

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's
New Arts, Commerce, and Science College, Ahmednagar
(Autonomous)
(Affiliated to Savitribai Phule Pune University, Pune)



National Education Policy (NEP)
Choice Based Credit System (CBCS)

Programme Skeleton and Syllabus of
B.Sc. Microbiology (Major)

Implemented from
Academic Year 2023-24

Credit Distribution: B.Sc. Microbiology (Major) including Minor and OE and other courses.

	Type of Courses	III Yr	IV Yrs (Honours)	IV Yrs Research
Major Marathi	Discipline-Specific Courses (DSC)	46	74	66
	Discipline Specific Elective (DSE)	08	16	16
	Skill Enhancement Courses (SEC)	06	06	06
	Vocational Skill Courses (VSC)	08	08	08
	On-Job Training (OJT)	04	08	04
	Field Project (FP)	04	04	04
	Community Engagement and Service (CEP)	02	02	02
	Research project	00	00	12
	Research Methodology	00	04	04
	Indian Knowledge System	02	02	02
	Total (I, II and III Year)	80	124	124
Minor	Minor	20	20	20
Other Courses	Open Elective (OE)/ Multidisciplinary Courses	12	12	12
	Co-Curricular Courses	08	08	08
	Ability Enhancement Courses	08	08	08
	Value Education Courses	04	04	04
	Total	132	176	176

B. Sc. Programme Framework: Credit Distribution

Y e a r	S e m e s t e r	L e v e l	Major											M i n o r	O E	C C	A E C	V E C	T o t a l
			D S C		D S E		SEC		VSC		FP/ OJ T /IN/C EP		I K S						
I	I	4.5	T	P	T	P	T	P	T	P	T	P			T/P	-	-	-	-
I	II	4.5	4	2	-	-	-	2	-	-	-	-	2	03	3	2	2	2	22
			6	-	-	-		2	-	2	-	-		03	3	2	2	2	22
Exit Option: Award of UG Certificate in Major with 44 credits and an additional 4 credit core NSQF course /Internship or Continue with Major and Minor																			
II	III	5.0	6	2	-	-		2	-	-	-	2		03	3	2	2	-	22
II	IV	5.0	6	2	-	-		-	-	2	-	2		03	3	2	2	-	22
Exit Option: Award of UG Diploma in Major with 88 credits and an additional 4 credit core NSQF course /Internship or Continue with major and minor																			
III	V	5.5	8	2	2	2	-	-	-	2		2		04	-	-	-	-	22
III	VI	5.5	6	2	2	2	-	-	-	2		4		04	-	-	-	-	22
Exit Option: Award of UG Degree in Major and Minor with 132 credits or continue with Major for a 4-year Degree																			
IV	VII	6.0	8	6	2	2	RM-4	-	-	-	-		-	-	-	-	-	-	22
IV	VIII	6.0	8	6	2	2	-	-	-	-	-	4		-	-	-	-	-	22
Four Year UG Degree(Honours) with Major and Minor with 176 credits																			
IV	VII	6.0	6	4	2	2	RM-4	-	-	-	4		-	-	-	-	-	-	22
IV	VIII	6.0	6	4	2	2	-	-	0	-	-	8		-	-	-	-	-	22
Four Year UG Degree (Honours with Research) with Major and Minor with 176 credits																			

B. Sc. Programme Framework: Course Distribution

Y e a r	S e m e s t e r	L e v e l	Major										M i n o r		O E	C C	A E C	V E C	T o t a l	
			D S C		D S E		SEC		VSC		FP/ OJ T /IN/C EP									I K S
I	-	-	T	P	T	P	T	P	T	P	T	P		T	P	-	-	-	-	
I	I	4.5	2	1	-	-	-	1	-	-	-	-	1	1	1	1	1	1	1	10
	II	4.5	2	-	-	-		1	-	1	-	-		1	1	1	1	1	1	09
Exit Option: Award of UG Certificate in Major with 44 credits and an additional 4 credit core NSQF course /Internship or Continue with major and minor																				
II	III	5.0	2	1	-	-		1	-	-	-	1		1	1	1	1	-	-	09
II	IV	5.0	2	1	-	-		-	-	1	-	1		1	1	1	1	-	-	09
Exit Option: Award of UG Diploma in Major with 88 credits and an \additional 4 credit core NSQF course /Internship or Continue with major and minor																				
III	V	5.5	2	1	1	1	-	-	-	1		1		1	-	-	-	-	-	08
III	VI	5.5	2	1	1	1	-	-	-	1		1		1	-	-	-	-	-	08
Exit Option: Award of UG Degree in Major and Minor with 132 credits or continue with Major for a 4-year Degree																				
IV	VII	6.0	3	3	1	1	0	1	-	-	-	-		-	-	-	-	-	-	09
IV	VIII	6.0	3	3	1	1	-	-	-	-	-	1		-	-	-	-	-	-	09
Four Year UG Degree(Honours) with Major and Minor with 176 credits																				
IV	VII	6.0	2	2	1	1	0	1	-	-	-	1		-	-	-	-	-	-	08
IV	VIII	6.0	2	2	1	1	-	-	-	-	-	1		-	-	-	-	-	-	07
Four Year UG Degree (Honours with Research) with Major and Minor with 176 credits																				

Programme Framework (Course Distribution): B.Sc. Microbiology (Major)

Y e a r	Se m e s t e r	L e v e l	Major											Total	
			DS C		DSE		SEC		VSC		FP/OJT /IN/CEP/PR		IKS		
			T	P	T	P	T	P	T	P	T	P	T	T	P/PR
I	I	4.5	2	1	-	-	-	1	-	-	-	-	01	03	02
I	II	4.5	2	-	-	-	-	1	-	1	-	-		02	02
II	III	5.0	2	1	-	-	-	1	-	-	-	1		02	03
II	IV	5.0	2	1	-	-	-	-	-	1	-	1		02	03
III	V	5.5	2	1	1	1	-	-	-	1		1		03	04
III	VI	5.5	2	1	1	1	-	-	-	1		1		03	04
B.Sc. Honours															
IV	VII	6.0	3	3	1	1	RM-1	-	-	-	-	-		05	04
IV	VIII	6.0	3	3	1	1	-	-	-	-	-	1		04	05

Programme Framework (Credit Distribution): B.Sc. Microbiology (Major)

Y e a r	Sem e s t e r	L e v e l	Major											T o t a l
			DSC		DSE		SEC		VSC		FP/OJT /IN/CEP/R P		IK S	
			T	P	T	P	T	P	T	P	T	P	T	
I	I	4.5	4	2	-	-	-	2	-	-	-	-	02	10
I	II	4.5	6	-	-	-	-	2	-	2	-	-		10
II	III	5.0	6	2	-	-	-	2	-	-	-	2		12
II	IV	5.0	6	2	-	-	-	-	-	2	-	2		12
III	V	5.5	8	2	2	2	-	-	-	2		2		18
III	VI	5.5	6	2	2	2	-	-	-	2		4		18
IV	VII	6.0	8	6	2	2	RM-4		-	-	-	-		22
IV	VIII	6.0	8	6	2	2	-	-	-	-	-	4		22
IV	VII	6.0	6	4	2	2	RM-4	-	-	-	-	4		22
IV	VIII	6.0	6	4	2	2	-	-	-	-	-	8		22

Programme Framework (Courses and Credits): B.Sc. Microbiology (Major)

Sr. No.	Year	Semester	Level	Course Type	Course Code	Title	Credits
1.	I	I	4.5	DSC-1	BS-MR111T	Introduction to Microbiology	02
2.	I	I	4.5	DSC-2	BS-MR112T	Basic Techniques in Microbiology	02
3.	I	I	4.5	DSC-3	BS-MR113P	Practical Course based on Theory Paper I and II	02
4.	I	I	4.5	SEC-1	BS-MR114P	Computer Applications	02
5.	I	I	4.5	IKS-1	BS-MR115T	Vedic Microbiology	02
6.	I	II	4.5	DSC-4	BS-MR121T	Cell Biology of Microorganisms	03
7.	I	II	4.5	DSC-5	BS-MR122T	Bacteriology and Virology	03
8.	I	II	4.5	SEC-2	BS-MR123P	Microbiology Methods	02
9.	I	II	4.5	VSC-1	BS-MR124P	Basic Laboratory Practices In Microbiology	02
10.	II	III	5.0	DSC-6	BS-MR231T	Immunology	03
11.	II	III	5.0	DSC-7	BS-MR232T	Environmental Microbiology	03
12.	II	III	5.0	DSC-8	BS-MR233P	Practical Course based On Theory Paper I and II	02
13.	II	III	5.0	SEC-3	BS-MR234P	Biochemical Techniques and Instrumentation	02
14.	II	III	5.0	FP-01	BS-MR235P	Field Project	02
15.	II	IV	5.0	DSC-9	BS-MR242T	Bacterial Genetics	03
16.	II	IV	5.0	DSC-10	BS-MR242T	Bacterial Physiology and Enzymology	03
17.	II	IV	5.0	DSC-11	BS-MR243P	Practical Course based On Theory Paper I and II	02

18.	II	IV	5.0	VSC-2	BS-MR244P	Clinical Pathology and Biochemistry	02
19.	II	IV	5.0	CEP-01	BS-MR245P	Community engagement and Service	02
20.	III	V	5.5	DSC-12	BS-MR351T	Medical Microbiology	04
21.	III	V	5.5	DSC-13	BS-MR352T	Molecular Biology	04
22.	III	V	5.5	DSC-14	BS-MR353P	Practical Course based On Theory Paper I and II	02
23.	III	V	5.5	DSE-01	BS-MR355T	Enzymology	02
24.	III	V	5.5	DSE-02	BS-MR356P	Practical Course based On Enzymology	02
25.	III	V	5.5	VSC-3	BS-MR357P	Food and Dairy Microbiology	02
26.	III	V	5.5	FP-02	BS-MR358P	Field Project	02
27.	III	VI	5.5	DSC-15	BS-MR361T	Fermentation Technology	03
28.	III	VI	5.5	DSC-16	BS-MR362T	Applied Microbiology	03
29.	III	VI	5.5	DSC-17	BS-MR363P	Practical Course based On Theory Paper I and II	02
30.	III	VI	5.5	DSE-03	BS-MR364T	Immunology	02
31.	III	VI	5.5	DSE-04	BS-MR365P	Practical course based on immunology	02
32.	III	VI	5.5	VSC-4	BS-MR366P	Industrial Microbiology	02
33.	III	VI	5.5	OJT-01	BS-MR367P	On Job Training	04

B.Sc. Microbiology (Major with Honours)

34.	IV	VII	6.0	DSC-18	BS-MR471T	Microbial Cell Organization And Biochemistry	03
35.	IV	VII	6.0	DSC-19	BS-MR472T	Quantitative Biology	03
36.	IV	VII	6.0	DSC-20	BS-MR473T	Microbial Systematics	02
37.	IV	VII	6.0	DSC-21	BS-MR474 P	Practical Course Based On Biochemical Techniques	02
38.	IV	VII	6.0	DSC-22	BS-MR475P	Practical Course Based On Biostatistics And Bioinformatics	02
39.	IV	VII	6.0	DSC-23	BS-MR476P	Practical Course Based On Developmental Biology And Microbial Diversity	02
40.	IV	VII	6.0	DSE-05	BS-MR477T	Virology	02
41.	IV	VII	6.0	DSE-06	BS-MR478P	Practical Course Based On Virology	02
42.	IV	VII	6.0	RM-01	BS-MR479T/P	Research Methodology	04
43.	IV	VIII	6.0	DSC-24	BS-MR481T	Instrumentation And Molecular Biophysics	03
44.	IV	VIII	6.0	DSC-25	BS-MR482T	Molecular Biology	03
45.	IV	VIII	6.0	DSC-26	BS-MR483T	Nitrogen Metabolism And Photosynthesis	02
46.	IV	VIII	6.0	DSC-27	BS-MR484P	Practical Course Based On Instrumentation Techniques	02
47.	IV	VIII	6.0	DSC-28	BS-MR485P	Practical Course Based On Molecular Biology	02

48.	IV	VIII	6.0	DSC-29	BS-MR486P	Practical Course Based On Nitrogen Metabolism And Photosynthesis	02
49.	IV	VIII	6.0	DSE-07	BS-MR487T	Enzymology And Bioenergetics	02
50.	IV	VIII	6.0	DSE-08	BS-MR488P	Practical Course Based On Enzymology	02
51.	IV	VIII	6.0	OJT-02	BS-MR489P	On Job Training	04

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's
New Arts, Commerce and Science College, Ahmednagar
(Autonomous)

Board of Studies in Microbiology

Sr. No.	Name	Designation
1.	Ms. Giramkar Dipali D.	Chairman
2.	Mr. Shaikh Sajid H.	Member
3.	Ms. Pansare Ragini P.	Member
4.	Ms. Shinde Ashwini A.	Member
5.	Ms. Mehetre Vidya S.	Member
6.	Ms. Shinde Supriya D.	Member
7.	Dr. Gahile Yogesh R.	Member
8.	Mr. Wani Ashish S.	Member
9.	Dr. Patil Ulhas K.	Member (Co-Opt)
10.	Dr. Dixit Prashant P.	Academic Council Nominee
11.	Dr. Naphade Bhushan S.	Academic Council Nominee
12.	Mr. Choure Rajendra G.	Vice-Chancellor Nominee
13.	Mr. Yewatkar Saikiran	Alumni
14.	Mr. Dube Chandrakant G.	Industry Expert

1. Prologue/ Introduction of the programme: At least one page

Microbiology is a broad discipline of Biology which encompasses five groups of microorganisms i.e. bacteria, protozoa, algae, fungi and viruses. It studies the interaction of microorganisms with their environments as well as how these organisms are harnessed in human endeavor and their impact on society. The study has its extensions in various other conventional and advanced fields of biology by employing microbes as study models. Since inception of Microbiology as a branch of Science, it has remained an ever-expanding field of active research, broadly categorized as Pure and Applied Science. Different branches of Pure Microbiology based on taxonomy are Bacteriology, Mycology, Protozoology and Parasitology, Phycology and Virology; with considerable overlap between these specific branches over each other and also with other disciplines of Life Sciences, like Botany, Zoology, Cell Biology, Biochemistry, Biotechnology, Nanotechnology, Bioinformatics, etc. Areas in the applied Microbial Sciences can be identified as: Medical, Pharmaceutical, Industrial (Fermentation, Pollution Control), Air, Water, Food and Dairy, Agriculture (Plant Pathology and Soil Microbiology), Veterinary, Environmental (Ecology, Geomicrobiology); and the technological aspects of these areas. Knowledge of different aspects of Microbiology has become crucial and indispensable to the society. Study of microbes has become an integral part of education and human progress. The science of Microbiology has an important role to play in health, agriculture, environment and industry. Several discoveries in the last two to three decades, which significantly impact these areas, have put Microbiology on the center stage of teaching, research and development all over the world. There is a continuous demand for microbiologists as work force – education, industry and research. Career opportunities for the graduate students are available in industry and research equally. In the post globalization world higher education has to play a significant role in creation of skilled human resources for the well-being of humanity.

The NEP-2020 offers an opportunity to effect paradigm shift from a teacher-centric to student-centric higher education system in India. It caters skill based education where the graduate attributes are first kept in mind to reverse-design the programs, courses and supplementary activities to attain the graduate attributes and learning attributes. The learning outcomes-based curriculum framework for a degree in B.Sc. (Honours) Microbiology is intended to provide a comprehensive foundation to the subject and to help students develop the ability to successfully continue with further studies and research in the subject while they are equipped with required

skills at various stages. Effort has been made to integrate use of recent technology and use of MOOCs to assist teaching-learning process among students. The framework is designed to equip students with valuable cognitive abilities and skills so that they are successful in meeting diverse needs of professional careers in a developing and knowledge-based society. The curriculum framework takes into account the need to maintain globally competitive standards of achievement in terms of knowledge and skills in Microbiology and allied courses, as well as develop scientific orientation, spirit of enquiry, problem solving skills, human and professional values which foster rational and critical thinking in the students. This course serves a plethora of opportunities in different fields right from classical to applied aspects in Microbiology. Some of the characteristic attributes a graduate in Microbiology should possess are:

- Disciplinary knowledge and skills • Skilled communication
- Critical thinking and problem solving capacity • Logical thinking and reasoning
- Team Spirit & Leadership Quality • Digital efficiency • Ethical awareness / reasoning
- National and international perspective • Lifelong learning

2. Programme Outcomes (POs)

Students enrolled in the program will complete a curriculum that exposes and trains students in a full range of essential skills and abilities. Theory supplemented with extensive practical skill sets will help a graduate student to avail the opportunities in the applied fields (research, industry or institutions), without any additional training. They will have the opportunity to master the following objectives.

1. To enrich students' knowledge and train them in the pure microbial sciences
2. To Acquire knowledge and understanding of the microbiology concepts as applicable to diverse areas such as medical, industrial, environment, genetics, agriculture, food etc.
3. To introduce the concepts of application and research in Microbiology
4. To inculcate sense of scientific responsibilities and social and environment awareness
5. To help students build-up a progressive and successful career

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's
New Arts, Commerce and Science College, Ahmednagar
(Autonomous)
Syllabus
B.Sc. Microbiology (Major)

Title of the Course: Introduction to Microbiology								
Year: I					Semester: I			
Course Type	Course Code	Credit Distribution		Credits	Allotted Hours	Allotted Marks		
		Theory	Practical			CIE	ESE	Total
DSC-1	BS-MR 111T	02	00	02	30	15	35	50

Learning Objectives: The objective of this course to introduce the students to the subject of Microbiology, different branches of microbiology, history and development of Microbiology as well as bacterial cytology.

Course Outcomes (Cos)

1. Students will learn the historical developments in Microbiology from the discovery of microbes to the role of microbes in various fields
2. Students will learn the contributions of various scientists in the historical and modern era of Microbiology and get acquainted with the work of Nobel Laureates
3. Students will explore the Diversity of microbes like algae, fungi, viruses, protozoa, etc. and know their distinguishing features
4. Students will understand the nature and scope of Microbiology and its applications to mankind like Normal flora, Bio fertilizers, Probiotics, etc.

Detailed Syllabus:

Unit No	Topic	Allotted lectures
Unit I	Introduction to Microbiology Beneficial and Harmful effects of microorganisms: <ol style="list-style-type: none"> 1. Medical Microbiology (Enlist diseases caused by various microorganisms, vaccines and antibiotics) 2. Environmental Microbiology (Eutrophication, red tide, Sewage treatment, bioremediation) 3. Food and Dairy Microbiology (Food spoilage, food borne diseases, Probiotics and fermented food) 4. Agriculture Microbiology (Plant diseases and Biofertilizers and Bio-control agents) 5. Industrial Microbiology (Production of antibiotics, enzymes, solvents and contaminants-bacteria and phages) 6. Immunology (Normal flora, Three lines of defense) 7. Scope and application of Microbiology 	7
Unit II	A. Development of microbiology as a discipline <ol style="list-style-type: none"> 1. Discovery of microscope and Microorganisms (Anton von Leeuwenhoek and Robert Hooke), 2. Abiogenesis v/s biogenesis (Aristotle's notion about spontaneous generation, Francesco Redi's experiment, Schulze and Shawn Experiment, Louis Pasteur's & Tyndall's experiments) B. Golden Era of Microbiology Contributions of – <ol style="list-style-type: none"> 1. Louis Pasteur (Fermentation, Rabies, Pasteurization and Cholera vaccine-fowl cholera experiment) 2. Robert Koch (Koch's Postulates, Germ theory of disease, Discovery of viruses (TMV and Bacteriophages), 3. River's Postulates Contribution of Joseph Lister (antiseptic surgery), Paul Ehrlich (Chemotherapy), Edward Jenner (Vaccination) and Alexander Fleming (Penicillin) in establishment of fields of medical microbiology and immunology, Discovery of Streptomycin by Waksman 	15
Unit III	A. Bacterial Cytology Microbial cell size, shape and arrangements B. Structure, chemical composition and functions of the following components in bacterial cell: <ol style="list-style-type: none"> 1. Cell wall (Gram positive, Gram negative) 2. Cell membrane 3. Endospore (spore formation and stages of sporulation) 4. Capsule Flagella 	8

5. Fimbriae and Pili
6. Ribosomes
7. Chromosomal & extra-chromosomal material
8. Cell inclusions

Suggested Readings/Material:

1. Daniel L., (1998). Microbiology, 2nd Edition, McGraw-Hill Publication.
2. Ingraham J. L. and Ingraham C.A. (2004). Introduction to Microbiology, 3rd Edition, Thomson Brooks/Cole.
3. Madigan M.T., Martinko J.M. (2006). Brock's Biology of Microorganisms. 11th Edition. Pearson Education Inc.
4. Pelczar M.J., Chan JR. E.C.S., Noel R. K. (1993). Microbiology, 5th Edition, Tata McGraw Hill Press.
5. Prescott L.M., Harley J.P., and Klein D.A. (2005). Microbiology, 6th Edition. McGraw Hill Companies Inc.
6. Prescott, Lancing. M., John, P. Harley and Donald, A. Klein (2006). Microbiology, 6th Edition, McGraw Hill Higher Education.
7. J. M., Sherwood L. M. and Woolverton C. J. (2013). Prescott's Microbiology, 8th Edition, McGraw-Hill Higher Education.
8. Salle A.J. (1971). Fundamental Principles of Bacteriology. 7th Edition, Tata McGraw Hill Publishing Co.
9. Stanier R.Y., Adelberg E.A. and Ingraham J.L. (1987). General Microbiology, 5th Edition, Macmillan Press Ltd.
10. Tortora G.J., Funke B.R., Case C.L. (2006). Microbiology: An Introduction. 8th Edition, Pearson Education Inc.

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Syllabus
B.Sc. Microbiology (Major)

Title of the Course: Basic Techniques in Microbiology								
Year: I				Semester: I				
Course Type	Course Code	Credit Distribution		Credits	Allotted Hours	Allotted Marks		
		Theory	Practical			CIE	ESE	Total
DSC-2	BS-MR112T	02	00	02	30	15	35	50

Learning Objectives:

The objectives of this course is (i) to provide knowledge to students about the types of microscopy and staining methods to observe microorganisms (ii) to appreciate various methods of sterilization and disinfection employed to ensure aseptic conditions in microbiology works

Course Outcomes (Cos)

1. Students will learn the units of measurements, Principle, working and ray diagram of bright field microscopy, phase contrast microscopy, fluorescence microscopy, electron microscopy; types ray diagram and function of – condensers, eyepieces and objectives.
2. Students will learn the staining techniques like monochrome staining, negative staining, differential staining and special staining
3. Students will learn the different methods of sterilization
4. Students will study different Chemical disinfectants and their mode of action
5. Students will learn to check of efficiency of sterilization (Dry and Moist) and disinfection.

Detailed Syllabus:

Unit No.	Topic	Allotted lectures
Unit I	Microscopy and Staining Techniques A. Microscopy 1. Units of measurement – Introduction to Modern SI units 2. Bright field Microscopy: a. Electromagnetic spectrum of light b. Structure, working of and ray diagram of a Compound light Microscope; c. Concepts of Magnification, Numerical aperture and Resolving Power. d. Types, ray diagram and functions of – condensers, eyepieces and objectives e. Aberrations in lenses 3. Principle, working and ray diagram of a. Phase Contrast Microscope b. Fluorescence Microscope c. Electron Microscope – TEM, SEM B. Staining Techniques: 1. Definition of Stain, Types of stains (Basic and Acidic) 2. Properties and role of Fixatives, Mordant, Decolorizers and Accentuators 3. Principle, Methodology and applications of- a. Monochrome staining and Negative (Relief) staining b. Differential staining - Gram staining and Acid-fast staining c. Special staining- Capsule, Cell wall, Spore, Flagella, Lipid granules, metachromatic granules	15
Unit II	Sterilization and Disinfection A. Sterilization Mode of action and applications of- 1. Physical Agents - Heat, Radiation, Filtration 2. Chemical agents –ethylene oxide, formaldehyde 3. Checking of efficiency of sterilization (Dry and Moist) – Biological and Chemical Indicators B. Disinfection 1. Characteristics of an ideal disinfectant 2. Mode of action and applications of- a. Chemical agents Aldehydes, Halogens, Quaternary ammonium compounds, Phenol and phenolic compounds, Heavy metals, Alcohol, Dyes, Detergents and Ethylene oxide.	15

- b. Checking of efficiency of disinfectant - Phenol Coefficient
(Rideal– Walker method)

Suggested Readings/Material:

1. Daniel Lim, Microbiology, 2nd Edition; McGraw-Hill Publication.
2. Ingraham J. L. and Ingraham C.A. (2004). Introduction to Microbiology. 3rd Edition. Thomson Brooks / Cole.
3. Madigan M.T., Martinko J.M. (2006). Brock's Biology of Microorganisms. 11th Edition. Pearson Education Inc.
4. Michael J Pelczar, JR. E.C.S. Chan, Noel R. Krieg. (1993) Microbiology, 5th Edition, Tata McGraw Hill Press.
5. Prescott L.M., Harley J.P., and Klein D.A. (2005). Microbiology, 6th Edition. McGraw Hill Companies Inc.
6. Prescott, Lancing. M., John, P. Harley and Donald, A. Klein (2006) Microbiology, 6th Edition, McGraw Hill Higher Education
7. Willey J. M., Sherwood L. M. and Woolverton C. J. (2013) Prescott's Microbiology, 8th Edition, McGraw-Hill Higher Education
8. Salle A.J. (1971) Fundamental Principles of Bacteriology. 7th Edition. Tata McGraw Hill Publishing Co.
9. Stanier R.Y., Adelberg E.A. and Ingraham J.L. (1987) General Microbiology, 5th Edition. Macmillan Press Ltd.
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Syllabus
B.Sc. Microbiology (Major)

Title of the Course: Practical Course based on Theory Paper I and II								
Year: I				Semester: I				
Course Type	Course Code	Credit Distribution		Credits	Allotted Hours	Allotted Marks		
		Theory	Practical			CIE	ESE	Total
DSC-3	BS-MR113P	00	02	02	60	15	35	50

Learning Objectives: The objective of this course is to make students familiar with basic working of Microbiology Laboratory and learn basic techniques such as Handling of instruments, glasswares, aseptic handling etc.

Course Outcomes (Cos)

1. Students will learn the Good Laboratory Practices for common Microbiology Laboratory instruments.
2. Students will learn construction, working and observation of microorganisms using compound microscope.
3. Students will learn different techniques of staining and motility of microorganisms.
4. Students will understand basic techniques in the laboratory such as handling, wrapping, plugging of laboratory glasswares etc.
5. Students will understand aseptic transfer techniques

Detailed Syllabus:

Sr.No.	Title of the Experiment	Allotted Practicals
1.	Safety measures and Good Laboratory Practices in microbiology laboratory	1
2.	Introduction, working principle, operation, precautions and use of common microbiology laboratory instruments: Analytical balance ,Incubator, Hot air oven, Autoclave, Colorimeter/ spectrophotometer , Laminar air flow hood/biosafety cabinet ,centrifuge, Distillation unit , pH meter	2
3.	Construction (mechanical and optical), working and care of compound microscope.	1
4.	Permanent slide observation/ : Algae, Fungi and Protozoa	1
5.	Wet mount slide preparation and its observation for: Bacteria, Algae, Fungi and Protozoa.	1
6.	Introduction and use of common laboratory wares: Test tubes, culture tubes, suspension tubes, screw capped tubes, Petri plates, pipettes (Mohr and serological) micropipettes, Pasteur pipettes, Erlenmeyer flask, volumetric flask, glass spreader, Durham's tube, Cragie's tube and inoculating needles (wire loop, stab needles),dessicator,anaerobic jar	1
7.	Learning basic techniques in Microbiology: Wrapping of glassware, cotton plugging, cleaning and washing of glassware, biological waste disposal.	1
8.	Aseptic transfer technique (Aseptic Behavior in the clean room or in the LAF (while working)	1
9.	Basic staining techniques: i. Monochrome staining ii. Negative staining	2
10.	Differential staining :Gram staining of bacteria	1
11.	Observation of motility in bacteria using: Hanging drop method and swarming growth method.	2

Suggested Readings/Material:

1. Laboratory Exercises in Microbiology (2002), 5th Edition, Harley–Prescott, The McGraw–Hill Companies,
2. A Handbook of Practical Microbiology (2013), R. Saravanan D. Dhachinamoorthi CH. MM. Prasada Rao LAP LAMBERT Academic Publishing
3. Practical Handbook of Microbiology (2015) 3rd Edition, by Emanuel Goldman and Lorrence H Green, (Editor) , CRC Press

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's
New Arts, Commerce and Science College, Ahmednagar
(Autonomous)
Syllabus
B.Sc. Microbiology (Major)

Title of the Course: Computer Applications								
Year: I					Semester: I			
Course Type	Course Code	Credit Distribution		Credits	Allotted Hours	Allotted Marks		
		Theory	Practical			CIE	ESE	Total
SEC-1	BS-MR114P	00	02	02	60	15	35	50

Learning Objectives: The objective of this course is to teach and enhance basic computer skills in students.

Course Outcomes (Cos)

1. The students will learn to create, edit, Microsoft word and power point presentation
2. The students will understand the working of Microsoft excel and its use in data processing
3. Students will create email id, write and forward emails.

Detailed Syllabus:

Unit No.	Topic	Allotted lectures/ hours
Unit I	Microsoft word	
	<ol style="list-style-type: none"> 1. Introduction- Introduction to Microsoft word – Creating, opening and closing document, naming and renaming the document, save and save as, Menu bar and use of different options of menu bar. 2. Creating and editing document-Text Creation and manipulation, Document Creation, Editing Text, Formatting the Text-Font and Size selection, Alignment of Text, Paragraph Indenting, Bullets and Numbering, Changing case 	20

3. **Table Manipulation**-Draw Table, Changing cell width and height, Alignment of Text in cell, Delete / Insertion of row and column, Border and shading
4. **Inserting**- images, clip art, shapes, text box, header, footer, hyperlink
5. **Printing**- Page Setup, Print Preview, connecting printer to the PC, Printing of Documents
6. **Applications of Microsoft word** Writing an application letter for job/internship/leave, CV making, Poster making, Flyer making, Project report/ survey report writing

Unit II Microsoft excel 15

1. Introduction- Creating, opening and closing document, naming and renaming the document, save and save as, Menu bar and use of different options of menu bar
2. Data entry and editing in the Excel
3. Data representation: Creating bar diagram, histograms, line graphs, pie chart,
4. Statistical tests and calculations in excel- Mean, student t- test, anova, F- test, Z test

Unit III Using Email 10

1. Opening Email account
2. Mailbox: Inbox and Outbox
3. Creating and Sending a new E-mail
4. Replying to an E-mail message
5. Forwarding an E-mail message
6. Sorting and Searching emails

Unit IV Making Small Presentations 15

1. Applying Themes, Layouts to Slides , Working with Objects , Entering, Editing, and Formatting Text ,Outline View and Proofing Presentations, Adding and Reading Notes , Inserting

Pictures, Graphics, Shapes, and Other Things, Charts , Adding Sound and Video, Adding Transitions and Animation, Working with Master Slides, Working with Smart Art, Printing, Sharing, and Exporting Slides

2. Preparing power point presentation for – seminars/project presentation etc.

Suggested Readings/Material:

1. MS Office, Dr. S.S. Shrivastava firewall media.
2. Microsoft office 2016 step by step ,joan lambert and Curtis frye, Microsoft press
3. MS Office 2007 in a Nutshell, sanjaysaxena, viskas publishing house pvt limited
4. Learn Microsoft office 2009, Linda Foulkes, Packt publication

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's
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Syllabus
B.Sc. Microbiology (Major)

Title of the Course: Vedic Microbiology								
Year: I				Semester: I				
Course Type	Course Code	Credit Distribution		Credits	Allotted Hours	Allotted Marks		
		Theory	Practical			CIE	ES E	Total
IKS-1	BS-MR115P	02	00	02	30	15	35	50

Learning Objectives: The objectives of this course are (i) To provide knowledge to students about the ancient microbiology concept (ii) To provide knowledge of origin, presence of germs in the environment. (iii) To know the pandemic and epidemic conditions of Vedic period (iv) To appreciate various methods of elimination and eradication of germs with help of natural sources.

Course Outcomes (Cos)

1. Students will learn the concept of Vedic microbiology.
2. Students will learn Names, Classification and methods of counting the krimis.
3. Students will understand the occurrence and prevalence of germs in the environment.
4. Students will learn different pandemic and epidemic diseases during Vedic period.
5. Students will understand elimination methods of krimis and significance of hawan.

Detailed Syllabus:

Unit No.	Topics	Allotted lectures
Unit I	A. Introduction to Vedas 1. Concept of Vedic period 2. Microbial disease during Vedic period B. Name and classification of germs (Krimis) 1. Names of Krimis in Veda 2. Names and color of krimis as described by Charaka 3. Major groups krimis in Veda C. Origin and prevalence of germs (krimis) 1. Occurrence of krimis in the environment 2. Prevalence krimis in water, milk and food / body 3. Methods of counting the number of krimis	15
Unit II	Human health and pathogenic germs 1. Kshudrarog in human (Jaundice , Mumps and Smallpox) 2. Pandemic and epidemic disease during Vedic period and their prevalence 3. Elimination of pathogens by Sun rays 4. Eradication of pathogens by medicinal plants 5. Significance of Hawan/ yagya	15

Suggested Readings/Material:

1. Vedic Microbiology(2020),Dubey, R.C. ,motilal banarsidass international publication
2. Collection and conservation of major medicinal plants of darjeeling and sikkim himalayas.(2006)Husaain,H. and D.K. Hore, Indian j. Traditional knowledge 6(2): 252-257
3. Caraka sam.vimansthan,chp.7, item 10

4. Scientific study of somyag yadya(2015) indian J.scientific Res 4 2080-2083
5. Agnihotra-the air purifier.(1998)Navneet,chand,S. and sharma, gurukul kangri university,Haridwar.
6. Extrapulmonary tuberculosis (2015) Sharma,S.K. and Mohan A.,Indian. J. Med. Res.12:316-353.
7. General medicine in Atharvaveda with special reference to Yaksma (consumption /tuberculosis)(2002), Prasad.P.V.V.,bull.Ind.Inst.Med.32:1-14.
8. The Aryan Debate(2005),Trautmann,T.,Oxford University press.
9. A survey based on smart medical diagnosis for epilepsy people(2015), Kanniga,E. and Ramprakash,Int.J.Adv.Res.Electric.Electron.Instr.Eng.4:7151-7155
10. History of ancient and early medieval India: From the stone age to the 12 th century(2009), Singh,Upinder,Longman press.
11. Sukshmjeevanu in Vedas: The Forgotten Past of Microbiology in Indian Vedic Knowledge (2020)[Urvashi Kuhad](#),¹ [Gunjan Goel](#),² [Pawan K. Maurya](#),² and [Ramesh C. Kuhad](#), Indian journal of microbiology.

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's
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Syllabus
B.Sc. Microbiology (Major)

Title of the Course: Cell Biology of Microorganisms								
Year: I				Semester: II				
Course Type	Course Code	Credit Distribution		Credits	Allotted Hours	Allotted Marks		
		Theory	Practical			CIE	ES E	Total
DSC-4	BS-MR121T	03	00	03	45	30	70	100

Learning Objectives: This course deals with characteristics, properties and biological significance of the biomolecules of life and in depth knowledge of the cell biology of bacteria.

Course Outcomes (Cos)

- Students will learn the structure and the function of each part of Bacterial cell.
- Students will have a brief overview of Bacterial classification and ICTV for viral classification.
- Students will understand the Biochemistry of bacterial cell.

Detailed Syllabus:

Unit No	Topic	Allotted lectures
Unit I	A. Ultrastructure of bacterial cell 1. Bacterial Cytology- Microbial cell size, shape and arrangements B. Structure, chemical composition and functions of the following components in bacterial cell: <ol style="list-style-type: none"> Cell wall (Gram positive, Gram negative) Cell membrane Endospore (spore formation and stages of sporulation) Capsule 	15

5. Flagella
6. Fimbriae and Pili
7. Ribosomes
8. Chromosomal & extra-chromosomal material
9. Cell inclusions (Gas vesicles, carboxysomes, PHB granules, metachromatic granules, glycogen bodies, starch granules, magnetosomes, sulfur granules, chlorosomes)

Unit II

A. Chemical Basis of Microbiology

15

- Atom, Biomolecules, types of bonds (covalent, coordinate bond, non-covalent) and linkages (ester, phospho-diester, peptide, glycosidic)

B. Chemistry of Biomolecules:

1. Structure, organization and functions Carbohydrates: Definition, classification
2. Monosaccharides: Classification based on aldehyde and ketone groups; structure of Ribose, Deoxyribose, Glucose, Galactose and Fructose.
3. Disaccharides: Glycosidic bond, structure of lactose and sucrose.
4. Polysaccharides: Structure and types
5. (Examples-Starch, glycogen, Peptidoglycan, chitin)

C. Lipids: Definition, classification

1. Simple lipids – Triglycerides, Fats and oils, waxes.
2. Compound lipids – Phospholipid, Glycolipids
3. Derived lipids – Steroids, Cholesterol

D. Proteins: Definition, classification

1. General structure of amino acids, peptide bond
2. Types of amino acids based on Rgroup
3. Structural levels of proteins: primary, secondary, tertiary

and

4. Quaternary Study of Hemoglobin, flagellin and cytoskeletal proteins

E. Nucleic acids: Definition, classification

- DNA – structure and composition
- RNA – Types (m-RNA, t-RNA, r-RNA), structure and functions.

F. Classification of Bacteria - Introduction to Bergey's Manual of Determinative and Systemic Bacteriology

Suggested Readings:

1. Madigan M.T., Martinko J.M. (2006). Brock's Biology of Microorganisms. 11th Edition. Pearson Education Inc.
2. Pelczar M.J., Chan JR. E.C.S., Noel R. K. (1993). Microbiology, 5th Edition, Tata McGraw Hill Press.
3. Prescott, Lancing. M., John, P. Harley and Donald, A. Klein (2006). Microbiology, 6th Edition, McGraw Hill Higher Education.
4. J. M., Sherwood L. M. and Woolverton C. J. (2013). Prescott's Microbiology, 8th Edition, McGraw-Hill Higher Education.
5. Salle A.J. (1971). Fundamental Principles of Bacteriology. 7th Edition, Tata McGraw Hill Publishing Co.
6. Stanier R. Y., Adelberg E.A. and Ingraham J.L. (1987). General Microbiology, 5th Edition, Macmillan Press Ltd
7. Tortora G.J., Funke B.R., Case C.L. (2006). Microbiology: An Introduction. 8th Edition, Pearson Education Inc.
8. Wilson K. and Walker J.M., (2005). Principles and Techniques of Biochemistry and Molecular Biology, 6th Edition, Cambridge University Press.
9. H.G., (1993). General Microbiology, 8th Edition, Cambridge University Press.

10. Plummer D.T., (1993). An Introduction To Practical Biochemistry, 3rd Edition, Tata McGraw-Hill Publishing Company Limited.

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's
New Arts, Commerce and Science College, Ahmednagar
(Autonomous)
Syllabus
B.Sc. Microbiology (Major)

Title of the Course: Bacteriology and Virology								
Year: I				Semester: II				
Course Type	Course Code	Credit Distribution		Credits	Allotted Hours	Allotted Marks		
		Theory	Practical			CIE	ESE	Total
DSC-5	BS-MR122T	03	00	03	45	30	70	100

Learning Objectives: The objective of this course is i) To make students aware about the nutritional classification of microorganisms and the types of culture media employed to isolate the microorganisms ii) To learn the method for isolation and maintenance of pure cultures and iii) to study the bacterial growth and study of virus.

Course Outcomes (Cos)

1. Students will understand the nutritional requirement of a microbial cell and nutritional classification of microorganisms.
2. Students will learn the design and preparation of different types of culture media and the methods for cultivation of different types of microorganisms
3. Students will learn the concept of pure culture, enrichment, isolation and preservation technique
4. Students will learn the bacterial growth kinetics, bacterial growth curve and diauxic growth.
5. Students will study different methods of enumeration of bacterial growth and about the factors affecting bacterial growth

Detailed Syllabus:

Unit No.	Topic	Allotted lectures
Unit I	Diversity of bacteria based on nutrition and environmental conditions <ol style="list-style-type: none">1. Nutritional requirements and nutritional classification2. Extremophiles and their significance3. Design and preparation of media:4. Common ingredients of culture media5. Types of media used for the cultivation of bacteria: General (Synthetic and complex media), Selective, differential, enriched, enrichment media, Minimal and complete media6. Methods for cultivation of photosynthetic, extremophilic and chemo- lithotrophic bacteria, anaerobic bacteria, algae, fungi, actinomycetes and viruses7. Concept of Enrichment, Pure Culture, Isolation of culture by streak plate, pour plate, spread plate8. Maintenance of bacterial and fungal cultures using different techniques9. Culture collection centers and their role	15
Unit II	Bacterial growth: <ol style="list-style-type: none">1. Asexual methods of reproduction2. Kinetics of bacterial growth (Exponential growth model)3. Bacterial Growth curve -Generation time and specific growth rate4. Diauxic growth curve5. Measurement of bacterial growth- Methods of enumeration:<ol style="list-style-type: none">a. Microscopic methods (Direct microscopic count, counting cells using improved Neubauer chamber, Petroff-Hausser counting chamber)b. Plate counts (Total viable count)	15

- c. Turbidometric methods (including Nephelometry)
- d. Estimation of biomass (Dry mass, Packed cell volume)
- 6. Bacterial growth in response to environment
 - a. pH(acidophiles, Neutrophils,Alkalophiles),
 - b. Temperature(Psychrophiles,mesophiles,thermophiles),
Solute Concentration and water activity
(halophiles,xerophiles,osmophilic)
 - c. oxygen (aerobic, anaerobic, microaerophilic,facultative anaerobe)
 - d. Heavy metals(Oligodynamic action)

Unit II Virology :

15

- 1. Discovery of viruses, nature and definition of viruses,
- 2. Types of Viruses: Animal viruses, plant viruses, bacteriophages
- 3. General properties of viruses
- 4. Concept of viroids, virusoids, satellite viruses and Prions.
- 5. Types of bacteriophages, lytic and lysogenic phages (lambda phage)
- 6. Structure of Viruses: Capsid symmetry, enveloped and non-enveloped viruses
- 7. Viral taxonomy: Classification and nomenclature of different groups of viruses-ICTV nomenclature

Suggested Readings/Material:

- 1. Michael J Pelczar, JR. E.C.S. Chan, Noel R. Krieg. (1993) Microbiology, 5th Edition, TataMcGraw Hill Press.
- 2. Prescott, Lancing. M., John, P. Harley and Donald, A. Klein (2006), Microbiology, 6th Edition, McGraw Hill Higher Education
- 3. Willey J. M., Sherwood L. M. and Woolverton C. J. (2013) Prescott's Microbiology, 8th Edition, McGraw-Hill Higher Education

4. Salle A.J. (1971) Fundamental Principles of Bacteriology. 7th Edition. Tata McGraw Hill Publishing Co.
5. Stanier R.Y., Adelberg E.A. and Ingraham J.L. (1987) General Microbiology, 5th Edition. Macmillan Press Ltd.
6. Tortora G.J., Funke B.R., Case C.L. (2006). Microbiology: An Introduction. 8th Edition. Pearson Education Inc

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's
New Arts, Commerce and Science College, Ahmednagar
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Syllabus
B.Sc. Microbiology (Major)

Title of the Course: Microbiology Methods								
Year: I				Semester: II				
Course Type	Course Code	Credit Distribution		Credits	Allotted Hours	Allotted Marks		
		Theory	Practical			CIE	ESE	Total
SEC-2	BS-MR123P	00	02	02	60	15	35	50

Learning Objectives: The objective of this course is to develop the Microbiology skills in students like preparation and sterilization of media, methods for isolation and cultivation of microorganisms and aseptic transfer techniques.

Course Outcomes (Cos)

1. Students will be able to prepare and sterilize culture media and observation of colony and cultural characteristics.
2. Students will be able to perform isolation and enumeration of bacteria by streak, spread, pour plate techniques and enumeration using Direct Microscopic count
3. Students will understand the aseptic transfer techniques and different methods of culture preservation.
4. Student will be able to check sterilization efficiency of autoclave and hot air oven
Students will learn counting of yeast cells using a counting chamber.
5. Student will be able to determine the effect of different parameter on microbial growth

Sr. No.	Title of the Experiment	Allotted Practicals
1	Preparation and sterilization of different Microbiological culture media (Nutrient agar/broth, MacConkey's agar).	1
2	Checking sterilization efficiency of autoclave and Hot air oven	1
3	Special staining techniques: i. Endospore staining ii. Capsule staining	2
4	Isolation of bacteria by streak plate technique (observation of Colony and cultural characteristics)	1
5	Enumeration of microorganism from fermented food / soil / water by: i. Spread plate method ii. Pour plate method	2
6	Direct microscopic count: Yeast cell enumeration using Improved Neubauer Chamber	1
7	Study of the effect of different parameters on growth of bacteria (pH, temperature, sodium chloride concentration)	3
8	Methods and Practices in Microbiology laboratory: MSDS (Material Safety Data Sheet),GCP(Good Clinical Practices),SOP(Standard Operating Procedures),GLP(Good Laboratory Practices),GMP(GOOD Manufacturing Practices) Procedures for Documentation Lab Maintenance and Repair reporting	3
9	Preservation of cultures on slants, soil and on grain surfaces; revival of these cultures and lyophilized cultures.	1

Suggested Readings/Material:

1. Laboratory Exercises in Microbiology (2002),5th Edition, Harley–Prescott, The McGraw–Hill companies
2. A Handbook of Practical Microbiology (2013), R. Saravanan D. Dhachinamoorthi CH. MM. Prasada Rao LAP LAMBERT Academic Publishing

3. Practical Handbook of Microbiology (2015) 3rd Edition, by Emanuel Goldman and Lorrence H Green, (Editor) CRC Press

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Syllabus
B.Sc. Microbiology (Major)

Title of the Course: Basic Laboratory Practices In Microbiology								
Year: I				Semester: II				
Course Type	Course Code	Credit Distribution		Credits	Allotted Hours	Allotted Marks		
		Theory	Practical			CIE	ESE	Total
VSC-1	BS-MR124P	00	02	02	60	15	35	50

Learning Objectives:

The course address on identification, evaluation and control of laboratory crucial quality issues to minimize lab errors by adopting risk management strategy.

Course Outcomes (Cos)

1. The Students will learn about the health and hygiene practices in Microbiology laboratory
2. The Students will learn methods of infection control and its prevention in Microbiology laboratory.
3. The students will learn about waste management and environmental protection.
- 4.

Detailed Syllabus:

Unit No.	Topic	Allotted Hours
Unit I	Introduction to Health and Hygiene in Microbiology	15
	<ul style="list-style-type: none"> • Importance of health and hygiene in microbiology • Microbial hazards and risks in laboratory settings • Roles and responsibilities in maintaining health and hygiene 	
Unit II	Personal Hygiene and Laboratory Safety	15
	<ul style="list-style-type: none"> • Hand hygiene and personal protective equipment (PPE) 	

- Scientific approach of hand washing and methodology for wearing hand gloves
- Evaluation of effectiveness of hand washing by ethanol-based sanitizer.
- Study of effect of washing on skin microflora
- (soap and disinfectant)
- Aseptic techniques and Good Microbiological Practices
- Biosafety levels and containment measures
- Biosafety cabinets- working of biosafety cabinets, using personal protective covering,
- specifications for BSL-1,BSL-2,BSL-3,BSL-4
- Use of First Aid

Unit III	Infection Control and Prevention	15
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- Modes of transmission and infection control strategies
- Environmentally Mediated Infection Transmission
- Handling and disposal of contaminated materials
- Decontamination in the Microbiology Laboratory
- Evaluation of disinfectant (RW/Chick martin method)
- Disinfectant efficiency test
- Oligodynamic action of heavy metal (e.g copper)
- To check the effectiveness and efficacy of preservative
- Lab Fumigation procedures

Unit IV	Waste Management and Environmental Protection	15
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- Classification and segregation of laboratory waste
- Proper storage, transport, and disposal of hazardous materials
- Biohazardous waste management
- Environmental impacts of improper waste management
- Introduction to emerging infectious diseases
- Case studies of notable outbreaks and pandemics
- Preparedness and response to emerging diseases

Suggested Readings/Material:

1. Erkmen, O. (2021). Laboratory Practices in Microbiology. Netherlands: Elsevier Science.
2. Chauhan, A., Jindal, T. (2020). Microbiological Methods for Environment, Food and Pharmaceutical Analysis. Germany: Springer International Publishing.
3. Ahern, H. (2018). Microbiology: A Laboratory Experience. (n.p.): State University of New York Oer Services.
4. Cheesbrough, M. (2006). District Laboratory Practice in Tropical Countries, Part 2. (n.p.): Cambridge University Press.
5. Biosafety in the Laboratory: Prudent Practices for Handling and Disposal of Infectious Materials. (1989). United States: National Academies Press.
6. Handbook of Laboratory Health and Safety Measures. (2013). Netherlands: Springer Netherlands.
7. Richmond, J. Y. (1999). Biosafety in Microbiological and Biomedical Laboratories. United States: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention.
8. Biological Safety: Principles and Practices. (2020). United States: Wiley.
9. Laboratory Biosafety Manual: Third Edition. (2004). Switzerland: World Health Organization.
10. Ahern, H. (2018). Microbiology: A Laboratory Experience. (n.p.): State University of New York Oer Services.
11. Richmond, J. Y. (1999). Biosafety in Microbiological and Biomedical Laboratories. United States: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention.

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<https://www.who.int/docs/default-source/medicines/norms-and-standards/guidelines/quality-control/trs961-annex2-goodpractices-pharmaceutical-microbiology-laboratories.pdf>