)	100	

Strength = 3 (if percentage > 20%); Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage < 10%)

Course Articulation Matrix for defined COs

CO	Learning Outcomes														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	√			√	√			√		√	√				
CO2	√		√	√	√			√		√	√		√		√
CO3	√	√	√	√	√	√				√	√			√	√
CO4	√		√	√	√	√		√		√	√		√		√
CO5	√	√	√	√	√	√		√	√		√	√	√		√

Elective Paper III: Entrepreneurship in Microbiology(26UPMBC1E03)

Course Objective

After completing this course, students will be able to understand the fundamentals of entrepreneurship for successful development of microbiology-based industries and the bioeconomy. Gain knowledge of government schemes, financial institutions, grants, and support systems available for establishing microbiology-based enterprises. Develop entrepreneurial competencies including communication, business planning, market analysis, financial management and marketing strategies. Understand the principles involved in the development and commercialization of teaching and diagnostic kits.

Course Outcomes (CO)

CO1	Explain the concepts of entrepreneurship, entrepreneurial development, food preservation techniques, and the scope of global and Indian bio-businesses.	LO1, LO4, LO5, LO8, LO11, LO15
CO2	Identify suitable government schemes, financial institutions, and funding opportunities for establishing microbiology-based entrepreneurial ventures	LO1, LO2, LO4, LO5, LO10, LO11, LO15
CO3	Prepare a basic business plan by applying market research, SWOT analysis, financial planning, communication, and marketing strategies for a microbiology enterprise	LO1, LO2, LO3, LO4, LO5, LO6, LO7, LO10, LO11, LO14, LO15
CO4	Demonstrate knowledge of the production processes, applications, and commercial potential of microbial products, including compost, vermicompost, single-cell protein, mushroom cultivation, biofertilizers, and biopesticides	LO1, LO4, LO5, LO6, LO7, LO8, LO11, LO13, LO15
CO5	Explain the principles, preparation, and entrepreneurial opportunities associated with microbiology-based teaching kits and diagnostic kits for educational and healthcare applications	LO1, LO2, LO4, LO5, LO6, LO8, LO10, LO11, LO13

Unit I: Evolution of the concept of entrepreneur

Entrepreneurship: Definitions – concept of Entrepreneurship. Methods of food preservation: Traditional, physical and chemical methods. Global bio business.Entrepreneurship in India. Development – need – role of resource, talent and spirit – process of Entrepreneurship to socio – economic gains.

Unit II: Grants and scholarships for entrepreneurship

Institutions and schemes of government of India – Schemes and programmes, Department of science and technology schemes, Nationalized banks – other financial institutions etc – SIDBI – NSIC – NABARD – IDBI – IFCI – ICICI etc.

Unit III: Skills for entrepreneurs

Communication skills, problem solving skills; Business plan development; Market need – market research, SWOT analysis, identify your competition. Financial plan – obtain financing for your business, insure your business, Marketing – mix – product, distribution, price, promotion, and set marketing goals.

Unit IV: Microbial Products

Composting domestic waste, agricultural and industrial waste, Types of composting. vermicomposting. SCP production, mushroom cultivation.

Unit V: Microbial Products

Production of teaching kits (plasmid DNA isolation, serum electrophoresis) and diagnostic kits (WIDAL test kits, ABO blood grouping kits). Mass production of Biofertilizers and Biopesticides

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12. Subba Rao, N.S., 1995. Biofertilizer in agriculture and forestry. Oxford and IBH, New york.
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Internal Assessment Matrix for the defined COs

CO	Test 1	Test 2	Quiz	Assignment	Seminar	Percentage allocation	Mapping Strength
CO1	6	6	1			13	2
CO2	6	6	1			13	2
CO3	6	6	2	7		21	3
CO4	12		1	8	5	21	3
CO5		12				12	2
CO6				10	10	20	2
Marks	30	30	5	25 (Assignment, Group discussions, Problem solving)	10 (Seminar)	100	

Strength = 3 (if percentage > 20%); Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage < 10%)

Course Articulation Matrix for defined COs

CO	Learning Outcomes														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	√			√	√			√			√				√
CO2	√	√		√	√					√	√				√
CO3	√	√	√	√	√	√	√			√	√				
CO4	√			√	√	√	√	√			√		√		√
CO5	√	√		√	√	√		√		√	√		√		

Elective Paper IV: Health and Hygiene

(Paper Code: 26UPMBC1E04)

Course Objective

The course aims to provide students with a comprehensive understanding of health, hygiene, nutrition, and healthy lifestyle practices. It focuses on personal and environmental hygiene, physical fitness, mental well-being, disease prevention, food safety, public health programmes, immunization, reproductive and child health to promote individual and community health.

Course Outcomes

CO1	Explain the concepts of health, hygiene, healthy lifestyle practices, and the scientific principles influencing human health	LO1, LO4, LO5, LO8, LO11
CO2	Describe the importance of balanced nutrition, food safety, environmental hygiene, and health laws in promoting public health.	LO1, LO4, LO5, LO8, LO13, LO11
CO3	Apply principles of physical fitness, personal hygiene, yoga, stress management, and preventive healthcare to maintain a healthy lifestyle while identifying harmful habits and addictions	LO1, LO4, LO5, LO8, LO9, LO11, LO15
CO4	Analyze factors affecting mental health and explain the importance of mental hygiene and emotional well-being during different stages of human development and occupational settings	LO1, LO4, LO5, LO9, LO12, LO13, LO11
CO5	Evaluate the significance of national health programmes, communicable disease control, immunization, family planning, and reproductive and child health programmes in improving community health	LO1, LO4, LO5, LO2, LO8, LO13, LO11

Unit I:

Introduction to hygiene and healthful live. Factors affecting health, health habits and practices.Recognizing positive & negative practices in the community. Scientific principles related to health.

Unit II

Nutrition and Health – Balanced diet, Food surveillance, food Fortification, adulteration and preventive measures. Health laws for food safety. Environmental and housing hygiene.Ventilation and lighting.

Unit III

Physical health, physical exercises and their importance – Walking, jogging, yoga and meditation, stress relief.International control of health, WHO.Personal hygiene, Sun bathing, Colon Hygiene.Health destroying habits and addictions - Pan, supari, ganja, drinking, smoking, tea and coffee.

Unit-4

Mental hygiene- factors responsible, developmental tasks, basic needs, emotional stability. Mental hygiene and health in infancy, early childhood, adolescence, adulthood and old age.Mental health occupational hazards.

Unit-5

Health programme and health education – Malaria control, Tuberculosis control, AIDS control programmes and Immunization Programmes. Family planning, Reproductive and Child health programmes (RCH).

Text Books

1. Bamji M. S., KrishnaswamyK. and BrahmamG. N. V. (2019). Textbook of Human Nutrition. (4thEdition). Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi
2. Swaminathan (1995)Food& Nutrition (Vol I) (2ndEdition). The Bangalore Printing &Publishing Co Ltd., Bangalore.
3. Paniker J. C. K. and Ananthanarayan R. (2017). Textbook of Microbiology. (10th Edition). Universities Press (India) Pvt. Ltd
4. Lindsay Dingwall.(2010). **Personal Hygiene Care.** Print ISBN:9781405163071 |Online ISBN:9781444318708 |DOI:10.1002/9781444318708
5. Walter C. C. Pakes(1900). The Science of Hygiene: a Text-book of Laboratory Practice. (London: Methuen and Co.,).

References Books

1. Khader V. (2000) Food, Nutrition and Health, Kalyan Publishers, New Delhi.
2. Srilakshmi, B. (2010)Food Science, (5thEdition) New Age International Ltd., New Delhi.
3. Dubey R.C. and Maheshwari D. K. (2010). Practical Microbiology. S. Chand.
4. Park K. 2007, Park's text book of Preventive and Social Medicine, Banarsidas Bhanot publishers, India.
5. Srilakshmi, 2002, Dietetics, New Age Publications, India

Web Resources

1. Health and Hygiene - Personal Hygiene, Community Hygiene and Diseases (vedantu.com)
2. Chapter-32.pdf (nios.ac.in)
3. Menstrual Health and Hygiene Guide | Student Health and Counseling Services (ucdavis.edu)
4. https://nap.nationalacademies.org/read/11756/chapter/13
5. http://ecoursesonline.iasri.res.in/mod/page/view.php?id=112325

Internal Assessment Matrix for the defined COs

CO	Test 1	Test 2	Quiz	Assignment	Seminar	Percentage allocation	Mapping Strength
CO1	6	6	1			13	2
CO2	6	6	1			13	2
CO3	6	6	2	7		21	3
CO4	12		1	8	5	21	3
CO5		12				12	2
CO6				10	10	20	2
Marks	30	30	5	25 (Assignment, Group discussions, Problem solving)	10 (Seminar)	100	

Strength = 3 (if percentage > 20%); Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage < 10%)

Course Articulation Matrix for defined COs

CO	Learning Outcomes														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	√			√	√			√			√				
CO2	√			√	√			√			√		√		
CO3	√			√	√			√	√		√				√
CO4	√			√	√				√		√	√	√		
CO5	√	√		√	√			√			√		√		

Elective Paper V: Bioprocess of Mushroom and Single Cell Protein

(Paper Code: 26UPMBC1E05)

Course Objectives

The course aims to provide students with a comprehensive understanding of mushroom biology, cultivation techniques, nutritional and medicinal significance, and biotechnological applications. It also introduces the principles, production methods, industrial applications, and future prospects of Single Cell Protein, enabling students to understand their role in sustainable food production, environmental management and biotechnological advancement.

Course Outcomes

CO1	Explain the classification, diversity, biology, biotechnology, and economic importance of mushrooms, and identify common mushroom spoilages and mushroom-borne diseases.	LO1, LO3, LO5, LO8
CO2	Describe the principles and techniques of mushroom cultivation, including spawn production, substrate preparation, crop management, harvesting, and evaluate commercial mushroom production systems and market trends.	LO1, LO4, LO5,LO8, LO15
CO3	Evaluate the nutritional, medicinal, nutraceutical, and environmental applications of mushrooms, with special emphasis on their role in human health and bioremediation.	LO1, LO3, LO5, LO8
CO4	Explain the principles of Single Cell Protein (SCP) production, compare different microbial sources, cultivation methods, production factors, and assess the challenges and status of SCP production in India.	LO1, LO3, LO4, LO5, LO8, LO9,LO10, LO11, LO15
CO5	Assess the nutritional benefits, industrial applications, limitations, strain improvement strategies, commercially available products, and future prospects of Single Cell Protein technology for sustainable food and feed production.	LO1, LO3, LO4, LO5, LO6, LO8, LO13, LO15

Unit I

Mushrooms and Applied Mushroom Biology. Definition of a Mushroom, Mushroom Hunting, Ecological Classification of Mushrooms, Magnitude of Mushroom Species. Mushroom Science- Food Supply through Mushroom Themselves, Mushroom Biotechnology. Mushroom spoilages and mushroom borne diseases.

Unit II

Principle of Mushroom Cultivation and Production. Mushroom Cultivation: Major Phases of Mushroom Cultivation, Selection of Acceptable Mushroom Species/Strains, secreting a Good Quality of Fruiting Culture, Development of Robust Spawn, Preparation of Selective Substrate/Compost, Care of Mycelial (Spawn) Running. Management of Fruiting/Mushroom Development, Harvesting Mushrooms Carefully.Differences in Mushroom Production Patterns, World Mushroom Market.

Unit III

Benefits of Mushroom. Enhancement of Human Health through Mushroom Derivatives: Nutritional Value of Mushrooms, Medicinal Properties of Mushrooms, Mushroom Nutraceuticals. Mushroom Bioremediation- Benefit the Environment through Mushroom Mycelia.

Unit IV

Single cell proteins - History, Sources - Alga, Yeast and Bacteria, Comparison of SCP microbes. Cultivation – Submerged fermentation and Semisolid fermentation. Production of SCP – Raw materials, Factors affecting SCP production. SCP production in India.Challenges in the cultivation of SCP.

Unit V

Benefits and Drawbacks of SCP - Nutritional Benefits of Single Cell Protein Technology, Other advantages and applications of SCP.Drawbacks of Single Cell Protein Technology. Strain improvement and Future of single cell proteins. Commercially available SCPs. Formulations optimized for SCPs.

Reference Books

1. Kaul, T. N. and B. L. Dhar. 2007. Biology and Cultivation of Edible Mushrooms. Westville Publishing House. New Delhi, 240pp
2. Chang, S. T. and P. G. Miles. 2004. Mushrooms: Cultivation, Nutritional Value, Medicinal Effect, and Environmental Impact (Second Edition). CRC Press.Boca Raton, 451pp.
3. Delcaire J. R. 1978. Economics of cultivated mushrooms. In The Biology and Cultivation of Edible Mushrooms, Chang, S. T. and H. A. Hayes, ed., Academic Press. Inc. New York. 726-793.
4. Dewhurst M. 2002. Phase III –the future? The Mushroom J. 626, 17-18.
5. Arora, D., Mukerji, K. & Marth, E. (1991)(vol. 3). Single cell protein in Hand book of applied mycology (pp. 499-539). India: Banaras Hind University
6. Weitzel, W. and Winchel, M. (1932) The Yeast, its Nutritive and Therapeutic Value. Verlag Rothgiese und Diesing, Berlin.
7. Bhalla, T.C., Sharma, N.N. and Sharma M. (2007). Production of Metabolites, Industrial Enzymes, Amino Acids, Organic Acids, Antibiotics, Vitamins and Single Cell Proteins. National Science Digital Library, India.

Internal Assessment Matrix for the defined COs

CO	Test 1	Test 2	Quiz	Assignment	Seminar	Percentage allocation	Mapping Strength
CO1	6	6	1			13	2
CO2	6	6	1			13	2
CO3	6	6	2	7		21	3
CO4	12		1	8	5	21	3
CO5		12				12	2
CO6				10	10	20	2
Marks	30	30	5	25 (Assignment, Group discussions, Problem solving)	10 (Seminar)	100	

Strength = 3 (if percentage > 20%); Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage < 10%)

Course Articulation Matrix for defined COs

CO	Learning Outcomes														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	√		√		√			√							
CO2	√			√	√			√							√
CO3	√		√		√			√							
CO4	√		√	√	√			√	√	√	√				√
CO5	√		√	√	√	√		√					√		√

Elective Paper VI: Eye Microbiome and Infectious Diseases

(Paper Code: 26UPMBC1E06)

Course Objectives: This course provides a comprehensive study of ocular pathogens addressing the public health and clinical management. The contents of this course also covers human eye structure, function and ocular normal flora.

Course Outcome

Upon successful completion of this course, students will be able to:

CO1 Remember	Identify the anatomical structures of the eye and normal ocular flora. List common eye diseases such as trachoma, glaucoma, conjunctivitis, and corneal ulcers. Recall the specific types of media and staining reagents for diagnostics of ocular diseases.	LO1,LO3
CO2 Understand	Explain the vision physiology and eye injuries. Describe the National plan for the control of Blindness and the operational protocols of Eye banks and corneal transplantation. Summarize the ocular fungal and parasite taxonomy.	LO4, LO5
CO3 Apply	Implement correct protocols for the collection of ocular samples. Preliminary diagnosis of eye infections by applying C-streak and specific staining techniques.	LO3, LO4, LO6
CO4 Analyze	Differentiate between various ocular bacterial and fungal pathogens. Analyze the life cycles and pathogenic mechanisms of ocular parasites.	LO3, LO4, LO8
CO5 Evaluate	Evaluate the results of ocular cultures and molecular diagnostic methods to confirm infections. Assess the diagnostic significance of specific microscopic findings in eye samples.	LO3,LO4,LO6
CO6 Create	Develop a comprehensive diagnostic and management workflow for ocular infectious diseases by integrating clinical symptoms with laboratory inoculation and interpretation of results. Design health education modules or strategies focused on the prevention of common eye diseases.	LO3,LO4,LO8,

Unit I

Introduction to Ocular Microbiology- Structure of the Eye and its functions, Normal ocular flora, Process of vision, common eye diseases & its prevention-trachoma, glaucoma conjunctivitis, corneal ulcer.mechanical, chemical & radiational injuries. Health education-National plan for control of Blindness- Functioning of Eye bank- Corneal transplant

Unit II

Basic Laboratory techniques in Ocular microbiology- Microscopy- LPCB, Grams staining, Geimsa staining & Calcofluor staining.Diagnosis of fungal infections of the eye - culture and molecular methods. Collection of ocular samples- conjunctival swab, corneal scraping, vitreous fluid, and corneal button. Media used for culture of microorganism, Methods of Inoculation-C streak and interpretation of culture.

Unit III

Ocular Bacteriology- Introduction- Bacteria of medical importance, Gram positive cocci-*Staphylococci*, *Streptococci*, Pneumococci, Gram positive bacilli-*Corynebacterium.*Gram negative cocci- *Neisseria,* Gram negative bacilli- Enterobacteriaceae, *Mycobacteria,* Actinomycetes-*Nocardia.*

Unit IV

Ocular Mycology- Introduction- Description of fungi, yeast, dimorphic fungi, Taxonomic classification of fungi, fungi causing ocular infection- *Fusarium*, *Aspergillus,Mucor*, *Candida*, *Rhinosporidium* and Dermatiaceous fungi.

Unit V

Ocular Parasitology- Introduction-Importance of parasites in Eye infection, Classification of medically important parasites- Life cycle, Pathogenesis and diseases caused by *Acanthamoeba, Microsporidia, Toxoplasma and Onchocerca.*

Reference Books:

1. Mukherjee PK &Bandyopadya Preeti Ocular Microbiology.(2010) Jayapee Publishers.
2. Savitri Sharma Ocular Microbiology. (1988) Aravind Eye Hospital and Post Graduate Institute of Ophthalmology, 189 pages.
3. Atlas of Diagnostic Ocular Microbiology. Wilhelmiuss. (1993) Mosby International Publishers.
4. Imtiaz Chaudhry Common Eye Infections. (2013) Open Access Peer reviewed Edited Volume Pg-266.
5. Kenneth J. Ryan John C. Shennis Medical Microbiology- An Introduction to Infectious Diseases.(1995) Appleton & Lange; (3rd edition).
6. Practical Medical Microbiology and Cytology of Eye- Kathleen Byrle, Eileen Bund, Khalid Tabbara, Robert Hyndiuk, Butterworth Heinemann.
7. Stephen J.H. Parson's Diseases of the eye. (1990). Miller Churchill Livingstone, pg 442.

Internal Assessment Matrix for the defined COs

CO	Test 1	Test 2	Quiz	Assignment	Seminar	Percentage allocation	Mapping Strength
CO1	6	6	1			13	2
CO2	6	6	1			13	2
CO3	6	6	2	7		21	3
CO4	12		1	8	5	21	3
CO5		12				12	2
CO6				10	10	20	2
Marks	30	30	5	25 (Assignment, Group discussion, etc.)	10 (Seminar)	100	

Course Articulation Matrix for defined COs

CO	Learning Outcomes														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	√		√												
CO2				√	√										
CO3			√	√		√									
CO4			√	√				√							
CO5			√	√		√									
CO6			√	√				√							

Elective Paper VII: Computational Microbiology and Artificial Intelligence

(Paper Code: 26UPMBC1E07)

Course Objectives

The course is designed to equip students with computational skills required for modern microbiological research through open-source scientific computing, programming languages, machine learning, and artificial intelligence. The course enables students to utilize Linux-based computational environments, develop biological data analysis pipelines using Python, R, and Julia, apply machine learning algorithms for microbial data interpretation, explore Generative AI for microbial genomics and protein engineering, and design reproducible computational solutions for industrial and biomedical microbiology.

Course Outcome

At the end of the course the students will have the ability to

CO1 Recall	Recall the philosophy of Free and Open-Source Software (FOSS), Linux operating system architecture, file system hierarchy, command-line tools, Bash scripting fundamentals, Git version control, basic syntax of Python, R and Julia, principles of machine learning, Generative AI, AlphaFold, AI agents and open-source software licensing.	LO1, LO4
CO2 Understand	Able to explain Linux commands for biological data processing, summarize the functions of Python, R and Julia in microbiology, describe sequence alignment algorithms, explain supervised and unsupervised learning approaches, interpret the principles of Large Language Models (LLMs), explain AI-assisted protein prediction and summarize ethical issues in AI-driven microbiology.	LO1, LO4
CO3 Apply	Apply Bash scripting, Git repositories, BioPython, Bioconductor and BioJulia for microbial data analysis. Implement sequence alignment, phylogenetic analysis, PCA, t-SNE and UMAP for microbial datasets. Utilize AI tools for literature mining, microbial genome analysis and protein structure prediction.	LO1, LO4, LO5, LO8, LO9, LO11,
CO4 Analyze	Analyzemicrobial sequence datasets using computational workflows. Compare machine learning models for pathogen identification and antimicrobial resistance prediction. Evaluate dimensionality reduction techniques, interpret computational outputs, investigate AI-generated biological predictions and analyze reproducibility and ethical concerns associated with AI-based microbial research.	LO1, LO4, LO5, LO8, LO9, LO11

CO5 Design	Design reproducible computational workflows for microbiological research using Python, R or Julia. Develop open-source computational tools, construct AI-assisted microbial data analysis pipelines, formulate computational strategies for industrial fermentation optimization, microbiome analytics and antimicrobial discovery, and propose capstone research projects integrating artificial intelligence.	LO1, LO4, LO5, LO8, LO9, LO11
CO6 Life-long learning etc.	Develop self-directed learning through seminars, programming assignments, collaborative GitHub projects and independent computational research. Critically evaluate emerging AI technologies, scientific software and open-source resources while demonstrating ethical scientific reasoning, computational problem-solving and lifelong learning skills.	LO2, LO3, LO8, LO9, LO10, LO11, LO15

Unit I: The Open-Source Scientific Computing Ecosystem

Philosophy of Free and Open-Source Software (FOSS) and its impact on reproducible research in Microbiology. The Linux Environment: GNU/Linux architecture, File System Hierarchy Standard (FHS), and user permissions. The Command Line Interface (CLI): Advanced text processing and pattern matching using grep, sed, and awk. Automation: Fundamentals of Bash scripting for high-throughput microbial data workflows. Version Control: Collaborative research using Git; documentation standards with Markdown; hosting biological repositories on GitHub/GitLab.

Unit II: Multi-Paradigm Programming for Microbiologists

Python for Life Sciences: Core syntax, data structures, and functions; utilizing Bio-python for sequence manipulation and NCBI Entrez database integration. Statistical Computing in R: The Tidyverse ecosystem; Bioconductor for genomic analysis; high-dimensional visualization of microbial diversity and growth kinetics using ggplot2. High-Performance Computing with Julia: Introduction to Julia's syntax and speed advantages; utilizing the Bio-Julia ecosystem for processing large-scale metagenomic and phylogenomic datasets.

Unit III: Heuristic Analysis and Machine Learning in Microbiology

From Bioinformatics to Data Science: Sequence alignment algorithms (Global vs. Local); Phylogenetic inference and molecular evolution. The Machine Learning Transition: Converting biological sequences into numerical descriptors (K-mer frequencies, codon bias, physicochemical properties). Learning Paradigms: Supervised learning for pathogen classification and Antibiotic Resistance (AMR) prediction. Unsupervised learning for microbial community clustering using Principal Component Analysis (PCA), t-Distributed Stochastic Neighbor Embedding (t-SNE), and Uniform Manifold Approximation and Projection (UMAP).

Unit IV: Generative AI and Autonomous Agents in Research

Generative AI Architecture: Principles of Large Language Models (LLMs) and Transformers in biological inquiry. Structural AI: Implementation of AlphaFold and Rosetta Fold for microbial protein structure prediction and de novo enzyme design. Autonomous Agents:

Introduction to AI Agents for automated literature synthesis and autonomous data retrieval from the Sequence Read Archive (SRA). Ethical AI: Addressing bias, reproducibility, and the "Black Box" challenge in microbial genomics.

Unit V: Industrial Applications and Open-Source Development

Applied AI in Microbiology: Optimization of industrial fermentation processes; AI-driven discovery of novel antimicrobials and probiotics. Microbiome Analytics: AI applications in personalized nutrition and gut microbiome modeling. Open-Source Tool Synthesis: Software development life cycle (SDLC) for biological tools; licensing models (GPL, MIT, Apache); packaging scripts for community distribution. Capstone Project Concept: Identification of a microbial research problem to be solved using Python, R, or Julia.

Reference Books

1. Buffalo, V. (2015). *Bioinformatics Data Skills: Reproducible and Robust Research with Open Source Tools*. O'Reilly Media.
2. Jones, M. (2015). *Python for Biologists: A Complete Programming Course for Beginners*. CreateSpace Independent Publishing.
3. Wickham, H., & Grolemund, G. (2017). *R for Data Science: Import, Tidy, Transform, Visualize, and Model Data*. O'Reilly Media.
4. Ramsundar, B., et al. (2019). *Deep Learning for the Life Sciences: Applying Deep Learning to Genomics, Microscopy, and Other Data*. O'Reilly Media.
5. Shotts, W. (2019). *The Linux Command Line: A Complete Introduction*. No Starch Press.
6. Bezanson, J., et al. (2017). Julia: A fresh approach to numerical computing. *SIAM Review.*
7. Jumper, J., et al. (2021). Highly accurate protein structure prediction with AlphaFold. *Nature*.
8. Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep Learning. MIT Press
9. Antao, T. (2022). Bioinformatics with Python Cookbook. Packt Publishing.
10. Durbin, R., Eddy, S. R., Krogh, A., &Mitchison, G. (1998). Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids. Cambridge University Press
11. Haddock, S. H., & Dunn, C. W. (2011). Practical Computing for Biologists. Sinauer Associates.
12. Hastie, T., Tibshirani, R., & Friedman, J. (2009). The Elements of Statistical Learning: Data Mining, Inference, and Prediction. Springer Science & Business Media

Web References

1. https://www.researchgate.net/publication/290120192_Free_software_philosophy_and_open_source
2. https://www.researchgate.net/publication/367737960_High_Performance_Computing_in_Julia

3. https://pmc.ncbi.nlm.nih.gov/articles/PMC9491192/
4. https://alphafold.ebi.ac.uk/
5. https://pmc.ncbi.nlm.nih.gov/articles/PMC12624538/
6. https://www.geeksforgeeks.org/software-engineering/software-development-life-cycle-sdlc/
7. https://biopython.org/docs/latest/Tutorial/index.html

Internal Assessment Matrix for the defined COs

CO	Test1	Test2	Quiz	Assignment	Seminar	Percentage allocation	Mapping Strength
CO1	6	6	1	-	-	13	2
CO2	6	6	1	-	-	13	2
CO3	6	6	2	7	-	21	3
CO4	12	-	1	8	5	21	3
CO5	-	12	-	-	-	12	2
CO6	-	-	-	10	5	20	2
Marks	30	30	5	25	10	100	

Strength = 3 (if percentage > 20%); Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage < 10%)

Course Articulation Matrix for defined COs

CO	Learning Outcomes														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	√			√											
CO2	√			√											
CO3	√			√	√			√	√		√				
CO4	√			√	√			√	√		√				
CO5	√			√	√			√	√		√				
CO6		√	√					√	√	√	√				√

Elective Paper VIII: Microbial Bioprospecting in Blue Economy

(Paper Code: 26UPMBC1E08)

Course Objective

The primary objective of this course is to provide comprehensive knowledge of marine microbial diversity and their ecological significance in the blue economy. The course enables students to understand marine bioprospecting strategies, advanced omics technologies, artificial intelligence applications, and sustainable utilization of marine bioresources for industrial, pharmaceutical, environmental, and entrepreneurial applications while promoting innovation and conservation of marine ecosystems

Course Outcome

At the end of the course the students will have the ability to

CO1 Recall	Recall the characteristics of marine ecosystems, microbial diversity, physicochemical parameters governing marine habitats, ecological roles of marine microorganisms, principles of marine bioprospecting, marine bioactive compounds, omics technologies, blue economy concepts, AI applications and futuristic marine biotechnology innovations.	LO1, LO4
CO2 Understand	Understand the ecological functions of marine microorganisms, describe marine microbial resources for enzymes, antibiotics, pigments, biosurfactants and biopolymers, summarize metagenomics, metatranscriptomics, metaproteomics, metabolomics, explain AI-assisted marine bioprospecting, synthetic biology, microbiome engineering and commercialization of marine bioresources.	LO1, LO4
CO3 Apply	Apply microbiological and molecular techniques for isolation and characterization of marine microorganisms, utilize omics technologies, NGS, bioinformatics tools and high-throughput screening for marine bioprospecting, implement AI tools for marine data analysis, and demonstrate microbial applications in biotechnology and blue economy.	LO1, LO4, LO5, LO8, LO9, LO11,
CO4 Analyze	Analyze marine microbial diversity using culture-dependent and culture-independent approaches, compare marine bioactive metabolites, evaluate genome mining strategies, investigate AI-driven prediction models, interpret omics datasets, and analyze climate change impacts on marine microbial ecosystems.	LO1, LO4, LO5, LO8, LO9, LO11
CO5 Design	Design innovative microbial bioprospecting workflows using omics technologies, formulate sustainable strategies for marine bioresource utilization, develop startup models for blue biotechnology, propose translational research frameworks and industrial applications utilizing marine	LO1, LO4, LO5, LO8, LO9, LO11

	microorganisms and artificial intelligence.	
CO6 Self-directed Life long learning etc.	Develop independent learning through seminars, literature reviews, case studies, industrial project proposals and entrepreneurship plans in marine biotechnology. Critically evaluate sustainable blue economy policies, emerging marine technologies and ethical issues related to marine resource utilization.	LO2, LO3, LO8, LO9, LO10, LO11, LO15

Unit I: Fundamentals of Marine Microbiology

Introduction to marine ecosystems: pelagic, benthic, coastal, deep sea, hydrothermal vents. Microbial diversity in oceans: bacteria, archaea, fungi, microalgae, viruses. Physicochemical parameters influencing marine microbes (salinity, pressure, temperature, light).Sustainable utilization of marine resources. Ecological roles: nutrient cycling (C, N, S cycles), symbiosis, biofilms.

Unit II: Marine Bioprospecting:

Definition and scope of bioprospecting Marine microbes as sources of: Enzymes (amylases, proteases, lipases – extremozymes), Secondary metabolites (antibiotics, anticancer, antivirals). Pigments, biosurfactants, biopolymers (PHA, EPS). Case studies: Drug discovery from marine actinomycetes, Anti-fouling compounds, Marine probiotics

Unit III: Advanced Tools & Omics Approaches in Marine Bioprospecting

Culture-dependent methods Culture-independent approaches: Metagenomics, Meta transcriptomics, Meta proteomics, Metabolomics. Tools & Techniques: Next Generation Sequencing (NGS), Bioinformatics tools for gene mining, CRISPR and genome editing in marine microbes, High-throughput screening (HTS), Single-cell genomics. Data Analysis: Functional annotation of genes, Databases for marine bioresources.

Unit IV: Blue Economy Innovations

Emerging Areas: AI & Machine Learning in bioprospecting, Synthetic biology for marine metabolite production, Microbiome engineering in oceans, Deep-sea mining and microbial interventions, Climate change and marine microbial responses. Innovation & Entrepreneurship:

Unit V: Futuristic applications

Startup models in blue biotechnology, Marine bioresource commercialization, Circular bioeconomy. Cutting-edge Technologies: Lab-on-chip systems, Biosensors for marine monitoring, Digital twins for ocean ecosystems. Translational research models, Industry collaboration frameworks.

Text Book

1. Munn, C. B., Priest, T., Roberts, C., Seymour, J., Warwick-Dugdale, J., & Zettler, E. (2025). *Marine Microbiology: Ecology & Applications* (4th Ed.). CRC Press.
2. Vala, A. K., &Dudhagara, D. R. (Eds.). (2025). Marine Biotechnology: A Gateway to Blue Economy (1st Ed.). CRC Press.
3. Barh, D., Zambare, V. P., & Azevedo, V. (Eds.). (2013). *OMICS: Applications in Biomedical, Agricultural, and Environmental Sciences* (1st ed.). CRC Press.

4. Sanjeewa, K. K. A. (2024). *Exploring the Blue Bioeconomy: Marine Bioresources and Sustainable Applications* (1st Edition). CRC Press.
5. Urban Jr., E. R., &Ittekkot, V. (Eds.). (2022). *Blue Economy: An Ocean Science Perspective* (1st ed.). Springer Nature.

A. REFERENCE BOOK

1. Kirchman, D. L. (Ed.). (2018). *Processes in Microbial Ecology* (2nd Ed.). Oxford University Press.
2. Kim, S. K. (Ed.). (2015). *Handbook of Marine Biotechnology*. Springer-Verlag.
3. Stal, L. J., &Cretoiu, M. S. (Eds.). (2016). *The Marine Microbiome: An Untapped Source of Biodiversity and Biotechnological Potential*. Springer Nature.
4. Urban Jr., E. R., &Ittekkot, V. (Eds.). (2022). *Blue Economy: An Ocean Science Perspective*. Springer Nature.

Web References

1. https://www.ncbi.nlm.nih.gov/books/NBK559439/
2. https://www.frontiersin.org/journals/marine science/articles/10.3389/fmars.2025.1698327/full
3. https://www.sciencedirect.com/science/article/abs/pii/S0010482523008909
4. https://pmc.ncbi.nlm.nih.gov/articles/PMC6919566/
5. https://academic.oup.com/nsr/article/13/3/nwag012/8431396

Internal Assessment Matrix for the defined COs

CO	Test1	Test2	Quiz	Assignment	Seminar	Percentage allocation	Mapping Strength
CO1	6	6	1	-	-	13	2
CO2	6	6	1	-	-	13	2
CO3	6	6	2	7	-	21	3
CO4	12	-	1	8	5	21	3
CO5	-	12	-	-	-	12	2
CO6	-	-	-	10	5	20	2
Marks	30	30	5	25	10	100	

Strength = 3 (if percentage > 20%); Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage < 10%)

Course Articulation Matrix for defined COs

CO	Learning Outcomes														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	√			√											
CO2	√			√											
CO3	√			√	√			√	√		√				
CO4	√			√	√			√	√		√				
CO5	√			√	√			√	√		√				
CO6		√	√					√	√	√	√				√

Elective Paper IX: Quality Control in Industries

(Paper Code: 26UPMBC1E09)

Course Objectives

CO1 Explain various microbiological quality standards for food, water and air regulatory practices and policies.

CO2 Discuss collection, processing and preservation of water samples from industries in different areas.

CO3 Enumeration and isolation of microorganism from the water samples.

CO4 Enumeration and isolation of microorganism from the air samples.

CO5 Gain knowledge on sterility testing of different components in industries and quality control techniques.

Course Outcome

At the end of the course the students will have the ability to

CO1 Recall	Recall the principles of Quality Assurance (QA), Quality Control (QC), Total Quality Management (TQM), Continuous Quality Improvement (CQI), microbial quality standards, ATCC and MTCC cultures, pharmaceutical quality assurance, wastewater characteristics, water quality parameters, air microflora, sterility testing methods, PCR, qPCR, NGS, MALDI-TOF and regulatory guidelines.	LO1, LO4
CO2 Understand	Understand industrial quality assurance systems, microbiological quality standards for pharmaceutical products, wastewater treatment processes, microbiological examination of water and air, potable water testing methods, sterility assurance procedures, molecular detection techniques and regulatory compliance for industrial quality management.	LO1, LO4
CO3 Apply	Apply microbiological techniques for collection, preservation and analysis of water and air samples, perform microbial enumeration using MPN, membrane filtration and culture-based methods, utilize PCR, qPCR, MALDI-TOF and automated microbial detection systems, and implement quality control protocols in industrial laboratories.	LO1, LO4, LO5, LO8, LO9, LO11,
CO4 Analyze	Analyze industrial wastewater quality, evaluate contamination sources, compare microbiological testing methodologies, interpret microbial quality data, investigate contamination events, assess sterility testing outcomes and analyze pharmaceutical recall case studies using molecular quality control tools.	LO1, LO4, LO5, LO8, LO9, LO11
CO5	Design microbiological quality assurance programmes for pharmaceutical and industrial facilities, develop	LO1, LO4, LO5, LO8,

Design	contamination monitoring strategies, formulate SOPs for water and air quality assessment, propose sterility testing workflows, and design corrective and preventive actions (CAPA) for quality improvement and regulatory compliance.	LO9, LO11
CO6 Self-directed Life long learning etc.	Develop independent learning through seminars, industrial case studies, quality audits, laboratory assignments and regulatory document reviews. Critically evaluate industrial quality systems, emerging microbial detection technologies and international quality standards while demonstrating professional ethics and lifelong learning.	LO2, LO3, LO8, LO9, LO10, LO11, LO15

Unit I:

Concepts of quality control techniques - quality assurance, Total Quality Management (TQM) Continuous Quality Improvement (CQI) Quality Assurance (QA) pre analytical and post analytical techniques, ATCC, MTCC, microbial based assay. Quality assurance framework, assessment of pharmaceutical quality, determinants of pharmaceutical quality, practical approaches to quality assurance. Quality control of pharma products

Unit II:

Waste water microbiology – types and sources of contamination, prevention of water borne diseases. Water management, water harvesting, water recycling. Characteristics of waste water from industries - Sugar factory, Pulp & Paper mill, Distillery, Textile, Engineering, Food Industry, Domestic waste. Waste water treatment plant types and quality control. Water pollution causes and remedies.

Unit III:

Microflora of water.Microbiological analysis of water sample. Microbiological analysis of water sample collection, drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive/MPN tests, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests Control of microbes in water: Water borne pathogens, water borne diseases. Control of water borne pathogens- Precipitation, chemical disinfection, filtration, high temperature, UV light.

Unit IV:

Microflora of air - Bioaerosols, Air borne microorganisms (bacteria, Viruses, fungi) and their impact on human health and environment, significance in food and pharma industries and operation theatres. Collection of air samples and analysis.Bioaerosol sampling, air samplers, methods of analysis, CFU, culture media for bacteria and fungi, isolation and Identification. Control Measures of Bioaerosols - UV light, HEPA filters, desiccation, Incineration.

Unit V:

Molecular Techniques: PCR and qPCR in microbial detection, Next-generation sequencing (NGS) in contamination tracking, Automated microbial detection systems, MALDI-TOF mass spectrometry, Biochemical and genetic identification systems, Warning letters and common deficiencies, Case studies on contamination and recalls.

Text Book

1. Patil, A. S., Nallasivan, P. K., Gandhimathi, R., & Devireddy, A. K. R. (2024). *A Textbook of Pharmaceutical Quality Assurance*. AkiNik Publications.
2. Roesti, D., &Goverde, M. (Eds.). (2020). *Pharmaceutical Microbiological Quality Assurance and Control: Practical Guide for Non-Sterile Manufacturing*. John Wiley & Sons.
3. Hammer, M. J., & Hammer, M. J. Jr. (2014). *Water and Wastewater Technology* (7th Edition). Pearson.
4. Bitton, G. (2010). *Wastewater Microbiology* (4th Edition). Wiley-Blackwell.
5. Gautam, S., Azri, C., & Khan, M. B. (2026). *Bioaerosols and Indoor Air Quality: Insights, Impacts, and Innovations*. CRC Press.
6. Tille, P. (2022). *Bailey & Scott's Diagnostic Microbiology* (15th Edition). Elsevier.

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1) World Health Organization. (2007). Quality Assurance of Pharmaceuticals: A Compendium of Guidelines and Related Materials (Vol. 2). WHO Press.
2) Metcalf & Eddy, Inc. (2013). Wastewater Engineering: Treatment and Resource Recovery (5th ed.). McGraw-Hill Education.
3) American Public Health Association (APHA). (2022). Standard Methods for the Examination of Water and Wastewater (24th ed.). APHA, AWWA, WEF.
4) Whyte, W. (2010). Cleanroom Technology (2nd ed.). John Wiley & Sons.

   Yates, M. V., Nakatsu, C. H., Miller, R. V., & Pillai, S. D. (Eds.). (2016). Manual of Environmental Microbiology (4th ed.). ASM Press

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1) https://www.who.int/publications/i/item/9789240099425
2) https://www.fda.gov/regulatory-information/search-fda-guidance-documents/quality-systems-approach-pharmaceutical-current-good-manufacturing-practice-regulations
3) https://www.epa.gov/water-research/wastewater-research
4) https://www.epa.gov/dwreginfo/revised-total-coliform-rule-and-total-coliform-rule
5) https://stacks.cdc.gov/view/cdc/181711

https://www.iso.org/standard/53394.htmlhttps://www.fda.gov/media/137710/download

Internal Assessment Matrix for the defined COs

CO	Test1	Test2	Quiz	Assignment	Seminar	Percentage allocation	Mapping Strength
CO1	6	6	1	-	-	13	2
CO2	6	6	1	-	-	13	2
CO3	6	6	2	7	-	21	3
CO4	12	-	1	8	5	21	3
CO5	-	12	-	-	-	12	2
CO6	-	-	-	10	5	20	2
Marks	30	30	5	25	10	100	

Strength = 3 (if percentage > 20%); Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage < 10%)

Course Articulation Matrix for defined COs

CO	Learning Outcomes														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	√			√											
CO2	√			√											
CO3	√			√	√			√	√		√				
CO4	√			√	√			√	√		√				
CO5	√			√	√			√	√		√				
CO6		√	√					√	√	√	√				√

SUPPORTIVE COURSES

Supportive Paper I: Entrepreneurship in Microbiology

(Paper Code: 26UPMBC1S01)

Course Objective

After completing this course, students will be able to understand the fundamentals of entrepreneurship for successful development of microbiology-based industries and the bioeconomy. Gain knowledge of government schemes, financial institutions, grants, and support systems available for establishing microbiology-based enterprises. Develop entrepreneurial competencies including communication, business planning, market analysis, financial management and marketing strategies. Understand the principles involved in the development and commercialization of teaching and diagnostic kits.

Course Outcomes (CO)

CO1	Explain the concepts of entrepreneurship, entrepreneurial development, food preservation techniques, and the scope of global and Indian bio-businesses.	LO1, LO4, LO5, LO8, LO11, LO15
CO2	Identify suitable government schemes, financial institutions, and funding opportunities for establishing microbiology-based entrepreneurial ventures	LO1, LO2, LO4, LO5, LO10, LO11, LO15
CO3	Prepare a basic business plan by applying market research, SWOT analysis, financial planning, communication, and marketing strategies for a microbiology enterprise	LO1, LO2, LO3, LO4, LO5, LO6, LO7, LO10, LO11, LO14, LO15
CO4	Demonstrate knowledge of the production processes, applications, and commercial potential of microbial products, including compost, vermicompost, single-cell protein, mushroom cultivation, biofertilizers, and biopesticides	LO1, LO4, LO5, LO6, LO7, LO8, LO11, LO13, LO15
CO5	Explain the principles, preparation, and entrepreneurial opportunities associated with microbiology-based teaching kits and diagnostic kits for educational and healthcare applications	LO1, LO2, LO4, LO5, LO6, LO8, LO10, LO11, LO13

Unit I: Evolution of the concept of entrepreneur

Entrepreneurship: Definitions – concept of Entrepreneurship. Methods of food preservation: Traditional, physical and chemical methods. Global bio business.Entrepreneurship in India. Development – need – role of resource, talent and spirit – process of Entrepreneurship to socio – economic gains.

Unit II: Grants and scholarships for entrepreneurship

Institutions and schemes of government of India – Schemes and programmes, Department of science and technology schemes, Nationalized banks – other financial institutions etc – SIDBI – NSIC – NABARD – IDBI – IFCI – ICICI etc.

Unit III: Skills for entrepreneurs

Communication skills, problem solving skills; Business plan development; Market need – market research, SWOT analysis, identify your competition. Financial plan – obtain financing for your business, insure your business, Marketing – mix – product, distribution, price, promotion, and set marketing goals.

Unit IV: Microbial Products

Composting domestic waste, agricultural and industrial waste, Types of composting. vermicomposting. SCP production, mushroom cultivation.

Unit V: Microbial Products

Production of teaching kits (plasmid DNA isolation, serum electrophoresis) and diagnostic kits (WIDAL test kits, ABO blood grouping kits). Mass production of Biofertilizers and Biopesticides

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4. Thompson, L. M. and T. Fredrick, 1979. Soils and Soil Fertility. Tata Mc Graw-Hill Publishing Co., New Delhi.
5. Rao, N.S., 1980. Biofertilizers in Agriculture. Oxford and IBH Publishing Co. Pvt. Ltd., Bombay.
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7. Harley, J.L. and S.E. Smith, 1983. Mycorrhizal Symbiosis. Academic Press, London.
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11. Subba Rao, N.S., 1995. Soil Microorganisms and plant growth. Oxford and IBH, New york.
12. Subba Rao, N.S., 1995. Biofertilizer in agriculture and forestry. Oxford and IBH, New york.
13. Totawat, K.L., L.L. Somani, R.A. Sharma and S.R. Maloo, 2004. Biofertilizer Technology. Agrotech Publishing Academy, Udaipur, Rajasthan.

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2.https://www.bmh.manchester.ac.uk/study/biosciences/options/entrepreneurship/

3.https://library.oapen.org/handle/20.500.12657/43214

4.https://www.biology.columbia.edu/courses/entrepreneurship-biotechnology-2

5.http://wrap.warwick.ac.uk/137180/

Internal Assessment Matrix for the defined COs

CO	Test 1	Test 2	Quiz	Assignment	Seminar	Percentage allocation	Mapping Strength
CO1	6	6	1			13	2
CO2	6	6	1			13	2
CO3	6	6	2	7		21	3
CO4	12		1	8	5	21	3
CO5		12				12	2
CO6				10	10	20	2
Marks	30	30	5	25 (Assignment, Group discussions, Problem solving)	10 (Seminar)	100	

Strength = 3 (if percentage > 20%); Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage < 10%)

Course Articulation Matrix for defined COs

CO	Learning Outcomes														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	√			√	√			√			√				√
CO2	√	√		√	√					√	√				√
CO3	√	√	√	√	√	√	√			√	√				
CO4	√			√	√	√	√	√			√		√		√
CO5	√	√		√	√	√		√		√	√		√		

Supportive Paper II: Microbiology

(Paper Code: 26UPMBC1S02)

Course Objectives: The content of the course provides to establish a historical context by studying early discoveries, providing technical training in basic laboratory skills, explaining the importance, principle of microscopy and staining techniques. This course explores the microbial taxonomy, physiology with biotechnological applications of microbes.

Course Outcome

Upon successful completion of this course, students will be able to

CO1 Remember	Identify pioneers and their specific contributions to the discovery of microorganisms and antibiotics. List various types of culture media, sterilization and preservation methods for microbial cultures. Recall the rules of nomenclature and the hierarchical organization of microbes.	LO1, LO3
CO2 Understand	Explain biogenesis and abiogenesis. Describe the structural components and cellular morphology of bacteria, fungi, and algae. Summarize the stages of the microbial growth curve and the factors that influence the growth of microorganisms.	LO2, LO3
CO3 Apply	Demonstrate microbial isolation using various techniques. Use specialized staining methods to identify cellular structures. Apply proper protocols for the collection and transport of clinical specimens for diagnostic tests.	LO4, LO6
CO4 Analyze	Differentiate oxidative and substrate-level phosphorylation. Compare the pathogenicity and diagnostic processes for different infectious diseases. Analyze the role of microbes in the industrial production of organic solvents and beverages.	LO3,LO5,LO8
CO5 Evaluate	Evaluate the effectiveness of physical and chemical methods for sterilization and disinfection. Assess the suitability of specific diagnostic treatments based on the causative agents.	LO4, LO5, LO6
CO6 Create	Create a workflow for the production of genetically engineered microbial products, biofertilizers and biopesticides. Develop a systematic laboratory plan to identify a causative agent from an unknown clinical sample.	LO4,LO6,LO7

Unit I: **History and discovery of microorganisms**

History and discovery of microorganisms- Biogenesis and abiogenesis, Contributions of Pasteur, Koch, and Flemming. Isolation of microorganism- Serial dilution, Pour plate and Spread plate technique. Types of culture media and uses, Sterilization and Disinfection.Preservation of microorganism.

Unit II: **Microscopy and Staining**

Microscopy: Principle and working of Bright field, Dark field, and Fluorescence microscope. Staining: Simple, Gram, Capsule, Spore staining, Acid fast and Fungal staining- Potassium hydroxide mount and Lactophenol cotton blue staining.Microbial cellular morphology-Structure and cellular components of Bacteria, fungi and algae.

Unit III: **Microbial Taxonomy & Physiology**

Microbial taxonomy: Definition, systematics, Nomenclature rules and identification, Hierarchical organization and the position of microbes in the living world, classification systems –Whittaker's five kingdom concept. Growth Curve and factors influencing microbial growth. Respiratory metabolism- Glycolysis, Kreb's cycle, Electron transport chain - oxidative and substrate level phosphorylation.

Unit IV: **Medical microbiology**

Introduction to medical microbiology - Infectious Diseases process – Diagnosis – Process of sample collection, transport and examinations of the clinical specimens. Pathogenicity, diagnosis and treatments of bacterial diseases - diarrhea, typhoid, cholera and tuberculosis, Fungal diseases - Athlete's foot, and Ringworm. Parasite diseases - malaria and taeniasis.

Unit V: **Microbial biotechnology**

Microbial metabolites - Production and use of enzymes, organic solvents, single cell proteins, beverages (beer and wine), baker's yeast and milk products.Production of microbes as biofertilizers and biopesticides.Production of genetically engineered microbial products.

Reference Books

1. Prescott, L.M., Harley, J.P. and Klein, D.A. (2003) *Microbiology*, 5th Edition, McGraw Hill, New York.
2. Madian, M.T., Martinko, J.M., Parker, J. and Brock, T.D. (1997) *Biology of Microorganisms, 8th edition*. Prentice Hall International Inc. London.
3. Elizabeth Moore Landecker (1996) *Fundamentals of the Fungi*, 4th edition, Prentice Hall International Inc, London.
4. Holt, J.S., Kreig, N.R., Sneath, P.H.A. and Williams, S.T. (1994) *Bergeys Manual of Determinative Bacteriology*, 9th edition. Williams and Wilkins, Baltimore.
5. Pelczar, J.R., Chan, M.J. and Krei, N.R. (1993) *Microbiology*. McGraw Hill, New York.
6. Alexopoulus, C.J. and Mims, C.W. (1993) *Introductory Mycology*, 3rd edition. Wiley Eastern Ltd, New Delhi.

Internal Assessment Matrix for the defined COs

CO	Test 1	Test 2	Quiz	Assignment	Seminar	Percentage allocation	Mapping Strength
CO1	6	6	1			13	2
CO2	6	6	1			13	2
CO3	6	6	2	7		21	3
CO4	12		1	8	5	21	3
CO5		12				12	2
CO6				10	10	20	2
Marks	30	30	5	25 (Assignment, Group discussion, etc.,)	10 (Seminar)	100	

Course Articulation Matrix for defined COs

CO	Learning Outcomes														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	√		√												
CO2		√	√												
CO3				√		√									
CO4			√		√			√							
CO5				√	√	√									
CO6				√		√	√								

Supportive Paper III: Medical Laboratory Technology

(Paper Code: 26UPMBC1S03)

Course Objectives

The course contents are designed to provide functional understanding of laboratory instrumentation, standardized clinical specimen management, core diagnostic skills in hematology, proficiency in waste management and infection control.

Course Outcome

Upon successful completion of this course, students will be able to:

CO1 Remember	Identify the roles and ethical principles governing clinical laboratory professionals. Recall safety measures and general precautions to avoid laboratory accidents and infections. List the types of culture media and various staining techniques.	LO1, LO3, LO4, LO13
CO2 Understand	Explain the principles and working mechanisms of essential laboratory instruments. DescribeGood Laboratory Practice (GLP) and the specific advantages of laboratory accreditation. Summarize the ways to prevent laboratory infections.	LO1,LO4,LO6
CO3 Apply	Demonstrate the collection and processing of clinical specimens. Use basic hematological procedures, apply staining techniques and fixation methods in histopathology. Implement waste management protocols.	LO3,LO4,LO6
CO4 Analyze	Differentiate various anticoagulants and their action. Advantages and disadvantages of different histopathological mounting media. Epidemiological investigation and control of nosocomial infections.	LO3,LO4,LO6,LO8
CO5 Evaluate	Assess the accuracy of instrument calibration, effectiveness of glassware cleaning. Evaluate the quality of clinical specimens and the suitability of specific fixatives for different tissue processing needs.	LO3,LO4,LO6
CO6 Create	Develop a comprehensive safety and waste management plan to minimize the risk of nosocomial infections. Plan the workflow of a histopathology laboratory from specimen receipt and fixation to final tissue mounting and archiving.	LO4,LO6,LO7

Unit I

Role of Medical Laboratory technologists: Ethics of laboratory practice. Ethical Principles and standards for a clinical laboratory professional, Good Laboratory Practice (GLP)- Introduction to Basics of GLP. Accreditation, Advantages of Accreditation. Safety measures in a Laboratory. Cleaning of glassware's General precautions for avoidance of laboratory accidents.

Unit II

Instrumentation: Principle, working, care & maintenance and calibration of Weighing balance, Magnetic stirrer, Centrifuges, Incubator Principle, working, care & maintenance and calibration of Weighing balance, Magnetic stirrer, Centrifuges, Incubator, Hot air oven, Spectrophotometer & pH meter. Incubator, Hot air oven, Spectrophotometer & pH meter. Safety measures in Microbiology Laboratory. Occurrence of lab infections, route of infections in laboratory & safety measures followed for use of pathogens in teaching & laboratory.

Unit III

Examination of clinical Specimens: Methods of Collection, transport and processing of clinical specimens - Blood, Urine, Sputum, Pus &Faeces for microbiological examination. Types of media- Semi synthetic, Synthetic, Enriched, Selective and Differential media.Staining techniques-Simple and differential- Gram's, Capsule & Spore.Fungi-Lactophenol cotton blue (LPCB) & Potassium Hydroxide.

Unit IV

Hematology: Introduction to hematology, collection of blood sample and anticoagulants, Specimen collection and processing in hematology, haemocytometer and procedure for RBC, WBC, ESR count. Introduction to histopathology- laboratory organization, care & maintenance of equipment's used in histopathology laboratory. Basic concepts of fixation and various types of fixative used in histopathology, tissue processing and mounting- mounting media, advantages & disadvantages

Unit V

Bio-medical waste: Concepts and Perceptions, Waste Generation, Segregation, Disposal, Record Keeping, Management of Bio-medical Waste. Hospital acquired infection, Specimen collection from patients, clinics and hospitals, Specimen collection for epidemiological investigations, role of microbiology laboratory in control of nosocomial infections.

References

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2. Tortora, G.J., Funke, B.R. and Case, C.L. (2016) *Microbiology: An Introduction*, 11th Edition, Pearson Education, India
3. Madigan, T.M., Martinko, M.J., Bender, S.K., Buckley, H.D., Stahl, A.D. and Brock, T. (2017) *Brock Biology of Microorganisms*. 14th Edition, Licensing agency, UK.
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9. Naigankar, A.V. and Burande, M.D. (2007) *A manual of Medical Laboratory Technology,* 5th Edition Pragati Books Pvt. Ltd.

10. Mukherjee, K.L. (2010) *Medical Laboratory Technology,* Vol. I, II & III - Manual of Histopathological Techniques &their Diagnostic application, Churchill Levingston.

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2. http://www.cartercenter.org/health/ephti/learning_materials/lecture_notes/medical_lab_technology_students.html

3. http://apps.who.int/iris/bitstream/10665/37042/1/WHO_OFFSET_21.pdf

4. http://www.sciencedirect.com/science/book/97814831679.

Internal Assessment Matrix for the defined COs

CO	Test 1	Test 2	Quiz	Assignment	Seminar	Percentage allocation	Mapping Strength
CO1	6	6	1			13	2
CO2	6	6	1			13	2
CO3	6	6	2	7		21	3
CO4	12		1	8	5	21	3
CO5		12				12	2
CO6				10	10	20	2
Marks	30	30	5	25 (Assignment, Group discussion, etc.,)	10 (Seminar)	100	

Course Articulation Matrix for defined COs

CO	Learning Outcomes														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	√		√	√									√		
CO2	√			√		√									
CO3			√	√		√									
CO4			√	√		√		√							
CO5			√	√		√									
CO6				√		√	√								

Supportive Paper IV: Health Science Management

(Paper Code: 26UPMBC1S04)

Course Objectives

The course aims to provide students with a complete understanding of health science management by introducing health policies, healthcare systems, healthcare delivery structures, and health reforms. It also develops knowledge of healthcare administration, public health programmes, communication, record management, ethical practices, and professional development, enabling students contributions in them.

Course Outcomes

CO1	Explain the concepts of health policy, public health law, policy-making processes, and the factors influencing health policy development and health system improvement.	LO1, LO3, LO5, LO6, LO13
CO2	Describe the structure and functioning of health care systems, including primary health care, indigenous systems of medicine, government health programmes, health insurance schemes, and hospital administration practices.	LO1, LO2, LO3, LO5, LO12
CO3	Analyze the organization and delivery of health care services at central, state, district, block, and village levels, and compare health care systems in developing and developed countries.	LO1, LO3, LO5, LO12
CO4	Evaluate the principles, importance, and scope of health care reforms, including health workforce management and major provisions of patient protection and health care legislation.	LO1, LO3, LO5, LO13, LO14
CO5	Demonstrate professionalism through effective communication, accurate record maintenance, ethical practices, self-evaluation, peer evaluation, and preparation of professional development action plans.	LO2, LO7, LO9, LO10, LO11, LO13, LO14, LO15

Unit I

Introduction to health policy: Health policy - Public health law - Individual rights vs. public interest. Analyzing Policy Options for Health System Improvement, Health policymaking and the policy process – factors influencing the policy.

Unit II

Health care system: Role of primary health care to achieve health for all, indigenous systems – Ayureda, Homeopathy and unani. government health scheme, health insurance schemes, Problems in hospital administration case studies evaluation – solutions.

Unit III

Health care delivery structure: central level – union ministry of health and family welfare, state, district, village and block levels; State level – ministry of health, state health directorate, district health organisations, Health care system in developing and developed countries.

Unit IV

Health care reform: Introduction, Importance and scope of Health care reform, Health care workforce, Understanding the Major Elements of the Patient Protection and Affordable Care Act

Unit V

Professionalism: Communication − Maintaining accurate records − Communicating with others. Professional Development Action Plans – Sharing Self Evaluation and Peer Evaluation.

Reference Books

1. Goel, S.L. Hospital Administration and Management: Theory and Practice. India: Deep &Deep Publications, 2007.
2. Hospital & Health Services administration-Principles & practices, Tabish, OUP
3. Statistical Methods in the Biological & Health Science: J. Susan Milton (McGraw-Hill)
4. An Introduction to Biostatistics, a manual for students in health sciences: P.S.S. Sunder Rao: J. Richard
5. An Introduction to Health Planning for Developing Health Systems, Andrew Green, Third Edition, Oxford university press.
6. Pradeep Bhardwaj 2015 Latest in Healthcare Management, Jaypee publishers , jaypee@jaypeebrothers.com

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2. http://onlinelibrary.wiley.com
3. http://www.bmj.com/content/
4. http://www.who.int/topics/health_policy/en/

Internal Assessment Matrix for the defined COs

CO	Test 1	Test 2	Quiz	Assignment	Seminar	Percentage allocation	Mapping Strength
CO1	6	6	1			13	2
CO2	6	6	1			13	2
CO3	6	6	2	7		21	3
CO4	12		1	8	5	21	3
CO5		12				12	2
CO6				10	10	20	2
Marks	30	30	5	25 (Assignment, Group discussions, Problem solving)	10 (Seminar)	100	

Strength = 3 (if percentage > 20%); Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage < 10%)

Course Articulation Matrix for defined COs

CO	Learning Outcomes														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	√				√	√							√		
CO2	√	√	√		√							√			
CO3	√		√		√							√			
CO4	√		√		√								√	√	
CO5		√					√		√	√	√		√	√	√

Course Type	Title of the Paper	Attainment of Learning outcomes at the end of Programme														
		LO 1	LO 2	LO 3	LO 4	LO 5	LO 6	LO 7	LO 8	LO 9	LO 10	LO 11	LO 12	LO 13	LO 14	LO 15
Core Courses	I: Foundation of Microbiology and Microbial Diversity	5	4	4	3	2	2	-	-	1	0	3	-	-	-	-
	II: Cell Biology and Microbial Genetics	5	1	1	5	3	-	-	4	4	1	4	-	-	-	1
	III: Molecular Biology and rDNA Technology	5	1	1	5	3	-	-	4	4	1	4	-	-	-	1
	IV: Immunology and Vaccinology	5	1	1	5	5	1	-	2	1	1	5	1	1	1	1
	V: Medical Bacteriology and Mycology	1	-	3	5	-	3	1	-	-	-	-	-	2	-	-
	VI:Medical Virology and Parasitology	5	1	1	5	3	-	-	4	4	1	4	-	-	-	1
	VII:Industrial Microbiology and Fermentation Technology	5	1	5	5	5	5	3	5	1	3	5	1	3	1	3
	VIII:Food and Dairy Microbiology	1	-	3	5	1	4	1	1	-	-	-	-	-	-	-
	IX:Soil and Environmental Microbiology	5	-	2	5	5	1	1	5	-	1	5	-	3	-	1
	X:Research Methodology and Biostatistics	5	1	1	5	4	6	-	4	3	-	1	1	1	-	1
Core Practicals	I: Basic Techniques in Microbiology	2	-	3	3	1	5	1	1	-	-	-	-	-	1	-
	II:Microbial genetics, and Molecular Biology	1	1	1	1	-	1	1	-	-	-	-	-	-	1	-
	III:Bacteriology and Mycology	1	-	1	3	1	5	1	-	-	-	-	-	1	-	-
	IV:Immunology, Virology and Parasitology	5	1	3	5	4	1	1	-	-	1	3	-	-	-	-
	V:Industrial and Food Microbiology	5	-	2	5	5	2	-	4	-	-	5	-	2	-	3
	VI:Soil and Environmental Microbiology	5	-	3	2	4	2	-	5	-	-	-	-	-	-	-
Project	Project	-	-	-	-	-	1	-	-	-	1	1	-	1	-	1
Internship	Internship	-	1	-	1	1	-	-	-	1	-	-	1	-	-	-