SAVITRIBAI PHULE PUNE UNIVERSITY
(Formerly University of Pune)

Four Year B.Sc. Degree Program in Microbiology
(Faculty of Science and Technology)

Choice-Based Credit System Syllabus (2024 Pattern)
(As Per NEP 2020)

Second Year B.Sc. Sem. III and IV

To be implemented from Academic Year 2025-2026

Prepared by: B.O.S. MICROBIOLOGY, SPPU

Recommended by: Faculty of Science and Technology

Approved by: Academic Council, SPPU
(For Colleges Affiliated to Savitribai Phule Pune University, Pune)

Title of the Program: B.Sc. (Microbiology)

Preamble:

Microbiology is a wide-ranging discipline of biology. It covers five major groups of microorganisms i.e., bacteria, protozoa, algae, fungi, viruses. In this subject, the interactions of these microorganisms with their surroundings are studied systematically. This also focuses on how the potential of these organisms can be tapped in improving human life and their impact on society and civilization. Being a branch of biology, microbes are used as a study model in different conventional and modern areas of biology. Microbiology has a great legacy of active research in pure and applied science from its establishment as a separate subject. Though the microorganisms were discovered by human over five hundred years ago, there are huge opportunities to explore their wide diversity. In the changing scenario of the world and environment, systematic knowledge of microbiology has become quintessential and crucial. There is always a demand for skilled and knowledgeable persons in education, research and industry. Students who graduate by taking this subject as a major are employable in industry and research.

Introduction: In the post-globalization world, higher education has to play a significant role in the creation of skilled human resources for the well-being of humanity and the environment. The barriers among the academic fields seem to have dissolved. However, disparities in the field of curriculum aspect, evaluation and mobility exist. With the changing situations at local and global levels, the syllabus restructuring should keep pace with developments in the education sector. National Education Policy (NEP) is being adopted and implemented to address the issues related to the traditional system and it also aims to maintain the best of the earlier curriculum. The student is at the centre of NEP-2020. The present curriculum focuses on students' needs, skill development, interdisciplinary approach to learning and enhancing employability. Microbiology curricula are offered at two levels viz. undergraduate and postgraduate. The undergraduate curricula are prepared to impart basic knowledge of the respective subject from all possible angles. In addition, students are to be trained to apply this knowledge in day-to-day applications and to get a glimpse of research.

Objectives to be achieved:

• To enrich students' knowledge and train them in the pure microbial sciences

• To introduce the concepts of application and research in Microbiology

• To inculcate a sense of scientific responsibility and social and environmental awareness

• To help students build up a progressive and successful career

Eligibility for Admission:

First Year B.Sc.:

a. Higher Secondary School Certificate (10+2) or its equivalent Examination with English and Biology; and two of the science subjects such as Physics, Chemistry, Mathematics, Geography, Geology, etc.

OR

b. Three Years Diploma in Pharmacy Course of Board of Technical Education conducted by Government of Maharashtra or its equivalent.

OR

c. Higher Secondary School Certificate (10+2) Examination with English and vocational subject of + 2 level (MCVC) - Medical Lab. Technician (Subject Code = P1/P2/P3)

Admissions will be given as per the selection procedure / policies adopted by the respective college keeping in accordance with conditions laid down by the University of Pune.

Reservation and relaxation will be as per the Government rules.

Medium of Instruction: English

After successful completion of the Under Graduate (UG) Degree program, the students would be able to:

Program Outcomes (POs) for B.Sc Programme

PO1. Disciplinary Knowledge: Demonstrate comprehensive knowledge of the disciplines that form a part of a graduate programme. Execute strong theoretical and practical understanding generated from the specific graduate programme in the area of work.

PO2. Social competence: Display the understanding, behavioural skills needed for successful social adaptation, work in groups, exhibit thoughts and ideas effectively in writing and orally.

PO3. Research-related skills and Scientific temper: Develop the working knowledge and applications of instrumentation and laboratory techniques. Able to apply skills to design and conduct independent experiments, interpret, establish hypothesis and inquisitiveness towards research.

PO4. Trans-disciplinary knowledge: Integrate different disciplines to uplift the domains of cognitive abilities and transcend beyond discipline-specific approaches to address a common problem.

PO5. Environment and Sustainability: Understand the impact of the scientific solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.

PO6. Self-directed and Life-long learning: Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes.

Programme specific outcomes for B.Sc. Microbiology

PSO 1 Demonstrate knowledge of the importance of microbes in various aspects of life.

PSO 2 Differentiate among various categories of microorganisms.

PSO 3 Acquire skills in basic experimental techniques in microbiology.

PSO 4 Understand and apply the principles of experimental setups and methodologies.

PSO 5 Analyze and interpret stained microbial slides and morphological features.

PSO 6 Develop critical thinking and problem-solving skills related to microbiological research.

PSO 7 Communicate scientific findings and concepts effectively in microbiology.

PSO 8 Understand the implications of microbiology in health, medicine, and biotechnology.

PSO 9 Foster collaborative skills and contribute to team-based scientific projects.

PSO 10 Cultivate a mindset for lifelong learning and professional development in the field of microbiology.

Board of Studies (BoS) in Microbiology

From 2023-24 to 27-28

Sr. No.	Name	Designation
1.	Dr. Pawar Sunil Trimbak	Chairman
2.	Dr. Pardesi Karishma Rajendra	Member
3.	Dr. Pabale Anupama Ashok	Member
4.	Dr. Wagh Pratima Pandit	Member
5.	Dr. Abhyankar Pragati Sunil	Member
6	Dr. Pathak Leena Pradeep	Member
7	Dr. Kulkarni Snehal V.	Member
8.	Dr. Kale Avinash Sudhakar	Member
9.	Dr. Shubhangi R.Shinde	Member
10.	Dr. Puranik Pravin R.	Member
11	Dr. Rajwade Jyotika Milind	Member
12.	Dr.Mali Gajanan Vishnu	Member
13	Dr. Shete Ashiwini Monish	Member
14	Dr. Patil Hemant jagatrao	Member

Course structure for S. Y. B.Sc. Microbiology (NEP 2020) 2024-25

Semester/Level	Course Type	Course Code	Theory/Practical	Title/Course Name	Credits
SEM-III/5.0	**Major core**	MB-201-MJ	Theory	Medical microbiology and Immunology	2
	Major core	MB-202-MJ	Theory	Bacterial Physiology and fermentation	2
	Major core	MB-203-MJP	Practical	Applications of microbiology I	2
	Vocational Skill Course	**MB-221-VSC**	Theory	Dairy Technology	2
	Field project	MB-231-FP	Field project		2
	Minor	MB-241-MN	Theory	Avenues in Microbiology	2
	Minor	MB-242-MNP	Practical	Utilization of Microbes	2
	Open Elective	OE-201-MB	Theory	Scope of Microbiology	2
	Indian Knowledge System	IKS-201-MB	Theory	IKS major subject Specific	2
	Ability Enhancement Course	AEC-201-MB	Theory	English/Hindi/Marathi	2
	Co curricular Course/minor	CC-201-PE,NSS,		NSS/NCC/PE	2
					Total (22)
	Major core	MB-251- MJ	Theory	Bacterial Genetics	2
SEM-IV/5.0	**Major core**	MB-252- MJ	Theory	Air and water Microbiology	2
	Major core	MB-253- MJP	Practical	Applications of Microbiology-II	2
	Vocational Skill Course	**MB-271-VSC**	Practical	Techniques in dairy Microbiology	2
	Community E. Programme	**MB-232-CEP**			2

	Minor	MB-291-MN	Theory	Environmental Microbiology	2
	Minor	MB-292-MNP	Practical	Practices in Environmental Microbiology	2
	Open Elective	OE -251-MB	Practical/Theory	Use of Microbes in Daily Life	2
	Skill Enhancement Course	SEC-251-MB	Practical	S.O.P. Preparation of laboratory Instruments	2
	Ability Enhancement Course	AEC-251-MB	Theory	English/Hindi/Marathi	2
	Co curricular **course/ minor**	CC-251-MB	-	PE/NSS/NCC	2
					Total (22)

Semester I
MB- 201 – MJ Medical Microbiology and Immunology

[2 Credits; 30 Working hours]

Course Objectives	
1	To impart foundational knowledge on key terminologies and concepts related to infectious diseases.
2	To develop an understanding of the classification, morphology, cultural and biochemical characteristics, and pathogenesis of medically important bacteria, fungi, protozoa, and viruses.
3	To familiarize students with immunological concepts.
4	To explore the mechanisms of antigen-antibody interactions.
5	To enable students to understand the epidemiology, prophylaxis, and treatment strategies of important infectious diseases.

Course Outcomes	
CO1	Define and explain core microbiological and immunological concepts such as incubation period, pathogenicity, and types of immunity.
CO2	Classify and describe key microbial pathogens (bacteria, fungi, protozoa, and viruses) based on morphology, biochemical characteristics, and antigenic structure.
CO3	Identify the role of various immune cells and lymphoid organs in the body's defense mechanisms and describe the process of hematopoiesis.
CO4	Interpret laboratory diagnostic methods and antigen-antibody reactions used in the detection and confirmation of microbial infections.
CO5	Apply epidemiological principles to assess disease outbreaks (epidemic, endemic, sporadic, pandemic) and propose appropriate prophylactic and chemotherapeutic measures.

MB 201	Medical Microbiology and Immunology	
Credit	Credit Title and Content	Hours
Credit 1	**Medical Microbiology**	15
Unit 1	Definitions Incubation period, Viability, Susceptibility, Pathogenicity, Virulence, Pathogenesis, Lab diagnosis, Epidemic, Sporadic, Endemic, Pandemic.	2
Unit 2	Study of following pathogens with respect to Classification, Morphological, Cultural and Biochemical characters, Antigenic structure, Viability characteristics, Pathogenicity, Pathogenesis, Symptoms, Laboratory diagnosis, Epidemiology, Prophylaxis and Chemotherapy: Bacteria: a) *Salmonella typhi* and *paratyphi* b) *Staphylococcus aureus* Fungi: a) *Candida albicans* b) *Aspergillus fumigates* Protozoal: a) *Plasmodium* spp. b) *Entamoeba histolytica* Viral: a) Hepatitis B. b) Rabies virus	13
Credit 2	**Immunology**	**15**
Unit 1	**a) Immunity** – Definition & Classification of Immunity- Innate & Acquired Immunity, Humoral & cell mediated Immunity	2
	b) Three lines of Defence mechanism	1
	c) Cells of Immune system: Hematopoesis Structure, Classification, properties and function of Stem cell, T	3

	cell, B cell, NK cell, Macrophage, Neutrophil, Eosinophil, Basophil, Mast cell, Dendritic cell.	
	d) Lymphoid Organs – location, classification & functions of - Bone Marrow, Thymus, Lymph Node, Spleen, GALT, MALT, CALT.	1
Unit 2	**a) Antigen** - Definition, concept of immunogen, epitopes, types of antigens	1
	b) Antibodies/Immunoglobulin - Definition, structure of typical immunoglobulin, classes and biological functions of Immunoglobulin	3
	c) Principles of antigen and antibody interactions	1
	d) Antigen-antibody Reactions – Precipitation Agglutination	3

REFERENCES:

1. Ananthanarayan and Paniker (2006). Text book of Microbiology. 8th Edition. Hyderabad. Orient Longman publication.

2. David Greenwood, Richard C.B. Slack and John. F. Peutherer (2008). Medical Microbiology. 7th Edition, New Delhi. Elsevier India Private Ltd.

3. Jawetz, Melnickand Adelbergs (2010). Medical Microbiology. 25th Edition. USA. McGraw Hill Companies.

4. Jenni Punt, Sharon A stranford, Patricia P Jones, Judith A Owen, Janis Kuby (2019). Immunology, 8th Edition; New York. W.H. Freeman and Company.

5. Kenneth Murphy, Caesar Weaver, Charles Janeway (2017). Janeway's Immunobiology. 9th Edition. New York. Garland Science.

6. Michael Barer, W L Irving (2018). Medical Microbiology 19thh Edition.

7. Peter J. Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt (2017). Roitts Essential Immunology, 13th Edition, Oxford. Wiley Blackwell.

8. Linda Sherwood, Christopher J. Woolverton, Lansing M. Prescott, and Joanne M. Willey (2011). Prescott's Microbiology.7th Edition. New York: McGraw-Hill.

MB-202 MJ: Bacterial Physiology and Fermentation Technology

[2 Credits; 30 Working hours]

Course objectives	
1	To introduce the fundamental concepts of enzymes, including their structure, function, classification, and factors influencing their activity.
2	To explain key bacterial metabolic pathways, including glycolysis, TCA cycle, and fermentation, and their energetic and regulatory significance.
3	To provide knowledge of fermentation technology.
4	To explore the industrial application of microbial strains.
5	To impart practical understanding of large-scale microbial product manufacturing.

Course Outcomes	
CO1	Acquainted with the term Enzymes, its nomenclature and classification and models for catalysis.
CO2	Understand the effect of pH, temperature, substrate concentration, enzyme concentration, activators and inhibitors on enzymes.
CO3	Understanding the concept of Bacterial Physiology with reference to metabolism, catabolism, anabolism, respiration and fermentation.
CO4	Comprehend the different metabolic pathways with structures.
CO5	To understand the general processes of fermentation technology, scale up.

Credit I	Bacterial Physiology	(15)
Unit 1	**Enzymes**	
	i. Introduction to Enzymes: Defination of enzyme, Properties of enzymes, Nature of active site, Structure of active site, commonly occurring amino acids at active site. Ribozymes, coenzymes, apoenzymes, prosthetic group and cofactors.	2
	ii. Models for catalysis– a) Lockland key b) Induced fit c) Transition state.	1
	iii. Effect of pH and temperature, substrate concentration and enzyme Concentration on enzyme activity, Concept of enzyme activators and inhibitors.	1
	iv. Nomenclature and classification as per IUB (up to class level) At least two examples of each class.	2
	Bacterial Physiology	
	i. Concept and Definition: Metabolism, catabolism, anabolism, respiration and fermentation	1
Unit 2	ii. Metabolic pathways (with structures and energetics) a) Embden-Meyerhof-Parnas pathway (Glycolysis) b) Hexose monophosphate pathway c) Entner-Doudoroff pathway d) Phosphoketolase pathway(Pentose and hexose) e) TCA cycle(with emphasis on amphibolism) and Glyoxylate bypass f) Gluconeogenesis and its significance	 2 1 1 1 2 1
Credit II	**Fermentation Technology**	**(15)**
Unit 1	a) Concept of Fermentation Technology i. Definition, History of fermentation.	1
	b) Types of fermentations: Concept of Batch, continuous and dual	1

	fermentation	
	c) Design of a Fermenter (typical CSTR Continuous stirred tank Reactor): Different parts and their working	1
	d) Media for industrial fermentations: Constituents of media (Carbon source, nitrogen source, aminoacids, vitamins, minerals, water, buffers, antifoam agents, precursors, inhibitors and inducers)	2
	e) Strains of industrially important microorganisms: i. Desirable characteristics of industrial strain ii. Principles and methods of primary and secondary screening iii. Development of inoculum : Master, working and seed culture iv. Preservation and maintenance of industrial strains.	4
Unit 2	**a) Monitoring of different fermentation parameters** Temperature, pH, aeration, agitation, foam (measurement and control)	2
	i. Introduction to different categories of fermentation products in brief (primary and secondary metabolites, biomass based, recombinant, fermented food and biotransformation). ii. General steps involved in large scale production. iii. Concept of Lab, Pilot and Large Scale production. iv. Large scale production of 1. Biofertiliser- Azotobacter (biomass based), 2. - Insulin (Recombinant product)	1 1 1
	b) Contamination: Sources, precautions and consequences	1

References:

1. BIOTOL Series.(1993).Biotechnology by open learning series. Defense Mechanisms. Butterworth and Heinemann Ltd., Oxford
2. Casida L.E.J.R.(2016).Industrial Microbiology. New Age International Private Limited. ISBN- 9788122438024
3. Conn E. E.,Stumpf P. K., Bruening G., DoiR. Y.(1987).Outlines of Biochemistry. 5thEdition, John Wiley and Sons, New Delhi. (Unit I&II)

4. Madigan M. T., Martinko J. M. and Brock T.D.(2006). Brock's Biology of Microorganisms. Pearson Prentice Hall, Upper Saddle River.
5. Moat A. G. and Foster J. W. (1988). Microbial Physiology. 2nd Edition. John Wiley and Sons New York.
6. Nelson D. L.andCoxM.M.(2005).Lehninger'sPrinciplesofBiochemistry.8th edition. MacMillanWorthPub.Co.NewDelhi.ISBN:9781319228002
7. Patel A. H.(2016).Industrial Microbiology. Trinity Press (Publisher). ISBN-13-9789385750267
8. Peppler H. L. and Perlman D.(1979).MicrobialTechnology.Volume1: Microbial Processes. Academic Press, NewYork.ISBN:978-0-12-551501
9. Peppler H. L. and Perlman D.(1979).Microbial Technology. Volume II: Fermentation Technology (2ndEdition). Academic Press. ISBN: 9781483268279
10. Prescott L. M., Harley J. P. and Klein D. A. (2005). Microbiology.6th Edition. Mac Graw Hill Companies Inc. (Unit II)
11. Reed G.(Editor).(1982).Prescott and Dunn's Industrial Microbiology. Westport, CT, AVI Publishing Co Inc.
12. Stanbury P.F., Whitaker A.and Hall S.J.(2016).Principles of Fermentation Technology.3rd Edition. Butterworth-Heinemann. ISBN: 9780080999531
13. Voet D.and Voet J.G.(1995).Biochemistry.2nd Edition.JohnWiley& sons. New York. ISBN 0-471-58651-X
14. Dixon M and Webb E.C (1964). Enzymes 2nd Edition, Academic Press, ISBN :0582462142
15. Stanier Y.S, General Microbiology, 4th Edition. Mac Milan publication, ISBN13:978-0333220146

MB-203 MJP: Application of Microbiology I

[2 Credits: 60 Working hours]

(Total Workload: 2 credits × 30 hrs = 60 hrs in a semester)

1 Practical credit = 30 hours **1 Practical = 4.00 hours**

Course Objectives	
1	To perform basic immunology tests **such as blood grouping, double diffusion, and cross-matching to understand how antigens and antibodies react.**
2	To identify disease-causing bacteria and fungi **from clinical samples by using lab techniques.**
3	To interpret the results of different biochemical tests to distinguish among medically significant microorganisms.
4	To apply microbiological screening techniques to **isolate useful microbes** from soil that produce **industrially important products.**
5	Integrate theoretical knowledge with practical laboratory skills to conduct safe, accurate, and reliable microbiological analyses relevant to clinical, industrial, and research microbiology.

Course Outcomes	
CO 1	Perform and interpret blood grouping and Rh typing, and conduct major and minor cross-matching procedures used in transfusion practices.
CO 2	Apply immunodiffusion techniques (e.g., Ouchterlony double diffusion) to detect antigen-antibody interactions.
CO 3	Isolate and identify clinical pathogens such as *Salmonella* and *Streptococci* using gram staining, motility, and a range of biochemical tests (e.g., IMViC, OF, TSI).
CO 4	Identify fungal pathogens like Candida albicans using techniques like germ tube test and slide culture.
CO 5	Conduct primary screening of industrially useful microbes from soil using crowded plate and giant colony methods for antibiotic and organic acid production.

MB-203 MJP: Application of Microbiology I		
Expt. No.	**Topics**	**No. of Practicals**
1	Blood grouping: ABO and Rh	**1**
2	Double diffusion (Ouchterlony) techniques	**1**
3	Immunohematology : Cross matching (Major and Minor)	**1**
4	A) Isolation and identification of pathogens from clinical samples: a) *Salmonella typhi and paratyphi* *b) Streptococci* by using following test a. Gram staining & motility, b. Cultural and Biochemical characteristics i. Sugar utilization test, ii. Sugar fermentation test, iii. Triple Sugar iron agar, iv. IMViC test v. Enzyme detection – Gelatinase, Catalase, Oxidase, amylase vi. Oxidative-fermentative test [Baird Parker's modification of Hugh and Leifson's oxidative- fermentative (OF) basal medium for Gram Positive and Hugh and Leifson's oxidative- fermentative (OF) basal medium for Gram negative; Public Health England, 2019] B) Isolation and identification of *Candida albicans* from skin/ mouth a) Slide culture Technique. b) Germ tube test.	**10**
5	**Primary screening of industrially important organisms:** Screening and isolation of antibiotic **and** organic acid producing organism from soil by **a)** Crowded plate and b) Giant colony method	**2**
	Total	**15**

References:

Experiment 1. Blood grouping:

1. Godkar D. P. (2003). Textbook of Medical Laboratory Technology. Bhalani Publishing House, New Delhi, India.
2. Mukherjee K. L. (2013). Medical Laboratory Technology. Second Edtion. Volume III. McGraw-Hill Companies, India

Experiment 2. Immunoprecipitation:

1. Saxena J., Baunthiyal M. and Ravi I. (2015). Laboratory Manual of Microbiology, Biochemistry and Molecular Biology. Scientific Publishers, New Delhi, India
2. Mukherjee K. L. and Ghosh S. (2010). Medical Laboratory Technology, Volume I: Procedure Manual for Routine Diagnostic Tests. 2nd edition. McGraw Hill Education (India) Private Limited. ISBN-13: 978-1259061233

Experiment 3. Immunohematology:

1. Baveja C. P. and Baveja V. (2019). Text and Practical Microbiology for MLT. 3rd Edition. Arya Publishing Company. ISBN-13: 9788178558387
2. Maheshwari N. (2017). Clinical Pathology Hematology and Blood Banking (For Dmlt Students). 3rd edition. Jaypee Brothers Medical Publishers. ISBN-13: 978-9386261182
3. Mukherjee K. L. and Ghosh S. (2010). Medical Laboratory Technology, Volume II: Procedure Manual for Routine Diagnostic Tests. 2nd edition. McGraw Hill Education (India) Private Limited. ISBN-13: 978-1259061240

Experiment 4. Isolation and identification of pathogens from clinical samples:

1. Mac Faddin J. F. (2000). Biochemical Tests for Identification of Medical Bacteria. United
2. Randhawa V. S., Mehta G. and Sharma K. B. (2009). Practicals and Viva in Medical Microbiology. Second Edition. Elsevier (A Division of Reed Elsevier India Pvt. Limited).
3. Verhaegen J. and Heuck C. C .(Editors). (2003). Basic Laboratory Procedures in Clinical Bacteriology. Second Edition. Switzerland: World Health Organization.

Experiment 4. b.i. Sugar utilization test: Minimal salt Medium (MSM with 1% sugar):

1. Mukred A. M., Hamid A. A., Hamzah A. and Wan Yusoff W. M. (2008). Enhancement of Biodegradation of Crude Petroleum-Oil in Contaminated Water by the Addition of Nitrogen Sources. Pakistan Journal of Biological Sciences, 11: 2122-2127.
2. Mahalingam B. L., Karuppan M. and Manickam V. (2013). Optimization of Minimal Salt Medium for Efficient Phenanthrene Biodegradation by Mycoplana sp. MVMB2 Isolated from Petroleum Contaminated Soil Using Factorial Design Experiments. CLEAN - Soil, Air, Water. 41(1): 51–59. Wiley-VCH Verlag GmbH and Co. KGaA, Weinheim

Experiment 4. b. ii. Sugar fermentation test:- Phenol Red Broth Base:

1. Aneja K. R. (2007). Experiments in Microbiology, Plant Pathology and Biotechnology. New Age International, New Delhi, India
2. Dubey R. C. and Maheshwari D. K. (2002). Practical Microbiology. S. Chand and Company Limited, New Delhi, India
3. Mac Faddin J. F. (2000). Biochemical Tests for Identification of Medical Bacteria.

United Kingdom: Lippincott Williams and Wilkins.

Experiment 4. b. iii. Triple sugar Iron Agar:

1. Jain A., Agarwal J. and Venkatesh V. (2018). Microbiology Practical Manual. 1st Edition. E- Book. Elsevier Health Sciences, India.
2. Mac Faddin J. F.(2000). Biochemical Tests for Identification of Medical Bacteria.United Kingdom:Lippincott Williams and Wilkins.
3. Randhawa V. S., Mehta G. and Sharma K. B. (2009). Practicals and Viva in Medical Microbiology. Second Edition. Elsevier (A Division of Reed Elsevier India Pvt. Limited).

Experiment 4. b. iv. IMViC test:

1. Dubey R. C. and Maheshwari D. K. (2002). Practical Microbiology. S. Chand and Company Limited, New Delhi, India
2. Jain A., Agarwal J. and Venkatesh V. (2018). Microbiology Practical Manual. 1st Edition. E- Book. Elsevier Health Sciences, India.
3. Randhawa V. S., Mehta G. and Sharma K. B. (2009). Practicals and Viva in Medical Microbiology. Second Edition. Elsevier (A Division of Reed Elsevier India Pvt. Limited).
4. Verma A. S., Das S., and Singh A. (2014). Laboratory Manual for Biotechnology. S Chand and Company Limited, New Delhi, India

Experiment 4. b. v. Enzyme detection:

1. Carroll K.C., Pfaller M. A., Landry M. L., McAdam A. J., Patel R., Richter S. S. and Warnock
D. W. (Editors). (2019). Manual of Clinical Microbiology. 2 Volume Set. 12th Edition. John
Wiley, USA
2. Dubey R. C. and Maheshwari D. K. (2002). Practical Microbiology. S. Chand and Company Limited, New Delhi, India
3. Goldman E. and Green L. H. (2008). Practical Handbook of Microbiology. United States: CRC Press.
4. Leber A. L. (2020). Clinical Microbiology Procedures Handbook. United States: Wiley.
5. Verhaegen J. and Heuck C. C . (Editors). (2003). Basic Laboratory Procedures in Clinical Bacteriology. Second Edition. Switzerland:World Health Organization.

Experiment 4: Isolation and identification of Candida from skin/ mouth (Slide culture Technique).

1. Rosana Y., Matsuzawa T., Gonoi T. and Karuniawati A. (2014). Modified slide culture method for faster and easier identification of dermatophytes. Microbiology Indonesia. 8(3): 135-139 https://doi.org/10.5454/mi.8.3.7
2. Greer D. L., Kane J., Summerbell R., Sigler L., Krajden S. and G. Land (Editors). (1999). Laboratory handbook of dermatophytes: a clinical guide and laboratory manual of dermatophytes and other filamentous fungi from skin, hair, and nails. Mycopathologia. 147: 113–114

Experiment 5. Primary screening of industrially important organisms:

1. Aneja K. R. (2007). Experiments in Microbiology, Plant Pathology and Biotechnology. New Age International, New Delhi, India
2. Dubey R. C. and Maheshwari D. K. (2002). Practical Microbiology. S. Chand and

Company Limited, New Delhi, India
3. Gunasekaran P. (2007). Laboratory Manual in Microbiology. New Age International Private Limited, New Delhi, India.

MB-221 VSC: Dairy Technology

[Credit: 02: 30 Working hours]

Course Objectives	
1	To introduce students to the fundamentals of Dairy Technology
2	To develop an understanding of dairy microbiology
3	To familiarize students with the composition, nutritional value, and microbiology of raw milk
4	To examine the causes, types, and consequences of milk spoilage
5	To train students in practical and analytical techniques used in dairy quality assessment

Course Outcomes	
CO1	Understand the fundamentals and scope of Dairy Technology and its allied disciplines.
CO2	Demonstrate knowledge of dairy microbiology and the role of microbiologists in ensuring dairy quality and safety.
CO3	Explain the composition and nutritional value of raw milk from various animals.
CO4	Identify and analyze microbial aspects of raw milk, including spoilage and preservation techniques.
CO5	Apply principles and methods of milk preservation to ensure product safety and quality.

Credit	Credit Title and Content	Number of hourss
Unit 1	**1. Dairy Technology** A. Definition, field of study (Dairy Sciences, Dairy Microbiology, Dairy Chemistry, Dairy Engineering) B. Scope of Dairy Technology • Present status related to milk production • International scenario National scenario • Production of milk by organized sector and unorganized sector • Market potential of milk and milk products	**2**
	2. Dairy Microbiology A. Definition B. Role of Microbiologist in Dairy Technology C. Scope of Dairy Microbiology in Dairy Technology i) Dairy processing and manufacturing quality assurance ii) Food Science and Technology, iii) Biotechnology iv) Food safety v) Education and research	**1**
	3. Fundamental of raw milk A. Definition B. Composition of milk from different animals (Cow, Buffalo, Camel, Reindeer and Donkey) C. Components of milk and their nutritional value	**3**

	i) Lactose ii) Lipids iii) Proteins(Caseins and Casein micelle, Whey proteins) iv) Milk salts **4.Microbiologyof raw milk** A. Initial microflora of milk. B. Influence of storage and transport on microflora of milk. **5.MilkSpoilage** A. Definition and basic concept, types of milk spoilage. B. Types of microorganisms involved in milk spoilage (Bacteria and fungi) With examples, role of Psychrotrophs with examples. C. Effects of spoilage on milk with examples of microbes causing it (Color changes, flavor changes, texture changes gas production, souring). D. Factors affecting milk spoilage. **6.Preservation of milk and milk products (Principle and Methods)** A. Refrigeration B. Pasteurization C. Sterilization D. Irradiation E. Chemical preservation F. Preservation through water removal(concentration and dehydration)	**2** **4** **3**
Credit II **Unit I**	**1. Methods in Dairy Technology** A. Milk adulteration: Definition, concept, Importance of detection of adulteration, types of milk adulterants B. Simple Qualitative tests to determine milk adulteration (Name, principle and procedure) • Edible adulterants o Water o Sugar (glucose, starch) o Common salts • Hazardous chemicals o Hydrogen peroxide o Melamine o Formalin o Ammonium sulphate	**7**

	○ Urea ○ Nitrates ○ Benzoic acid and salicyclic acid ○ Borax and Boric acid • Mixed adulterants ○ Detergents ○ Pulverized soap ○ Coloring matter **2. Microbiological analysis of milk** A. Enumeration of bacteria. • Direct method- standard plate count with atleast one numerical problem. • Indirect method-direct microscopic count with atleast one numerical example. B. Methods and techniques to determine quality of milk (Name, principle, application/significance) • Dye reduction tests (Methylene blue reduction test (MBRT), Resazurin test) • Mastitis test (California Mastitis test, Somatic cellcount, Milk culture) Phosphatase test	**8**

References:

1. Robinson, Richard K.2002.Dairy Microbiology Handbook: The Microbiology of Milk and Milk Products, 3rd Edition. New York: Wiley Interscience.

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Links:
https://agrimoon.com/wp-content/uploads/Introductory-Dairy-Microbiology.pdfhttps://egyankosh.ac.in/bitstream/123456789/65956/1/Unit%2015.pdfhttps://dahd.gov.in/

MB 231 FP– Field Project In Microbiology

2 credits [30 Hrs.]

Course Objectives	
1	To expose students to practical field-based applications of microbiology.
2	To understand indigenous microbial techniques like fermentation, hygiene practices, and natural antimicrobials
3	To encourage independent project work, teamwork, and reporting based on real-world microbiological issues.
4	To help students understand the role of microbiology in agriculture, environment, industry, health, and public hygiene sectors.
5	To build skills in scientific documentation, field ethics, and communication.

Course Outcomes Upon completion of the course, students will be able to:	
CO1	Apply microbiological knowledge in real-world field settings
CO2	Collect, process, and analyze microbiological samples from natural, industrial, or clinical environments.
CO3	Prepare a professional field project report demonstrating scientific analysis and interpretation.
CO4	Demonstrate an understanding of biosafety, field ethics, and community engagement during microbiological fieldwork.
CO5	Able to write the report of field work and present it.

Field Work	Minimum 2 field visits or a single extended project
Report Submission	Field Project Report (Mandatory)

Possible Field Areas:

1. Dairy industry (microbial quality and hygiene study)
2. Water bodies (microbial water quality analysis)
3. Soil (microbial diversity, biofertilizer study)
4. Waste management sites (compost microbiology, landfill studies)
5. Food processing units

6. Hospital/Clinical settings (infection control studies) — (with permissions)
7. Pharmaceutical or biotechnology industries
8. Environmental microbiology (pollution monitoring, bioremediation)
9. Fermentation industry
10. Agricultural industry, etc.

Project Examples: [These are just for sample. Topics can be chosen depending up on local needs, gaps, infrastructural set up etc.]

1. Isolation of bacteria from contaminated water sources.
2. Study of microbial load in street foods or dairy products.
3. Survey on antimicrobial resistance awareness in a community.
4. Analysis of microbial compost maturity indicators.
5. Study on traditional fermented food microbial profile.

Teaching-Learning Methods:

1. Orientation lectures on project planning and safety.
2. Field visits and guided sample collection.
3. Data analysis workshops.
4. Guidance sessions for report writing and presentation.

Assessment Scheme:

Component	Marks
Field Participation	20%
Sample Collection and Lab Work	20%
Field Notes and Data Sheets	10%
Project Report (Written)	30%
Project Presentation (Oral/Poster)	20%

Project Report Guidelines:

- Introduction (Problem statement, objectives)
- Materials and Methods (Sample collection, techniques)
- Results (Tables, figures)
- Conclusion (Summary of findings)
- References (At least 5 scientific references)

Recommended Resources:

- Field and Laboratory Methods for General Ecology – James E. Brower
- Manual of Environmental Microbiology – ASM Press
- Research articles related to field microbiology.

MB 241 MN: Avenues in Microbiology Theory

Minor Theory

Total: 2 Credits Workload:-15hrs. /credit

(Total Workload):-2 credits x 15 hrs. = 30 hrs in semester)

Course Objectives	
1	To introduce students to the types of clinical infections
2	To develop foundational knowledge in molecular biology
3	To familiarize students with industrial and food microbiology
4	To equip students with the skills and knowledge for quality control in food microbiology
5	To introduce applied microbiology concepts

Course Outcomes	
CO1	Students will be able to identify and explain different types of infections
CO2	Students will be able to describe the molecular structure of DNA
CO3	Students will demonstrate understanding of food microbiology
CO4	Students will be able to perform and interpret quality control tests such as TPC, MPN, pH analysis, and shelf-life testing for food and beverage products
CO5	Students will understand the principles of applied microbiology, including vaccine types

MB 241 MN: Avenues in Microbiology Theory Minor Theory		
Credits	**Credit Title and Contents**	**Number of Lectures**
Unit I	Clinical and Molecular Biology **A] Introduction to Clinical Microbiology** 1Types of infections with respect to mode of transmission, clinical specimen for diagnosis. a) Respiratory tract infection (Tuberculosis, COVID-19) b) Gastrointestinal tract infection (Cholera, Gastroenteritis) c) Urinary tract infection. 2. Common Antibiotics and their mode of action a) Penicillin b) Streptomycin c) Tetracycline **B] Introduction to Molecular Biology** 1. Structure of DNA and forms of DNA (A, B, Z) 2. Role of different enzymes in DNA replication 3. Introduction to central dogma of molecular biology a) Concept of genetic code b) Overview of Transcription and translation	**15**
Unit II	**Industrial and Applied Microbiology** **A] Introduction to Industrial Microbiology** 1. Definition of terminologies related to fermentation and food microbiology. 2. Food Microbiology a) Hazard Analysis and Critical Control Points(HACCP) b) Food Preservation Methods: Pasteurization, Drying Method 3. Quality Control a. Total Plate Count (TPC) b. Coliform Testing: Most Probable Number (MPN) and Membrane Filtration Technique MFT) c. pH maintenance d. Shelf-Life testing: Chemical and nutritional analysis	**15**

	methods 4. Environmental Microbiology a) Introduction to environmental microbes b) Introduction to Bioremediation and its types c) Applications of Bioremediation d) Waste water treatment **B] Introduction to Applied Microbiology** 1. Explain the terms: Applied Microbiology, vaccines and their types 2. Production and route of administration of different vaccines: a) BCG Vaccine (live attenuated) b) Rabies Vaccine (Inactivated) c) HPV Vaccine (Subunit/Recombinant) d) COVID-19 (mRNA)	

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MB 242 MNP: Utilization of Microbes

Minor Practical

[2 Credits: 60 Lectures]

(Total Workload: 2 credits × 30 hrs = 60 hrs in a semester)

1 Practical credit = 30 hours **1 Practical = 4.00 hours**

Course Objectives	
1	To develop practical skills in the isolation, identification, and characterization of clinical pathogens
2	To introduce students to the principles and techniques used in antibiotic sensitivity testing and genomic DNA extraction from bacteria.
3	To equip students with the ability to conduct an epidemiological survey, including hypothesis development, data collection, statistical analysis, and report writing.
4	To train students in food microbiology quality assurance techniques, including the phosphatase test, coliform testing (MPN, membrane filter), and HACCP practices.
5	To expose students to applied microbiology and immunology practices

Course Outcomes	
CO1	Students will be able to isolate and identify pathogenic bacteria from clinical samples
CO2	Students will be able to perform and interpret antibiotic assay results using the agar gel diffusion method
CO3	Students will be able to design and execute an epidemiological study
CO4	Students will demonstrate the ability to evaluate food safety using HACCP guidelines, assess pasteurization efficiency
CO5	Students will gain hands-on experience in applied microbiology, including isolation of environmental microbes

MB 241 MNP: Utilization of Microbes Minor Practical		
Sr. No.	**Title of the practical**	**No. of Practical's**
1.	Isolation and identification of pathogens from clinical samples: (*Escherichia coli*, *Vibrio* spp.) by- a. Gram staining, motility b. Cultural and Biochemical characteristics	3
2.	Antibiotic assay (agar gel diffusion technique)	2
3.	Extraction of genomic DNA from bacteria.	1
4.	Epidemiological survey: Development of hypothesis, Data collection, organization, statistical analysis, graphical representation using computers and interpretation, Preparation of report	2
5.	HACCP guidelines for food industry (activity based)	1
6.	Efficiency of Pasteurization. (Phosphatise test)	1
7.	Bacteriological tests for presence of coliforms a. MPN b. Membrane filter technique	2
8.	Enrichment and isolation of hydrocarbon degrading bacteria.	1
9.	Study of Immunization schedules in India.	1
10.	Visit to any food industry or a fermentation industry and report writing.	1
	Total	15

Suggested References -

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OE 201 – MB- Scope of Microbiology

2 credits (30 Working hours)

Sr.No.	Course Objectives
1.	To understand the diverse branches of microbiology and their significance in environmental, agricultural, medical, industrial, food, dairy, and pharmaceutical sectors.
2.	To acquire knowledge of the applied aspects of microbiology in medical, industrial, agricultural, food, dairy, and pharmaceutical sectors.
3.	To appreciate the practical and commercial significance of microbes in improving human health, agriculture, food safety, and pharmaceutical production.
4	To study the microbiological aspects of food and dairy products
5	To understand pharmaceutical microbiology

Sr.No.	Course Outcomes
CO1	Students will be introduced to the scope, significance, and applications of various branches of microbiology.
CO2	Students will get conceptual understanding of microbial roles in diverse fields like environment, health, food, agriculture, industry, and pharmaceuticals.
CO3	Students will understand the applied aspects of microbiology in fields such as medicine, industry, agriculture, food, dairy, and pharmaceuticals.
CO4	Students will be able to classify foods based on perishability
CO5	Students will be able to **describe types and actions of antibiotics**

Credit No	OE 201 – MB- Scope of Microbiology	No. of hours
Credit 1	**Branches of Microbiology**	**15**

Unit 1	a) Introduction to various branches of microbiology – Air, water, soil microbiology, geomicrobiology, microbial genetics, molecular biology	3
	b) Industrial microbiology- Fermentation and its types, Parts of Fermenter, outline of fermentation process.	3
	c) Agricultural Microbiology- Introduction, microbial fertilizers, advantages, disadvantages of chemical and biological fertilizers.	3
	d) Food and Dairy microbiology- Classification of Foods based on stability: Perishable, Semi-perishable and stable. Definition and Composition of milk, Types of Milk (skimmed, toned, and homogenized).	3
	e) Pharmaceutical microbiology- Introduction and history of chemotherapy, Selective toxicity- definition, examples of penicillin and streptomycin, Methods of administration of drugs (oral, intramuscular, intravenous, intra dermal, subcutaneous, ocular, intranasal),	3
Credit 2	**Applied Microbiology**	**15**
Unit I	a) Industrial microbiology- Ethanol production. Distillation, Batch and Continuous distillation, Various aspects and production of distilled beverages - Beer and Wine production.	4
	b) Agricultural microbiology - Microbes as Biofertilizers and Biocontrol agents. Advantages, disadvantages of natural and chemical pesticides, Definition and scope of bio fungicide, bio insecticide (*Bacillus thuringiensis* .	4
	c) Food and Dairy microbiology - Chemical and physical properties of food affecting microbial growth, Fermented foods- nutritional value, advantages and health benefits,	4

	Probiotics and prebiotics, .Fermented dairy products Yoghurt and buttermilk	
	d) Pharmaceutical microbiology – Antibiotic- definition, examples, (Types of antibiotics- Natural, Semi synthetic) Over view of development of drug resistance and precautions to control drug resistance. Vaccines- Types (Live and killed with one example each) , functions and vaccination schedule in India.	3

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IKS - 201-MB Indian Knowledge System and Microbiology

2 credits (30 Working hours)

Course Objectives	
1	To explore Indian traditional knowledge related to microbes, health, food, and environment
2	To understand indigenous microbial techniques like fermentation, hygiene practices, and natural antimicrobials
3	To encourage scientific validation of traditional microbiology-related knowledge
4	To study indigenous environmental microbiological practices
5	To develop awareness of biopiracy issues and how India's Traditional Knowledge Digital Library

Course Outcomes After studying this course students will able to	
CO 1	Explain microbial concepts present in ancient Indian knowledge systems.
CO 2	Identify traditional microbial processes in food, medicine, and environment
CO 3	Analyze traditional antimicrobial and probiotic applications scientifically.
CO 4	Appreciate the relevance of indigenous practices to modern microbiology
CO 5	Students will understand the concept of biopiracy and be able to discuss real-world cases

Credit I	Title	Working Hours
Unit 1	1. Microbes and Health in Ancient India a) Krimi" (microorganisms) concept in Ayurveda. b) Disease causation, immunity ("Ojas"), hygiene (Dinacharya, Ritucharya).	5
	2. Traditional Fermented Foods and Microbes (6 hours) a) Indigenous fermentation practices: Curd, Idli, Dosa, Pickles, kanji, Anarasa (methodology & traditional importance)	5

	b) Role of beneficial microbes and probiotic concepts. (Health benefits of probiotics)	
	3.Natural Antimicrobials and Hygiene Practices a. Antimicrobial properties of Neem, Turmeric, Honey, Tulsi. b. Traditional sanitation: Ash Washing, Cow dung, smoke fumigation (sambrani smoke), herbal cleansers.	6
Credit II Unit I	A)Environmental Microbiology and Indigenous Practices Traditional water purification: Copper, silver, kasya vessels, plant-based methods (tulsi, moringa etc.) Soil microbial health management: Panchagavya and organic practices, traditional farming practices	8
	B) Scientific Validation and Biopiracy C) Example: Neem , Basmati patent case, Turmeric patent issue. D) How Traditional Knowledge Digital Library (TKDL) prevented biopiracy.	6

Recommended Resources:

1. *Indian Knowledge Systems* – NPTEL (IISc Bangalore)
2. *Science and Technology in Ancient India* – Debiprasad Chattopadhyaya
3. *Traditional Fermented Foods* – Ramesh C. Ray
4. Recent journal articles on microbiological validation of traditional practices.

Semester II

MB-251- MJ: Bacterial Genetics

[2 Credits; 30 Working hours]

Course Objectives	
1	To introduce the experimental evidence establishing DNA (and RNA) as genetic material
2	To explain the structural organization of nucleic acids
3	To familiarize students with the process of DNA replication
4	To build foundational knowledge of gene expression
5	To introduce students to plasmid genetics

Course Outcomes	
CO 1	Describe and interpret the experimental evidence that established DNA as the hereditary material in bacteria and viruses.
CO 2	Differentiate between DNA and RNA in terms of structure and function, and explain the molecular structure of DNA, including nucleotides, bonding, and conformational forms.
CO 3	Explain the mechanisms and models of DNA replication in prokaryotes, and identify the roles of associated enzymes and replication modes.
CO 4	Illustrate the basic processes of gene expression in bacteria, including the genetic code, transcription, and translation.
CO 5	Analyze the types, causes, and mechanisms of spontaneous and induced mutations in bacteria, and describe methods for mutant isolation and detection.

Credit I	**Topics**	**15**
Unit 1	**Understanding DNA: Experimental evidence for nucleic acid as genetic material.** a. Discovery of transforming material (hereditary material):Griffith's experiment b. Avery and MacLeod experiment c. Fraenkel-Conrat and Singer experiment (TMV virus) d. Hershay and Chase experiment	5

	Types of nucleic acids (DNA and RNAs)	2
	Structure of DNA a. Structure of Nitrogen bases, Nucleoside, Nucleotide and polynucleotide chain b. Bonds involved in DNA structure c. Different forms of DNA (A, B and Z form)	3
	Prokaryotic DNA replication a. Models of DNA replication (Conservative, semi-conservative and Dispersive) b. Meselson and Stahl's experiment (semi-conservative) c. Six basic rules of DNA replication d. Enzymes, proteins and other factors involved in DNA replication. e. Modes of DNA replication Rolling circle mechanism, theta and linear DNA replication	5
Credit II		
Unit 1	**Gene expression concept** a. Genetic code and its properties b. Outline of transcription and translation	3
	Mutations and reversions Concept of Mutation, Mutation rate, Mutation frequency. Types of mutations: Point mutation, Nonsense, Missense, Silent, Conditional lethal-temperature sensitive, Amber, Reverse, suppressor a. **Spontaneous Mutation**s - Discovery of spontaneous mutation (Fluctuation test) - Mechanism of spontaneous mutation (Tautomerism) - Isolation of Mutants: Replica plate technique b**. Concept of Induced Mutations** - Base pair substitution (Transitions, Transversions), Insertions and deletions-Frame / Phase shift mutations **Physical Mutagenic agents**: UV and X-ray **Chemical mutagenic agents:** - Base analogues (2 amino purine, 5 bromouracil), - HNO_2, Alkylating agents - Intercalating agents (EtBr, acridine orange)	3 3 4
	Plasmid genetics a. Properties of Plasmid b. Types of plasmids c.Plasmid curing	2

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MB-252 MJ: Air and Water Microbiology
[2 Credits; 30 Working hours]

Course Objectives	
1	To introduce the fundamental concepts of air and water microbiology
2	To familiarize students with airborne and waterborne pathogens
3	To equip students with the skills to apply sampling and detection techniques
4	To develop an understanding of control, mitigation, and sanitation strategies
5	To educate students on national and international standards and guidelines

Course Outcomes	
CO 1	Define and classify bioaerosols and explain their biological composition and environmental significance.
CO 2	Identify the sources and transmission routes of airborne microorganisms, including bacteria, fungi, viruses, and protozoa.
CO 3	Analyze the health impacts of airborne pathogens and understand mechanisms of infection, particularly in healthcare settings.
CO 4	Demonstrate understanding of various air sampling techniques used for the detection and study of airborne microorganisms.
CO 5	Evaluate air quality control measures, including sanitation methods, air filtration, PPE usage, and public health policies.

MB-252	Air and Water Microbiology	30
Credit I	Air Microbiology	15
	a. Introduction to Air Microbiology i. Definition and classification of bioaerosols: Droplet, droplet nuclei and aerosols ii. Normal flora of air and transient flora: Bacteria, fungi, viruses, and protozoa. iii. Sources and transmission pathways of airborne microbes. iv. Role of microorganisms in the atmosphere (e.g., as cloud condensation nuclei eg. Uredospore of rust and Fungi).	3

	b. Airborne infections (The types of airborne pathogens with respect to causative agent and infection) **i.** Bacterial pathogens **ii.** Fungal pathogens **iii.** Viruses **iv.** Nosocomial infections in healthcare settings (hospital-acquired infections) MRSA, *Acinetobacter, Streptococcus*.	1 1
	c. Air sampling methods: **i.** Passive Air Sampling (Settle Plate Method) **ii.** Impaction Air Samplers- Andersen **iii.** Filtration Method **iv.** Liquid Impingement (e.g., AGI-30, Bio Sampler, Lemon) **v.** Cyclone Samplers **vi.** Electrostatic Air Samplers **vii.** Real-Time Bioaerosol Monitors (e.g., FLIR IBAC, UV-LIF sensors)	4
	d. Control Measures and Mitigation Strategies: i. Air filtration, ventilation systems, and HVAC standards (Heating, Ventilation and Air Conditioning systems) ii. Personal protective equipment (PPE) in healthcare settings. iii. Public health measures and regulations (e.g., mask-wearing, social distancing) - Surveillance and outbreak monitoring of airborne diseases. e. Air sanitation: Physical and chemical methods f. Microbiological air quality standards MPCB: Air (Prevention and Control of Pollution) Act, 1981	6
Credit II	Water Microbiology	15
	a. Introduction to water microbiology i. Types of water: Potable water, Salt water, Brackish water, Hard water, Soft water, Distilled water, Wastewater, Black water, Grey water, Raw water ii. Enlist types of microorganisms found in water (bacteria, viruses, protozoa, algae, fungi)	1
	b.Waterborne Diseases: i. Bacterial Pathogens in Water:- Mechanisms of bacterial	3

	survival and proliferation in water. ii. Viral Pathogens in Water and their persistence. iii. Protozoan Pathogens:- Protozoa of concern (e.g., *Giardia lamblia*, *Cryptosporidium parvum*, *Entamoeba histolytica*) Challenges in detecting protozoan cysts in water. iv. Fungal and Algal Contaminants:- Role of fungi and algae in waterborne diseases (e.g., *Acanthamoeba*, algal toxins). v. Harmful algal blooms (HABs) and their health impacts.	
	c. Water Quality and Microbial Contaminants: i. Definition of "safe" drinking water ii. Microbial water quality indicators and their significance. • *Escherichia coli* • *Bifidobacterium* • *Streptococcus faecalis* • *Clostridium perfringens* • New indicators: *Campylobacter and Pseudomonas*, • Coliphages, Enteric viruses iii. Bacteriological analysis of potable water: • Presumptive coliform count • Confirmed test • Completed test • Eijkman test • Membrane filter technique	3 4
	d. Introduction to Molecular Techniques in Water Microbiology:- i.PCR and qPCR for detecting pathogens in water and Metagenomics for water Microbiome analysis ii. New Advances in Water Quality Monitoring:- Point-of-use testing and portable water testing kits and Biosensors for real-time detection of pathogens	1
	e. Regulatory Standards for Water Quality: i.World Health Organization (WHO) guidelines for drinking water quality. ii.Bacteriological standards of potable water: Bureau of Indian standards (BIS)	1
	f. Water purification Processes: i.Physical, chemical, and biological methods (Slow sand filter)of water purification	2

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2. Després, V. R., et al. (2012). "Microbial Aerosols in the Atmosphere." *Science*, 336(6081), 1205-1211.
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MB-253 -MJP: Applications of Microbiology II

[2 Credits: 60 Working hours]

(Total Workload: 2 credits × 30 hrs = 60 hrs in a semester)

1 Practical credit = 30 hours **1 Practical = 4.00 hours**

Course Objectives	
1	To impart knowledge and hands-on experience in air sampling techniques
2	To develop the skills necessary for identifying airborne pathogens
3	To train students in assessing the microbiological quality of potable water
4	To introduce students to molecular and genetic techniques
5	To expose students to real-world applications of microbiological practices

Course Outcomes	
CO 1	Demonstrate proficiency in air sampling and interpret microbial diversity
CO 2	Isolate, identify, and characterize airborne pathogens
CO 3	Evaluate the safety and potability of water samples
CO 4	Quantify DNA using the diphenylamine method
CO 5	Understand the operational aspects of microbial and environmental monitoring

Semester IV: MB-253 MJP: Applications of Microbiology II		
Expt. No.	**Topics**	**No. of Practical**
1.	Air sampling using an air sampler, calculation of air flora from different locations with the knowledge of respective standards of bacterial and fungal counts.	1
2.	Air Flora: a. Diversity determination. b. Simpson index and settling velocity determination	2
3.	Isolation and identification of air borne pathogens from clinical samples:	4

	a) *Staphylococcus aureus*and b) *Aspergillus* by a. Morphological, Cultural and Biochemical characteristics b. Morphological characteristics (Slide culture technique)	
4.	Bacteriological tests for potability of water a. MPN, Confirmed and Completed test. b. Membrane filter technique (Demonstration)	3
5.	Chemical estimation of DNA using DPA method	1
6.	a. Induction of mutation by using physical mutagen, UV rays anddetermination of UV- survival curve b. Isolation of mutants by Replica Plate Technique	2
7.	Visit to Industry/ Drinking Water treatment plant	2
Total		15

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Experiment 1. Air sampling using an air sampler:

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Experiment 2. Air Flora:

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Experiment 3. Isolation and identification of air borne pathogens

1. Mac Faddin J. F. (2000). Biochemical Tests for Identification of Medical Bacteria. United

2. Randhawa V. S., Mehta G. and Sharma K. B. (2009). practical and Viva in Medical Microbiology. Second Edition. Elsevier (A Division of Reed Elsevier India Pvt. Limited).

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Experiment 4. Acid fast staining.

1. Reynolds J, Moyes RB, Breakwell DP. Differential staining of bacteria: acid fast stain. Curr ProtocMicrobiol. 2009 Nov.

2. Van Deun A, Hossain MA, Gumusboga M, Rieder HL. Ziehl-Neelsen staining: theory and practice. Int J Tuberc Lung Dis. 2008 Jan;12(1):108-10.

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Experiment 5. Bacteriological tests for potability of water

1. Aneja K. R. (2007). Experiments in Microbiology, Plant Pathology and Biotechnology. New Age International, New Delhi, India

2. Atlas R. M. (1986; Digitized 2007). Basic and Practical Microbiology. United Kingdom: Macmillan.

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Experiment 6. Induction of mutations:

1. Bisen P. S. (2014). Laboratory Protocols in Applied Life Sciences. United Kingdom: CRC Press.

2. Gunasekaran P. (2007). Laboratory Manual In Microbiology. New Age International (P) Limited New Delhi, India

MB -271- VSC
Course Title: Techniques in Dairy Microbiology (Practical)
[2 Credits: 60 working hours]

(Total Workload: 2 credits × 30 hrs = 60 hrs in a semester)

1 Practical credit = 30 hours **1 Practical = 4.00 hours**

Course Objectives	
1	To train students in aseptic sampling and microbiological analysis of milk and milk products
2	To provide in-depth knowledge of microbial quality assessment of milk
3	To introduce chemical testing methods for detection of adulterants
4	To develop skills in probiotic microbiology
5	To familiarize students with advanced techniques in dairy quality control

Course Outcomes	
CO 1	To provide hands-on training in microbiological analysis of milk and milk products.
CO 2	To develop skills in detecting microbial contamination and ensuring dairy safety and quality.
CO 3	To introduce molecular and rapid detection techniques relevant to dairy microbiology.
CO 4	Isolate beneficial lactic acid bacteria (LAB)
CO 5	Apply chemical and rapid microbiological techniques

VSC- MB 271- Techniques in Dairy Microbiology (Practical)

Expt. No.	Topic	No. of Practical
	Module I: Basic Microbiological Techniques in Dairy	
1.	Sampling of milk and milk products – aseptic techniques and preservation.	1

	Milk Fat estimation technique.	
2.	Microscopic examination – Monochrome staining, Gram staining of milk samples.	2
3.	Standard Plate Count (SPC) – total viable count in milk.	1
4.	Methylene Blue Reduction Time Test (MBRT) and Resazurin Test for milk quality. (Phosphatase test, Mastitis test, Brucella ring test)	1
	Module II: Detection of Contaminants & Pathogens	
5.	Coliform count in milk – MPN (presumptive), confirmed, and completed tests.	1
6.	Detection of Yeast / mold in curd/yogurt.	1
7.	Detection of adulterants (e.g., starch, urea, detergents, etc.) using chemical methods.	1
	Module III: Fermentation and Probiotic Dairy Microbiology	
8.	i) Isolation of lactic acid bacteria (LAB) from curd/yogurt. ii) Antifungal activity of lactic acid bacteria (LAB).	2
9.	Preparation of dahi/yogurt using starter cultures.	1
10.	Acidity and pH determination of fermented dairy products.	1
	Module IV: Modern Techniques & Quality Control	
11.	Use of chromogenic media for rapid detection of *E. coli* and *Listeria*.	1
12.	Visit to Dairy Industry	2
	Total	15

References:

1. Robinson,RichardK.2002.DairyMicrobiologyHandbook:TheMicrobiologyofMilkandMilk Products, 3rd Edition. New York: Wiley Interscience.
2. Marth,E.H.,&Steele,J.(Eds.).(2001).AppliedDairyMicrobiology(2nded.).CRCPress. https://doi.org/10.1201/9781482294606
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Microbe, 2, 100034. Doi: https://doi.org/10.1016/j.microb.2024.100034

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Evaluation:
Continuous Assessment (30%) – attendance, viva, lab records.

Final Practical Exam (70%) – experiments, spotting, viva voce.

MB- 232- CEP Community Engagement Program

2 Credits [30 Hrs.] [Field Activities + Planning + Reporting]

Course Objectives	
1	To enable students to apply microbiological concepts for the benefit of local communities.
2	To promote awareness of public health, hygiene, sanitation, water safety, food safety, and antimicrobial resistance.
3	To develop skills in communication, teamwork, leadership, and public outreach..
4	To cultivate social responsibility and ethical scientific practices among microbiology students.
5	To bridge the gap between classroom learning and real-world community problems.

Course Outcomes Upon completion of the course, students will be able to:	
CO 1	Plan and participate in outreach activities based on microbiological issues affecting public health and environment.
CO 2	Communicate microbiological concepts effectively to non-scientific audiences.
CO 3	Collaborate with peers, faculty, and local stakeholders to organize awareness programs.
CO 4	Reflect on the role of microbiologists in addressing societal challenges.
CO5	Will able to write report and present it.

Core Components:

1. Orientation & Planning (6 hours)

- Importance of science outreach and microbiology in community health.
- Training in communication skills, ethics, and safety.
- Team formation and selection of target community/topic.

2. Community Engagement Activities (12–15 hours)

Students (in groups) will carry out one or more of the following:

- Awareness campaigns on:
  - Personal and community hygiene
  - Safe water and sanitation

- Vector-borne and communicable diseases
- Antimicrobial resistance (AMR)
- Safe food practices (e.g., hand washing, street food hygiene)

- Demonstrations (using posters, models, videos, or hands-on activities).
- Distribution of pamphlets/infographics created by students.
- Interaction with schools, self-help groups, farmers, or healthcare workers.

etc

Documentation & Reflection **(6–8 hours)**

- Maintain logbooks or field diaries.
- Collect community feedback and summarize outcomes.
- Final group report submission.
- Oral/poster/ppt presentation of experiences and impact.

Evaluation Scheme:

Component	Marks
Participation and Attendance	10
Community Interaction Quality	10
Educational Material Developed	10
Report and Presentation	15
Reflection and Teamwork	05
Total	50

Suggested sample Community Topics:

- Why handwashing matters: Microbes under our nails
- Antibiotic misuse and resistance: A village-level survey
- How to store and handle food safely at home
- Preventing waterborne diseases: Tips for local households
- Role of kitchen herbs as antimicrobials (Turmeric, Neem, Garlic)

Teaching Methods:

- Brief lectures on outreach and science communication
- Group mentoring and progress checks
- Field visits and direct community interaction

• Use of vernacular language for communication is encouraged
Activity Outcomes [Fieldwork Report Components] (per group of 2 – 3 students / pair) • Activity plan + photos • Public awareness materials (pamphlets/posters) • Community feedback (optional) • Final group report + presentation

Recommended Resources:

1.WHO Hand Hygiene Guidelines

2. India AMR Surveillance Network (ICMR)

3.National Guidelines on Food Safety and Hygiene

4.Online portals: Swachh Bharat, Jal Shakti Abhiyan

5.Science Communication: A Practical Guide for Scientists" *Laura Bowater & Kay Yeoman*– Covers effective public engagement and communication strategies.

6."Outreach and Engagement for Health Professions"*Lynn Blanchard* – Useful for structuring community-based health and hygiene programs.

7."Microbiology and Health Care"*R. Ananthanarayan and C.K. Jayaram Paniker*– Basic concepts for community health microbiology (infection, sanitation).

➢ Journal Articles & Case Studies:

1."Community-based education in health sciences"(Indian Journal of Community Medicine, ICMR),– Discusses integrating field exposure with academic microbiology.

2."Effectiveness of awareness programs on hygiene practices in rural areas" (Available via PubMed, ResearchGate)– Good source for data-driven outcomes and survey design.

3."Antimicrobial Resistance: A Community Perspective"(WHO Bulletin, 2022)– Focus on engaging communities to fight AMR.

➢ Online Portals & Government Resources:

1.Swachh Bharat Abhiyan Portal,https://swachhbharatmission.gov.in – Resources, posters, and outreach guidelines for hygiene campaigns.

2.National Centre for Disease Control (NCDC) – Health education materials. https://ncdc.gov.in

3.World Health Organization – Public Health Education Materials https://www.who.int– Ready-to-use content on hygiene, AMR, food safety, etc.

4.Traditional Knowledge Digital Library (TKDL) – CSIRhttps://www.tkdl.res.in – If your program includes traditional practices.

Videos & Toolkits:

1.WHO “SAVE LIVES: Clean Your Hands” Toolkit – For hand hygiene campaigns. Posters and videos available.

2.CDC (USA) Educational Resources https://www.cdc.gov/healthcommunication

– Public health outreach examples.

MB -291-MN: Environmental Microbiology

2 Credits (15 x 2 = 30 Working hours)

Course Objectives	
1	To introduce the fundamental concepts of environmental microbiology
2	To study the role of microorganisms in air and water quality
3	To explore microbial diversity in aquatic environments
4	To examine the structure and function of soil microbiomes
5	To understand the applications of microorganisms in biodegradation, bioremediation, and plant growth promotion

Course Outcomes	
CO1	The students will be able to get knowledge about environmental microbiology as a discipline.
CO2	The students will gain the knowledge of air, water ans soil microorganisms and their role in the ecosystems
CO3	The students will understand the sources of air and water pollution and will learn the methods of detection of these pollutants.
CO4	The students will know soil microbiome and role of microorganisms in soil health
CO5	The students will understand importance of microorganisms in agriculture and the concept of bioremediation

Credits	Subject	No. of Lectures
Credit 1	Introduction to environmental Microbiology and microbial diversity in air and aquatic ecosystem	15
Unit 1 A)	Introduction to Environmental Microbiology a. Environmental Microbiology as a discipline	2
B)	Air Microbiology a. Microbial diversity of air b. Dispersal of microorganisms in air and airborne infections c. Air pollution and air quality standards	4
C)	Water Microbiology a. Microbial diversity of fresh water (pond, lake, river) and	9

	marine water. b. Sources and types of water pollution. c. Biological indicators of water pollution, and methods to detect potability of drinking water (1) Standard qualitative procedure: presumptive test/MPN test, confirmed and completed tests for faecal coliforms (2) Membrane filter technique d. New indicators of water pollution (*Compylobacter* and *Pseudomonas*)	
Credit 2	Microbial diversity in soil ecosystem And biodegradation	15
A)	Soil Microbiology a. Composition of soil b. Microbial diversity of soil c. Rhizosphere d. Role of microorganisms in composting e. Biogeochemical cycles and role of microorganisms in Carbon, Nitrogen, Sulphur, Phosphorus cycle	8
B)	PGPR, Mycorrhizae, Nitrogen fixing bacteria, phosphate-solubilizers, microorganisms as biocontrol agent	4
C)	a. Introduction to biodegradation, bioremediation and bioaugmentation. b. Role of microorganisms in biodegradation and bioremediation.	3

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1. Dubey R. C. and Maheswari D.K. Textbook of Microbiology. S. Chand Publishing. ISBN: 9788121926201
2. Pawar C. B. and Daginawala H.F. (1982). General Microbiology. Vol. I and II. 1st Edition. Himalaya Publishing House, Mumbai. ISBN: 9789350240892and ISBN9789350240908
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4. Prescott L. M., Harley J. P. and Klein D. A. (2006). Microbiology. 6th Edition. McGraw Hill Higher Education. ISBN-13: 978-0-07-295175-2
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MB-292-MNP: Practices in Environmental Microbiology

[2 Credits: 60 Lectures]

(Total Workload: 2 credits × 30 hrs = 60 hrs in a semester)

1 Practical credit = 30 hours **1 Practical = 4.00 hours**

Course Objectives	
1	To equip students with practical skills for sampling and analyzing airborne microorganisms
2	To train students in evaluating water quality and potability
3	To introduce methods for enrichment, isolation, and application of microbial bioinoculants
4	To develop competency in screening rhizobacteria
5	To provide experiential learning through field visits

Course Outcomes:	
CO1	The students will be able to discover, recognise and categorise microorganisms from environmental samples
CO2	The students will be able to differentiate and evaluate the diversity of air microflora
CO3	The students will be able to detect, demonstrate and estimate water pollution due to faecal bacteria
CO4	The students will be able to isolate, characterise and evaluate the role of nitrogen-fixing or photosynthetic bacteria
CO5	The students will be able to isolate, characterise and evaluate the role of plant growth-promoting bacteria

Semester IV:MB-292-MNP: Practical course based on MB-291-MN		
Expt. No.	**Topics**	**No. of Practicals**
1	**Air sampling** Calculation of air flora from different locations (with the knowledge of respective standards of bacterial and fungal counts) using an air sampler.	1
2	**Study of air microflora** a) Diversity determination b) Simpson's diversity index and settling velocity determination	2
3	**Bacteriological tests for the potability of water** a) MPN, confirmed and completed tests b) Membrane filter technique (Demonstration)	3
4	**Enrichment, isolation, preparation and application of bioinoculants** a) *Azotobacter* species (free living) and b)*Rhizobium* species (symbiotic) or Blue-green algae (*Cyanobacteria*)	4

5	**Screening for and detection of plant growth-promoting activity** Phosphate-solubilizing / indole acetic acid synthesizing /siderophore producing rhizobacteria	3
6	Visit to a sewage treatment plant/drinking water treatment plant or Visit to a biofertilizer manufacturing organization / biocomposting organization	2
	Total	**15**

REFERENCES:

Experiment 1: Air sampling

- ChosewoodL.C.andWilsonD.E.(2007).BiosafetyinMicrobiologicalandBiomedicalLaboratories.DIANE PublishingCompany.USA
- GeisA.P.(2020).CosmeticMicrobiology:APracticalApproach.UnitedStates:CRCPress.
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- D.(Editors)(2008).ManualofEnvironmentalMicrobiology.UnitedStates:ASMPress.72(2):ISBN 9781555813796.
- YatesM.V.(ChiefEditor),NakatsuC.H.,MillerR.V.andPillaiS.D.(Editors)(2016).Manual ofEnvironmental Microbiology.United States:Wiley.ISBN: 9781683673231
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- WHOGuidelinesforIndoorAirQuality:DampnessandMould.(2009). Philippines:WHO.

Experiment 2: Airflora

- AnejaK.R.(2007).ExperimentsinMicrobiology,PlantPathologyandBiotechnology.New AgeInternational,NewDelhi,India.ISBN:9788122414943
- CoxC.C.andWathesC.M.(2020).BioaerosolsHandbook.UnitedStates:CRCPress.ISBN: 9781000115048
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- VermaA.S.,DasS.,andSinghA.(2014).LaboratoryManualforBiotechnology.SChandand CompanyLimited, New Delhi,India.ISBN: 9789383746224

Experiment3:Bacteriologicaltests forthe potability ofwater

- AnejaK.R.(2007).ExperimentsinMicrobiology,PlantPathologyandBiotechnology.New AgeInternational,NewDelhi,India.ISBN:9788122414943
- AtlasR.M.(1986;Digitized2007).BasicandPracticalMicrobiology.UnitedKingdom:Macmillan.ISBN: 9780023043505
- DubeyR.C.andMaheshwariD.K.(2002).PracticalMicrobiology.S.ChandandCompanyLimited,NewDelhi,India.ISBN: 9788121921534
- NolletL. M.L.and De GelderL. S. P. (2013). Handbook ofWaterAnalysis. Third Edition.United States:Taylorand Francis.ISBN:ISBN 9781439889640

Experiment4:Enrichment,isolation,preparationandapplicationofbioinoculants

*Azotobacter*species:

- AnejaK.R.(2007).ExperimentsinMicrobiology,PlantPathologyandBiotechnology.New AgeInternational,NewDelhi,India.ISBN:9788122414943
- Dubey R. C. andMaheshwariD. K. (2002). PracticalMicrobiology. S. ChandandCompanyLimited,NewDelhi,India.ISBN: 9788121921534
- GunasekaranP.(2007).LaboratoryManualinMicrobiology.NewAgeInternational(P)LimitedNewDelhi,India.ISBN: 9788122407830

*Rhizobium*species:

- AnejaK.R.(2007).ExperimentsinMicrobiology,PlantPathologyandBiotechnology.New

AgeInternational,NewDelhi,India.ISBN:9788122414943
- Dubey R. C. andMaheshwariD. K. (2002). PracticalMicrobiology. S. ChandandCompanyLimited,NewDelhi,India.ISBN: 9788121921534
- GunasekaranP.(2007).LaboratoryManualInMicrobiology.NewAgeInternational(P)LimitedNewDelhi,India.ISBN: 9788122407830

Blue Green Algae (cyanobacteria):

- AnejaK.R.(2007).ExperimentsinMicrobiology,PlantPathologyandBiotechnology.New AgeInternational,NewDelhi,India.ISBN:9788122414943
- BisenP.S.(2014).LaboratoryProtocolsinAppliedLifeSciences.Firstedition.UnitedKingdom: CRC Press.ISBN: 9780429097287
- Dubey R. C. andMaheshwariD. K. (2002). PracticalMicrobiology. S. ChandandCompanyLimited,NewDelhi,India.ISBN: 9788121921534
- KumarV.(2012).LaboratoryManualofMicrobiology.ScientificPublishers,Jodhpur,Rajasthan,India.ISBN:9789387307841

Experiment 5:Screening for and detection of plant growth-promoting activity

- AnejaK.R.(2007).ExperimentsinMicrobiology,PlantPathologyandBiotechnology.New AgeInternational,NewDelhi,India.ISBN:9788122414943
- Dubey R. C. andMaheshwariD. K. (2002). PracticalMicrobiology. S. ChandandCompanyLimited,NewDelhi,India.ISBN: 9788121921534
- KumarV.(2012).LaboratoryManualofMicrobiology.ScientificPublishers,Jodhpur,Rajasthan,India.ISBN:9789387307841

OE-251- MB Use of Microorganisms in Daily Life

[2 Credits: 60 Working hours]

(Total Workload: 2 credits × 30 hrs = 60 hrs in a semester)

1 Practical credit = 30 hours **1 Practical = 4.00 hours**

Course Objectives	
1	To acquaint with the new discipline of science along with major course
2	To develop awareness about use full and harm full microbes
3	To use the knowledge of microbes in daily life
4	To gain practical knowledge of handling of microbes and microbiology instruments
5	To encourage observational and diagnostic skills in field-based microbiology

Course Outcomes	
CO1	Demonstrate understanding and implementation of microbiological safety measures
CO2	Identify and properly use microbiology lab instruments and glassware
CO3	Operate and handle a compound microscope proficiently
CO4	Prepare and observe wet mounts and perform basic staining techniques
CO5	Collect and identify microbial infections in plant samples

Sr.	Title	Lectures
1.	Safety rules in Microbiology laboratory	1
2	Introduction of lab instruments used in microbiology- incubator, hot air oven, autoclave, table top centrifuge.	1
3.	Introduction of glassware used in microbiology – test tube, pipettes, conical flasks, beaker, petri dish, slide, coverslip – uses and care	1
4	How to write record book of microbiology	1
5	Handling of compound microscope- parts, adjustment of light, focusing, use of 10x, 40x objectives	1

6	Technique of wet mount preparation of pond water –	2
7	Observation of microorganism from natural sources- spoiled bread, coconut, infected leaf, fruits etc. by wet mount preparation	2
8	Cultivation and observation of protozoa from hay infusion broth	2
9	Collection of infected plant samples from nature – recording of symptoms, identification of diseases (Five samples)	1
10	Aseptic techniques used in microbiology – disinfection of hands, working between two burners, sterilization of nichrome wire loop, transferring suspension aseptically	1
11	Monochrome staining of yeast.	1
12	Negative staining of yeast.	1
	Total	15

References:

1. Aneja K. R. (2007). Experiments in Microbiology, Plant Pathology And Biotechnology. New Age International, New Delhi, India
2. Smith H. and Brown A. (2023). Benson's Microbiological Applications, Laboratory ,Manual,15thEdition. McGraw Hill.
3. Cappuccino J. G. and Welsh C. T. (2016). Microbiology: A Laboratory Manual. Pearson Education
4. Deshmukh A. M. (2007). Handbook of Media Stains Reagents Microbiology. Oxford BookCompany
5. Garratt D. C. (2012). The Quantitative Analysis of Drugs: 3rd Edition. United Kingdom:Springer US.

SEC-251-MB – Study of S.O.P.'s (Laboratory Instruments)

[2 Credits: 60 Working hours]

(Total Workload: 2 credits × 30 hrs = 60 hrs in a semester)

1 Practical credit = 30 hours **1 Practical = 4.00 hours**

Course Objectives	
1	Understand Standard operating procedures (SOPs) of various instruments used in microbiology laboratory
2	Prepare S.O. P. for Laboratory Instruments
3	Inculcate importance of Standard operating procedures (SOPs)
4	Use of Laboratory Instruments in scientific manner
5	Apply their in-depth knowledge and skills of Laboratory Instruments in various industries

Course Outcomes	
CO1	Demonstrate proper operation and maintenance of microbiology laboratory instruments
CO2	Execute accurate measurements using analytical instruments
CO3	Perform sterilization and aseptic procedures efficiently
CO4	Calibrate and troubleshoot common laboratory instruments
CO5	Document and follow SOPs for each instrument accurately

Practical No.	Title of the Experiment	No. of Practicals
1	Study of S.O.P. of Weighing balance	1
2	Study of S.O.P. of Colorimeter	1
3	Study of S.O.P. of Spectrophotometer	1
4	Study of S.O.P. of Incubator	1
5	Study of S.O.P. of Hot air Oven	1

6	Study of S.O.P. of Autoclave	1
7	Study of S.O.P. of Rotary Shaker	1
8	Study of S.O.P. of Air flow meter	1
9	Study of S.O.P. of Distillation unit	1
10	Study of S.O.P. of pH meter	1
11	Study of S.O.P. of Centrifuge	1
12	Study of S.O.P. of membrane filter assembly	1
13	Study of S.O.P. of Incubator shaker	1
14	Study of S.O.P. of Laminar air flow	1
15	Study of S.O.P. of BOD incubator	1
TOTAL		**15**