

UNIVERSITY OF MUMBAI



Revised Syllabus for MSc (Part2)

In Microbiology

SEM III and SEM IV

Program: M.Sc.

Course: MICROBIOLOGY

(PSMB)

Choice Based Credit System with effect from the
academic year **2020–2021**

MSc part 2 Microbiology Syllabus (Semester 3 and 4)

Revised for Choice Based Credit System (CBCS) from academic year 2020-21

INDEX Semester 3 THEORY

Course Code	Unit	Topic Headings	Credits	Lec/topic
PSMB301 Tools and Techniques in Microbiology	I	Biological sample preparation and Modified analytical techniques	04	15
	II	Advanced Electron Microscopy		15
	III	Spectroscopic and Chromatography Techniques: Principle, working and applications		15
	IV	Identification methods in microbiology		15
PSMB 302 Pharmaceutical & Cosmetic Microbiology	I	Introduction to Pharmaceutical Microbiology	04	15
	II	Pharmaceutical Analysis & Regulation		15
	III	Cosmetic Microbiology		15
	IV	Audit, Validation & documentation		15
PSMB 303 Cell Biology	I	Introduction To Cell Biology And Cell Membrane	04	15
	II	Organisation And Function Of Mitochondria, Chloroplast, Peroxisomes And Cytoskeleton		15
	III	Cell Division, Cell Cycle And Cell Junctions		15
	IV	Cell Communication And Multi cellular Cell Development		15
PSMB 304 Advances in Biotechnology	I	IPR and Biodiversity Law	04	15
	II	Bioethics		15
	III	Nano Biotechnology		15
	IV	Algal Biotechnology		15

PRACTICALS

PSMBP-301	Tools and Techniques in Microbiology	2	04
PSMBP-302	Pharmaceutical & Cosmetic Microbiology	2	04
PSMBP- 303	Cell Biology	2	04
PSMBP-304	Advances in Biotechnology	2	04

Semester 4

THEORY

Course Code	UNIT	TOPIC HEADINGS	Credits	L / Week
Paper PSMB401- Industrial & Food Microbiology	I	Applications of Microbial technology in food processing	4	01
	II	Food Preservation & Food safety		01
	III	Strain improvement: Modern methods		01
	IV	Fermentations of Microbial products for commercial use		01
PSMB402 Applied Microbiology	I	Applications of Microbiology in bioremediation & pollution control	4	01
	II	Applications of Enzymes		01
	III	Microbial bio-molecules in diagnostics and therapeutics		01
	IV	Novel uses of microorganisms and microbial products		01
PSMB403 Plant, Agriculture and Animal Biotechnology	I	Plant Biotechnology	4	01
	II	Animal Biotechnology		01
	III	Bio-augmentation and Bio-stimulation in Agriculture		01
	IV	Bio-control in Agriculture		01
PSMB404 Mycology, Virology & Protozoology	I	Fungal technology	4	01
	II	Animal and Plant Virology		01
	III	Study of Bacteriophages and Algal Phages		01
	IV	Protozoology		01

PRACTICALS

PSMBP-401	Industrial & Food Microbiology	2	04
PSMBP-402	Applied Microbiology	2	04
PSMBP- 403	Plant, Agriculture and Animal Biotechnology	2	04
PSMBP-404	Mycology, Virology & Protozoology	2	04

SEMESTER 3

DETAIL SYLLABUS

PSMB-301 : TOOLS AND TECHNIQUES IN MICROBIOLOGY

Objectives:

The course will focus on

- Advanced imaging techniques and emerging super-resolution methods, their principle, working and applications in biological fields with special emphasis to current imaging literature.
- describing the methods of chromatography and their applications to achieve understanding of advanced analytical techniques used in analysis of biological samples.
- Understanding the current scenario of identification of microbial species using different molecular techniques.
- introducing the students to techniques in metagenomics

Learning Outcome:

At the end of the course students will

- 1) be able to understand mechanism of imaging by advance microscopy enabling them to have a complete view of mechanism and application of advance microscopy
- 2) be able to learn instrumentation which will help them in their professional career.
- 3) be able to gain analytical and interpretative skills which is critical for working in the laboratory.

Detailed Syllabi

Code	Unit	Subunit	Title	lectures	Credits
PSMB 301			Tools and Techniques in Microbiology	60L	04
	1		Biological sample preparation and Modified analytical techniques	15	01
		1.1	Sample preparation: An analytical perspective	01	
		1.2	General sample preparation for analysis of Phyto pharmaceuticals	02	
		1.3	Preparation of sample and staining for SEM, TEM, Atomic force Microscopy, Confocal Microscopy.	05	
		1.4	Preparation of sample and general principle of chromatography and spectroscopic techniques	02	
		1.5	Combination procedures for analysis with relevant examples/case studies :	02	

			a) TLC and HPLC b) HPTLC and MS c) TLC and FTIR d) TLC and Raman spectroscopy		
		1.6	Sample preparation plans with examples for analysis of 1. Volatile oils 2. Pigments 3. glycosides 4. Flavonoids 5. Antibiotic, Analgesic and Anti tubercular drug	03	
	2		Advanced Microscopy Techniques	15	01
		2.1	Principle and working of a. TEM & SEM	3	
			b. Confocal Microscopy	2	
			c. AFM	2	
		2.2	Principle & Working of a. Fluorescence Microscopy, b. High Resolution Fluorescent Microscope, Concept Understanding of Fluorescence recovery after photobleaching (FRPA), and Forster Resonance Energy Transfer (FRET)	4	
		2.3	Application of Fluorescence and electron microscopy with relevant examples /case studies	4	
	3		Advanced Spectroscopic and Chromatography Techniques: Principle, working and applications	15	01
		3.1	Mass Spectroscopy : ESI-MS and MALDI-MS	04	
		3.2	NMR : Approach to determine structure of Carbohydrate by NMR	03	
		3.3	FTIR	02	
		3.4	HPTLC	02	
		3.5	Ion exchange chromatography	02	
		3.6	Gel filtration chromatography	02	
	4		Identification methods in microbiology	15	01
		4.1	Introduction of microbial systematic Phylogeny: Overview of phylogeny and Phylogenetic trees Importance of ribosomal RNA	02	
		4.2	i) Culture dependent analysis of microbial communities: Laser Tweezer Flow cytometry	02	

			ii) For classification & identification through Phenotypic analysis using VITEK , API 20, FAME and BIOLOG	02	
		4.3	Culture independent methods	09	
			i) Methods for DNA / RNA extraction		
			ii) Basic PCR methods with respect to identification of microorganisms		
			iii) Gene sequence analysis 1. Amplification of 16S rRNA gene for prokaryotes and SSU, LSU, ITS. 2. Multi-locus sequence typing 3. Genome fingerprinting (Multi gene and whole genome)– Ribotyping		
			iv) Sequencing genomes • First generation - Sanger sequencing and sequence analysis using different tools (Chromas – Pro, SeqMan) • Shotgun – genomic library • Second generation - Amplicon sequencing Illumina • Third and fourth generation- Heliscope and Ion torrent Oxford nanopore • Genome assembly		
			v) Environmental genomics An introduction to meta-genomics, meta transcriptomes and Meta-proteomics		

PRACTICALS BASED ON PAPER 301

- Extraction and Qualitative detection of different phyto-chemicals using chemical methods. (Tannins, Saponins, Flavonoids, Alkaloids, Glycosides, Steroids, Phenolic compounds)
- Extraction and separation of different pigments using TLC
- Spectrum analysis of pigments using UV spectrophotometer.
- Separation of proteins using gel filtration
- Generation of phylogenetic tree.
- Extraction of DNA from soil and checking its purity using agarose electrophoresis and UV 260/280 ratio

SELF STUDY

- Determination of purity of extracted DNA using Qubit
- Study the working of TEM, SEM, Fluorescence and Confocal microscopy /Nuclear magnetic resonance spectroscopy and evaluation of simple ¹H NMR spectra of select organic compounds / Determination of Molar Mass of Simple Compounds Using Mass Spectroscopy using virtual lab

- Assignment on “Application of advanced electron microscopy”./ protocol for culture submission to NCBI database
- Use of VITEK (Demonstration)

References

- 1) Sample Preparation Techniques in Analytical Chemistry by S. Mitra (01-06)
- 2) Herbal Drug Technology by S S Agarwal and m Paridhavi
- 3) Scanning Electron Microscopy by V Kazmiruk
- 4) Handbook of TEM by Ayache J., Beaunier L., Boomendil J., Ehret G.
- 5) Atomic force Microscopy by Nunu C.Santos.
- 6) Methods in molecular biology- Confocal Microscopy by Paddock
- 7) Advanced Techniques in Biological electron microscopy , James K Koehler
- 8) Handbook from Anchrome laboratory
- 9) Thin layer chromatography- a modern practical approach by Peter E. Wall
- 10) Biotechniques by N. Arumugan, V kumaresan
- 11) A Textbook of Biophysics by R N Roy
- 12) Study of Transmission Electron Microscopy (TEM) and Scanning Electron Microscopy (SEM) by Hongbao Ma , Kuan-Jiunn Shieh , Tracy X. Qiao
- 13) A beginner's Guide to SEM by Anwer Ul Hamid
- 14) Modern Biophysical Chemistry, Detection and Analysis of Biomolecules by Peter Jomo Walla , Second, Updated and Expanded Edition (2014) Wiley-VCH Verlag GmbH & Co. KGaA, Boschstr. 12, 69469 Weinheim, Germany Pg No. 149-165
- 15) Applied NMR Spectroscopy for Chemists and Life Scientists by Oliver Zerbe and Simon Jurt, (2014) Wiley-VCH Verlag GmbH & Co. KGaA, Boschstr. 12, 69469 Weinheim, Germany
- 16) Techniques and Instrumentation in Analytical Chemistry Volume 18, 1997
- 17) High-Performance Thin-Layer Chromatography (HPTLC) by ManMohanSrivastava. 2011 Springer-Verlag Berlin Heidelberg
- 18) Protein Purification: Principles, High Resolution Methods, and Applications by Jan-Christer Janson. 2011. Third Edition John Wiley & Sons, Inc., Hoboken, New Jersey
- 19) Brock Biology of microorganisms 14th ed.
- 20) Molecular cloning : a lab manual, Green and Sambrook vol. 1 4th edn
- 21) <https://www.olympus-lifescience.com/en/microscope-resource/primer/techniques/confocal/confocalintro/>
- 22) <http://www.ammr.org.au/myscope/pdfs/tem.pdf>
- 23) <https://www.olympus-lifescience.com/en/microscope-resource/primer/techniques/confocal/applications/fretintro/>
- 24) <https://www.microscopyu.com/techniques/fluorescence/introduction-to-fluorescence-microscopy>

PAPER 302 : PHARMACEUTICAL & COSMETIC MICROBIOLOGY

Learning Objectives:

The course will focus on

- the different process and work culture in the Pharmaceutical & Cosmetic Industry.
- providing in-depth knowledge wrt regulations and audit procedures carried out in an industry

Learning outcomes :

At the end of the course learners will be

- equipped with risk assessment tools and process understanding to make them skilled and competent as per job requirement.

Course Code		Title	Lectures	Credits
PSMB-302		Pharmaceutical & Cosmetic Microbiology	(60L)	04
Unit : I		Introduction to Pharmaceutical Microbiology	(15L)	01
	1.1	Role of Microbiology for pharmaceuticals industries	01	
	1.2	GMP and Regulations	03	
	1.3	Laboratory management and design	02	
	1.4	Microbiological culture media & Microbiology laboratory techniques	02	
	1.5	Bio burden determination	02	
	1.6	Specified and objectionable microorganisms	01	
	1.7	Guidelines for preparing a laboratory information file	04	
Unit 2		Pharmaceutical Analysis & Regulation	(15L)	01
	2.1	Assessment of pharmaceutical water systems and Endotoxin and pyrogen testing	01	
	2.2	Sterilization and sterility assurance. Use of Biological indicators for measuring sterilization	01	
	2.3	Cleaning and disinfection Use of Antibiotics and preservatives ,Clean rooms and environmental monitoring	01	
	2.4	Rapid microbiological methods	03	
	2.5	Risk assessment and microbiology	03	
	2.5	Good practices for pharmaceutical quality control laboratories	02	
	2.6	Good manufacturing practices for pharmaceutical Products Pharmaceutical Legislation & Regulation	04	

Unit III :	3.1	Cosmetic Microbiology	(15L)	01
	3.1	History of cosmetic Microbiology ,Preservation of cosmetics	03	
	3.2	Antimicrobial preservative efficacy & microbial content testing	02	
	3.3	Microbiology Laboratory methods in support of sterility Assurance System	03	
	3.4	Bio burden testing & Environmental monitoring	02	
	3.5	Sampling: Principles and Practice	03	
	3.6	Global regulations & toxicological aspects	02	
UNIT IV:		Audit, Validation & Documentation	(15L)	01
	4.1	Microbiological hazard analysis & audit Validation	04	
	4.2	IS and ISO standards: 9000, 17025.	05	
	4.3	Introduction to Validation and documentation	03	
	4.4	Auditing sterilization processes and facilities	03	

PRACTICAL BASED ON PAPER PSMB302

- 1) Perform an audit of any test, with proper documentation.
- 2) Preservative efficacy test as per ISO 11930
- 3) Bio burden test
- 4) Quality control of microbial content of cosmetics as per IS 14648:2011 wrt to heterotrophic count , presence of *Pseudomonas spp*, *Staphylococci spp* & *P. acne*
- 5) MIC of an antibiotic by tube method using Indian Pharmacopeia protocol

SELF-STUDY :

1. Market survey of 5 cosmetic products and the Common cosmetic preservatives used
2. HACCP of College canteen or home kitchen wrt a food preparation.

REFERENCES

UNIT I	<ul style="list-style-type: none"> •Pharmaceutical Microbiology by Tim Sandle •WHO Guidelines for preparing a laboratory information file
UNIT II	<ul style="list-style-type: none"> •WHO Good practices for pharmaceutical microbiology laboratories •WHO-GMP for pharmaceutical products
UNIT III	<ul style="list-style-type: none"> •Cosmetic Microbiology: A practical Approach, 2nd edition. Philip A Geiss. Taylor & Francis group.
UNIT IV	<ul style="list-style-type: none"> •Handbook of Microbiological Quality Control for Pharmaceuticals and Medical Devices, Rosamund M.Baird, Stephen P.Denyer, Norman Hodges

	<ul style="list-style-type: none"> • International standard ISO/IEC-17025 ,Third edition,2017-11 • Validation Standard Operating Procedures - A Step-by-Step Guide for Achieving Compliance in the Pharmaceutical, Medical Device, and Biotech Industries by Syed Imtiaz Haider, • Sterility, sterilization and sterility assurance for pharmaceuticals. by Tim Sandle
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PSMB-303 : CELL BIOLOGY

Learning objectives

The course is designed for learners to

- Understand basic cellular structures
- Understand advanced cellular processes in eukaryotes
- Understand protein transport and export in prokaryotes and eukaryotes, molecular basis of cell division, signalling pathways, cellular development
- Integrate the different levels of biological organisation, from molecules to cells to organisms and regulation of development
- Learn basic skills in cell biology

Learning outcome

At the end of the course learners will be able to

- Understand the structure and compartmentalisation of organelles, protein export, protein sorting
- Understand the events of cell cycle and its regulation
- Explain the communications of cells with other cells and to the environment
- Explain the process of development in general

UNIT NO.	SUB UNIT	TITLE	NO. OF LEC.	CREDIT
I		Introduction To Cell Biology And Cell Membrane	15	01
	1.1	Introduction to cell biology- Structural organization and function of intracellular organelles (Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast	01	
	1.2	Membrane structure : Cell membrane structure: Lipid bilayer, membrane proteins, Spectrins, Glycophorin, Multipass membrane proteins Bacteriorhodopsin	01	
	1.3	Membrane Transport: Principles of membrane transport, ion channels and electrical properties of membranes. protein transport, post translation transport and co translation transport, protein transport and protein secretion pathways in bacteria. endocytosis	05	
	1.4	Intracellular Compartments and protein sorting: Compartmentalization of cells, transport of molecules between the nucleus and cytosol, peroxisomes, Endoplasmic reticulum,	04	

		transport of proteins into mitochondria and chloroplasts,		
	1.5	Cell wall and extracellular matrix- matrix proteins, matrix polysaccharides	02	
	1.6	Cell-cell interaction	02	
II		Organisation And Function Of Mitochondria, Chloroplast And Cytoskeleton	15	1
	2.1	Mitochondria: Structure, electron-transport chains and proton pump, Chloroplasts: Structure, energy capture from sunlight, genetic system of Mitochondrion and chloroplast,	03	
	2.2	Intracellular vesicular traffic : The molecular mechanism of membrane transport and the maintenance of compartmental diversity, transport from the ER through the Golgi apparatus, transport from trans Golgi network to lysosomes	05	
	2.3	Cytoskeleton: The self-assembly and dynamic structure of cytoskeletal filaments, How cells regulate their cytoskeletal filament, (Cytoskeletal filaments, Microtubules, Actin and intermediate filaments), molecular motors, cell behaviour	07	
III		Cell Division , Cell Cycle And Cell Junctions	15L	01
	3.1	Mechanism of cell division: M-phase, Mitosis, Cytokinesis, Germ cells and fertilization, Meiosis, eggs, sperm, fertilization	05	
	3.2	Cell cycle and Programmed cell death: Control system, intracellular control of cell cycle events, Apoptosis, extracellular control of cell growth and apoptosis. Autophagy	05	
	3.3	Cell Junctions and cell-cell adhesion: Anchoring, adherence junctions, Desmosomes, Gap junctions, cell-cell adhesion, Cadherins, Selectins, N-CAM, The extracellular matrix of animals., Integrins,	05	
IV		Cell Communication And Multicellular Cell Development	15L	1
	4.1	Cell communication: General principles of cell communication (Nitric oxide gas signal and nuclear receptors, Three classes surface receptors), Signaling through G-protein linked cell surface receptors	06	
	4.2	Signalling through enzyme linked cell surface receptors: Tyrosine kinase, Docking sites, Ras, MAP kinase, PI-3 kinase, TGF- β , Signaling pathways by regulated proteolysis. Signalling in plants: Serine / Threonine kinases, role of ethylene, Phytochromes	05	
	4.3	Development of multicellular organisms: <i>Caenorhabditis elegans</i> , <i>Drosophila melanogaster</i> , Mouse Neural development	04	

PRACTICALS BASED ON PAPER PSMB303

1. Disruption of bacterial cells followed by characterization of cellular proteins by SDS-PAGE
2. Isolation of lymphocytes and its Viability staining using trypan blue
3. Determination of cell viability of lymphocytes by MTT Assay & neutral red uptake assay
4. Comparison of various cell viability techniques
5. Isolation of mitochondria and check activity of respiratory enzyme succinate dehydrogenase
6. Isolation of chloroplast and checking photophosphorylation

References

1. Molecular Biology of the Cell – Alberts, Johnson, Lewis, Raff, Roberts & Walter, 6th edition.
2. Cooper, G.M., Hausman R.E. (2009) The Cell: A Molecular Approach- 6th edition.
3. Molecular Cell Biology. Harvey Lodish; Arnold Berk; Chris A. Kaiser; Monty Krieger; Anthony Bretscher; Hidde Ploegh; Angelika Amon; Kelsey C. Martin, 8th edition
4. Karp G. (2008). Cell and Molecular Biology: Concepts and Experiments. John Wiley & Sons.
5. Gilbert, Barresi (2016) Developmental Biology : 11th Edition

PSMB304: ADVANCES IN BIOTECHNOLOGY

(60L)

Learning Objectives:

The course is designed for learners to

- To understand the significance of IPR and patents in Biotechnology
- To learn about the biodiversity law
- To introduce ethical issues in Biotechnology ethics
- To learn the principles of nanotechnology
- To understand the importance of algal biotechnology

Learning Outcomes:

At the end of the course students will:

- Reflect on the need and implications of patents in Biotechnology
- Understand the biodiversity law
- Learn the bioethical guidelines in Biotechnology and Microbiology
- Relate to various applications of nano technology
- Learn the culturing and application of algal technology

Course Code	Unit	Subunit	Title	No.of Lectures	Credits
PSMB304			Advances in Biotechnology	(60L)	04
Unit 1	1		IPR and Biodiversity Law	(15L)	01
		1.1	Need for IPR in Biotechnology	(02L)	
		1.2	Patents for Biotechnology	(02L)	
		1.3	Implications of Patents in Biotechnology	(03L)	
		1.4	Case Studies <ul style="list-style-type: none"> - Basmati Rice Issue - Turmeric Patent - Agriculture Neem Patent - Chakraborty case - Corn genetically engineered with an insecticide 	(05L)	
		1.5	Biodiversity law: introduction, Development, International and National Biodiversity laws	(03L)	
Unit 2	2		Bioethics	(15L)	01
		2.1	The goals of biotechnology, Challenging characteristics of biotechnology	(01L)	
		2.2	Bioethics and microbiology Ethical issues and Perspectives in the Discipline of Microbiology Ethics Perspectives from India Bioethics, bioweapons and the microbiologist	(03 L)	
		2.3	Ethical guidelines for Biomedical research on Human subjects	(05L)	
		2.4	Case study –Infectious disease <ul style="list-style-type: none"> -Effects ,Causes and Prevention of infectious diseases through vaccination -Benefits and risks of vaccination -Alternative approaches to vaccination: voluntary, quasi-mandatory and incentivized Schemes, Comparing and assessing vaccination strategies, Children as special cases, Surveillance - HIV and AIDS as notifiable diseases, - Control of infectious diseases, 	(04L)	

			- Issues raised by quarantine and isolation, -Use of vaccines in control of infectious diseases		
		2.5	Public perception of biotechnology: Genetic engineering –safety, social, moral and ethical considerations	(02L)	
Unit 3	3		Nano Biotechnology	(15 L)	01
		3.1	Basics of Nanotechnology - Types of nano materials -Properties of nano materials	(01L)	
		3.2	Fundamentals of Bio-nanotechnology - nanomotors of biological systems - ATPsynthase: a nanoturbine - Flagellar motors in bacteria -Linear molecular motors	(05 L)	
		3.3	Biosynthesis of nanomaterials biosystems as nano factories - Bacteria as machinery for synthesis of nano metals- gold, silver, Zinc, cadmium, platinum - Fungi and Actinomycetes as fabricators of nano metals- - Plants as nano engineers - Algae as nanotechnologists	(03L)	
		3.4	DNA and proteins as templates for molecular Nanotechnology and nano electronics	(03L)	
		3.5	Applications of nanotechnology – Nanomedicine, nano bio-devices, nano implants, applications in agriculture, food and cosmetics.	(03L)	
Unit 4	4		Algal Biotechnology	(15 L)	01
		4.1	Culture techniques and media for growth of fresh water algae: - Measurement of algal growth in culture - lag phase, log phase, stationary phase and death phase using biomass, chlorophyll content, Measurement of algal pigemnts.	(05 L)	
		4.2	Culturing microalgae in Photo bioreactors, Fermentor and Outdoor ponds: Variation in design, culture conditions, scale up, economics, advantages and disadvantages	(05L)	
		4.3	Applications of Algal Biotechnology: Food Supplements and fertilizers, Bioactive compounds and cosmetics, Biofuel, high value commercial products, Bioplastics.	(05L)	

PRACTICAL FOR PAPER PSMB 304

1. Preparation and characterization of Silver Nanoparticles
2. Survival Curve and antibacterial activity of nano silver particles
3. Study of nano silver coated gauze / textiles for antimicrobial effect on different bacteria.
4. Preparation of growth culture medium for fresh water algae and study its diversity with respect to its type count and morphology .
5. Counting algal Cells in Cultures with the Light Microscope.
8. Isolation, inoculation and growth of microalgae.

SELF STUDY

1. Assignment on Measurement of Chlorophyll a and Carotenoids Concentration in Cyanobacteria
2. Study various types of microalgae and its role in climate change

REFERENCES:

For Unit 1

1. Molecular Biology by M D Morris
2. Microbial Biotechnology – principles and applications by Lee Yuan Kun
3. IPR- Unleashing the knowledge economy by Prabuddha Ganguli
4. Issues and Dilemmas of Biotechnology by Bernice Schacter
5. Biotechnology and IPR – Legal and Social Implications by Kshitij Kumar Singh
6. Law and National Biodiversity Strategies and Action Plans by the Law Division for the United Nations Environment Programme

For Unit 2

1. <https://www.researchgate.net/publication/23467644> Bioethics and biotechnology Article in Cytotechnology · May 2007
2. Ethical issues in microbiology, *P Desikan, A Chakrabarti, V Muthuswamy. Indian Journal of Medical Microbiology, (2011) 29(4): 327-301
3. Ethical Perspectives in the Discipline of Microbiology: Article · December 2015 DOI: 10.18099/ijetv.v1i2.6817 Article · December 2015 DOI 10.18099/ijetv.v1i2.6817
4. Health Ethics in South-East Asia. Health ethics in six sear countries. Volume 1 Edited by Nilam Kasturiaratchi, Redar Lie, Jens Seeberg.
5. Bioethics, bioweapons and the microbiologist: Fernando Anaya-Velázquez *Rev Latinoam Microbiol 2002;44 (1)
6. Ethical guidelines For Biomedical research on Human subjects .National Institute of Tuberculosis and Respiratory Diseases. Based on ICMR, CDSCO, GCP & International Ethical Guidelines.
7. Ethics in medical research: General principles with special reference to psychiatry research. Ajit Avasthi, Abhishek Ghosh, Sidharth Sarkar, Sandeep Grover. Indian Journal of Psychiatry 55(1), Jan-Mar 2013
8. Case study: Public health - ethical issues, Nuffield Council on Bioethics, Chapter 4 page no.51- 77.
9. Biotechnology- John E. Smith Fifth edition, Chapter 15, 232-242.

For Unit 3

1. Bionanotechnology –concepts and applications. Madhuri Sharon, Maheshwar Sharon, Sunil Pandey,Goldie Oza
- 2.Nanotechnology- Principles and Practices 2 nd edition Sulabha K. Kulkarni Capital Publishing Company
3. Nanotechnology- Nanomaterials and Nanodevices G.Mohan Kumar .Narosa Publications

For Unit 4

1. Bellinger, E. G. and Sigeo, D. C. (2010). Freshwater algae: Identification and use as a bioindicators.Wiley-Blackwell (Pre-read Book)
2. Lee, R. E. (2008). Phycology. 4ed. Cambridge University Press (Pre-read Book)
3. Andersen, R. A. (2005). Algal culturing techniques. Elsevier Academic Press
4. Sahoo, D. and Seckbach, J. (2015). The Algae World. Springer
5. Prescott, G. W. (1954). How to Know Fresh-Water Algae. WM C. Brown Company (For practicals only)
6. Vuuren, S. J. (2006). Easy identification of the most common freshwater algae. A guide for the identification of microscopic algae in South African freshwaters. DWAF and NWU (For practicals only)
7. Sharma, P., Sharma, N. (2017) Industrial and Biotechnological Applications of Algae: A Review. Journal of Advances in Plant Biology - 1(1):01-25. (Review Paper)
- 8.Barkia, I., Saari, N., Manning, S. R. (2019). Microalgae for High-Value Products Towards Human Health and Nutrition. Mar. Drugs 2019, 17, 304; doi:10.3390/md17050304 (Review Paper)
9. Rasul, I. et. al. (2017) Algae Biotechnology: A green light for engineered algae. From Algae Based Polymers, Blends and Composites. Elsevier (Book Chapter)
- 10.Barsanti, L. and Gualtieri P. (2014). Algae: Anatomy, Biochemistry, and Biotechnology, 2ed. CRC Press.
11. Richmond, A. and Hu, Q. (2013). Handbook of Microalgal Culture: Applied Phycology and Biotechnology, 2ed. John Wiley & Sons, Ltd.

Semester 4

THEORY

Course Code	UNIT	TOPIC HEADINGS	Credits	L / Week
Paper PSMB401- Industrial & Food Microbiology	I	Applications of Microbial technology in food processing	4	01
	II	Food Preservation & Food safety		01
	III	Strain improvement: The modern methods		01
	IV	Fermentations of Microbial products for commercial use		01
PSMB402 Applied Microbiology	I	Applications of Microbiology in bioremediation & pollution control	4	01
	II	Applications of Enzymes		01
	III	Microbial bio-molecules in diagnostics and therapeutics		01
	IV	Novel uses of microorganisms and microbial products		01
PSMB403 Plant, Agriculture and Animal Biotechnology	I	Plant Biotechnology	4	01
	II	Animal Biotechnology		01
	III	Bio-augmentation and Bio-stimulation in Agriculture		01
	IV	Bio-control in Agriculture		01
PSMB404 Mycology, Virology & Protozoology	I	Fungal technology	4	01
	II	Animal and Plant Virology		01
	III	Study of Bacteriophages and Algal Phages		01
	IV	Protozoology		01

PRACTICALS

PSMBP-401	Industrial & Food Microbiology	2	04
PSMBP-402	Applied Microbiology	2	04
PSMBP- 403	Plant, Agriculture and Animal Biotechnology	2	04
PSMBP-404	Mycology, Virology & Protozoology	2	04

PSMB401- INDUSTRIAL & FOOD MICROBIOLOGY

Learning Objective

The course is designed for learners to

- study recent advances in food microbiology & industrial fermentation technology
- Understand the basic knowledge of food fermentation, along with advanced methods of food preservation, food analysis and food safety.
- acquire knowledge about probiotics and prebiotics and their applications
- understand the high throughput screening techniques used for fermentation microorganisms.

Learning outcomes

At the end of the course the learner will be able

- to develop employable skills concurrently with an understanding of various fermentations process.
- To develop the skill for production & assessment of probiotic microbes

Detail Syllabi :

Course Code	Unit	Subunit	Title	No.of Lectures	Credits
PSMB304			Industrial & Food Microbiology	(60L)	04
	1		Applications of Microbial technology in food processing	15	
		1.1	Starter culture of bacteria , yeast & mold used in food fermentation	02	
		1.2	Fermented Foods :- 1.2.1 General methods of fermented food production 1.2.2 Fermented cereals :- Bread production 1.2.3 Fermented vegetables: - Sauerkraut production. 1.2.4 Production of microbial flavoring compounds :- Vanilla flavor	06	
		1.3	Prebiotic & Probiotic 1.2.1 Probiotics 1.2.2 Screening of Potential Probiotics 1.2.3 Industrial Aspects of Probiotic Production	07	

		1.2.4 Prebiotics		
	2	Food Preservation & Food safety	15	
		2.1 Advanced methods of food preservation Microwave Processing, Ohmic Heating, High-Pressure Processing, Pulsed Electric Fields, High-Voltage Arc Discharge Pulsed Light Technology Magnetic Fields, Ultrasound, Pulsed X-Rays, Ozone, Antimicrobial Edible Films	06	
		2.2 Advanced methods of detection of microorganisms in food Sampling plans and sample preparation, physical methods, chemical methods, immunoassay methods, others- Biosensors	05	
		2.3 Controlling quality of food Control at Source, Codes of Good Manufacturing Practice ,The Hazard Analysis and Critical Control Point (HACCP) Concept Quality Systems: BS 5750 and ISO 9000 Series Risk Analysis	04	
	3	Strain improvement: Modern methods	15	
		3.1 Screening methods and high throughput screening	01	
		3.2 Return of natural products	01	
		3.3 Broadening the base of the discovery process and increasing the gene expression	02	
		3.4 Post genomics era- the influence of genomics, transcriptomics and fluxomics on the improvement of primary metabolite producers	02	
		3.5 Use of recombination systems for the improvement of secondary metabolite production a. The application of parasexual cycle b. Protoplast fusion c. Recombinant technology	06	
		3.6 Post genomics era- the influence of genomics, transcriptomics and proteomics on the improvement of primary metabolite producers	03	
	4	Fermentations of Microbial products for commercial use	15	

		4.1	Microbial production of Rosmeric acid & Caffeic acid	05	
		4.2	Production of bacterial polysaccharide & Commercially produced Polysaccharides	04	
		4.3	Microbial Production of Riboflavin	02	
		4.4	Microbial Production of Antibiotic :- Cephalosporin , Tetracycline	04	

References

1. Bibek Ray and Arun Bhunia (2008) Fundamental Food Microbiology. 4th Ed. CRC Press.
2. Petra Foerst, Chalat Santivarangkna 2016 Advances in Probiotic Technology ,CRC Press A Science Publishers Book
3. Prescott and Dunn's "Industrial Microbiology".1982 4th Edition, McMillan Publishers
4. Okafor Nkuda 2007 "Modern Industrial Microbiology and Biotechnology", Science Publications Enfield, NH, USA.
5. Wilfried Schwab, Bernd Markus Lange, Bernd Markus Lange "Biotechnology of natural products" Springer International Publishing,
6. Pepler, H. J. and Perlman, D. (1979), "Microbial Technology". Vol 1 &2 , Academic Press
7. Stanbury P. F., Whitaker A. & Hall--S. J., 1997, "Principles of Fermentation Technology", 2nd Edition, Aditya Books Pvt. Ltd, New Delhi.
8. Osman Erkmén, T. Faruk Bozoglu, Food Microbiology - Principles into Practice Volume I and II, John Wiley (2016)
9. Adams and Moss , Food Microbiology, 3rd edition, RSC Publishing (2008)
10. Robert E.C. , Wildman 2nd Ed. " Handbook of Nutraceuticals & Functional Foods " CRC Press A SCIENCE PUBLISHERS BOOK
11. Ronald Ross Watson, Victor R. Preedy 1st Edition 2010 "Bioactive Foods in Promoting Health: Probiotics and Prebiotics" Academic Press is an imprint of Elsevier
12. Vijay K. Gupta, Helen Treichel, Volha Shapaval, Luiz Antonio de Oliveira, Maria Tuohy (eds.) - Microbial functional foods and Nutraceuticals-Wiley (2018)

Practical:-Industrial & Food Microbiology

1. Isolation & Characterization of organisms with probiotic potential from food samples .
2. Effect of prebiotic on probiotic culture
3. Sauerkraut preparation and Microbiological analysis
4. Production of antibiotic and assay

Assignment

1. Detection of microorganism in food by any one Novel method.

2. BIS methods to study different adulterants in foods

PAPER 402 APPLIED MICROBIOLOGY

Learning objectives

The course is designed for learners to

- To understand the role of microbiology in pollution control and remediation
- To study the applications of various enzymes and biomolecules
- To assess the novel uses of microorganisms and microbial products

Learning outcomes:

At the end of the course the learner will be able

- To make the students aware of the different applications of Microbiology
- To teach them the skill sets for application of those subjects in industry
- To enthuse an interest for entrepreneurship among students
- To prepare them for the job market.

Course Code	Subunit	Title		Credits
PSMB 402		APPLIED MICROBIOLOGY	(60L)	04
Unit 1		Applications of Microbiology in bioremediation & pollution control	(15L)	01
	1.1	Introduction to Bioremediation strategies for synthetic compounds, petrochemicals, inorganic waste.	02	
	1.2	Bioremediation strategies and techniques in situ and testing its efficacy and side effects	03	
	1.3	Bioremediation of metals & gaseous ex situ. Environment modification for bioremediation	03	
	1.4	Approaches to bioremediation : Microbial seeding & bioengineering using rDNA technology	03	
	1.5	Bioremediation of various ecosystems-Soil, aquifers, marine, air	04	
	Unit : II	Applications of enzymes	(15L)	01
	2.1	Enzymes as analytical tool for the assessment of food quality, safety, and monitoring food processing.	05	
	2.2	<u>Applications of enzymes in food :</u> Baking, fruit juice production, processing, brewing, and dairy. Applications of nonfood enzymes in detergents, laundry, Textiles, medical, therapy and chemical industry.	05	
	2.3	<u>New industrial enzyme applications:</u> Cosmetics, enzymes for preservation. Hard surface cleaning, oil field application, waste water treatment, pH Shift	05	
	Unit III :	Microbial biomolecules in diagnostics and therapeutics	(15L)	01

	3.1	Protein therapeutics: Hormones, cytokines, Monoclonal antibodies, regenerative medicines, molecular diagnostics, NAS as therapeutic agents, Vaccines	09	
	3.2	Use of monoclonal antibodies in diagnostics: RA ,Blood grouping.	06	
	UNIT IV:	Novel uses of microorganisms and microbial products	(15L)	01
	4.1	Biosensors, microbial concrete, Biobleaching, Enhanced oil recovery, Biofuels,	05	
	4.2	Biotech of the marine environment, microbial contribution of climate change,	05	
	4.3	Biopolymers, Bio surfactants	05	

PRACTICALS FOR Paper PSMB 402

- 1) Enrichment and isolation of Agarase producing bacteria
- 2) Isolation of pigment producing bacteria from marine environment and extraction of pigments through solvent extraction procedures
- 3) Isolation of biopolymer producing bacteria and quantify the biopolymer produced
- 4) Removal of blood stains by using proteases/detergents.
- 5). Residual starch degradation by amylase

SELF STUDY

1. Report on an visit to an relevant industry/institute

References

Unit -I	Environmental Biotechnology by Alan_Scragg ^{2nd} edition
Unit -II	<ul style="list-style-type: none"> • Wolfgang Aehle ,Enzyme in industry • Muthuswamy --Enzymes in Food and Beverage Processing Edited by Muthusamy Chandrasekaran,CRC Press- • Medical Biotechnology –Pratibha Nallari – • Comprehensive Biotechnology-Ramawat 4th Edition.
Unit -III	Glick: Molecular Biotechnology - Principles and Applications of Recombinant DNA (3rd, Third Edition) By Bernard R. Glick Nallari
Unit -IV	Alans Cragg ,Environmental Biotechnology by Alan Scragg B. D. Singh Kalyani Publishers, 2010 - Biotechnology -

PAPER PSMB403- PLANT, AGRICULTURE AND ANIMAL BIOTECHNOLOGY

Course Objective:

The course is designed for learners to

- To familiarize the students with the new concepts and advanced research areas and applications of plant and animal biotechnology.
- To promote integration of the concepts of Bioaugmentation, Biostimulation and Biocontrol in the field of Agriculture.
- To acquaint them with the concept and scope of Organic Farming.

Course outcome:

By the end of the course, the learner will have sufficient scientific understanding & will be able to: -

1. Demonstrate different methods to get transgenic crops and their applications in getting resistant varieties.
2. Comprehend the different methods of obtaining Transgenic animals and their applications.
3. Assess the importance of Vermicomposting and Biofertilizers in agriculture.
4. Understand the role of microbiologist in Organic farming and its scope.
5. Critically evaluate the need for the use of Biocontrol agents in the field of a agriculture.

PSMB403			PLANT, AGRICULTURE AND ANIMAL BIOTECHNOLOGY	60L	04
	Unit 1	Subunit	Unit 1- Plant Biotechnology	15L	01
		1.1	Genetic engineering of Plants		
			Plant transformation with Ti plasmids of <i>Agrobacterium tumefaciens</i> , Ti plasmid derived vector systems, physical methods of transferring genes to plants:, Use of guns and electric shock to transfer DNA into plant cells, Microprojectile bombardment, Chloroplast engineering (04)	04	
		1.2	Bombardment with DNA coated beads can produce transgenic organelles, Plant genes can be cloned by using transposable elements, T-DNA is used as an insertion mutagen. Use of reporter genes in transformed plant cells, viruses can be used as vectors for whole plants, Manipulation of gene expression in plants: Gene targeting, Facilitating protein purification: Oleosins,	04	

			Rhizosecretion, Glycosylation (04)		
		1.3	Uses genetically engineered plants: To overcome Biotic and abiotic stress: Insect resistance: Increasing expression of the <i>B.thuringiensis</i> protoxin, other strategies for protecting plants against insects, Virus resistance, Herbicide resistance, fungus and bacterium resistance, Oxidative stress, Salt and drought stress, Fruit ripening and Flower wilting. To improve plant quality and proteins.	04	
		1.4	Modification of plant nutritional content, Modification of plant taste and appearance, Plants as bioreactors, edible vaccines	03	
	Unit 2		Unit 2- Animal Biotechnology	15L	01
		2.1	Transgenic animals: Transgenic Mice: methodology: The retroviral Vector method, The DNA microinjection method, The engineering embryonic stem cell method, Genetic modification with the Cre-loxP recombination system, RNA interference, Transgenesis with high capacity vectors. (07)	07	
		2.2	Uses of transgenic animals: Transgenic disease model, transgenic mice as test system, Conditional regulation of transgene expression, , Cloning live stock by Nuclear transfer, Transgenic livestock: production of pharmaceuticals, Production of Donor organs, Disease resistant livestock, Improving milk quality, Improving animal production traits, Transgenic poultry and transgenic fish (08)	08	
\	Unit 3		Bioaugmentation and Biostimulation in Agriculture	15L	01
		3.1	Introduction	02	
		3.2	Vermicomposting	03	
		3.3	Bio-intensive Nutrient Management, Use of Biofertilizers: Rhizobium, blue green algae, phosphate solubilizers, Mycorrhiza.	09	
		3.4	Organic Farming and scope of organic farming in India	01	
	Unit		Biocontrol in Agriculture	15L	01

	4				
		4.1	Biological control of Pests: Biological Control agent, mechanism of biocontrol, biopesticide, bioinsecticide, bioherbicide	05	
		4.2	Induced systemic resistance in Biocontrol of Plant diseases: a) Induction of systemic resistance by <i>Pseudomonas</i> , <i>Bacillus</i> , <i>Trichoderma</i> , Fungi and others. b) Mechanism of Induced systemic resistance	04	
		4.3	Microbial control strategies: Postharvest diseases of Fruits, Vegetables, Roots and Tubers a) Mode of action of biocontrol agents b) Extensive of use of biocontrol agents c) Enhancing biocontrol efficacy of Microbial Antagonist d) Biotechnological Approach	06	

REFERENCES:

1. B.R. Glick, J.J. Pasternak and C.L. Patten. Molecular Biotechnology: Principles and Applications of Recombinant DNA. 4th Edition. ASM Press, Washington D.C.
2. J.D. Watson, M. Gilman, J. Witkowski and M. Zoller. Recombinant DNA. 2nd Edition. Scientific American Books.
3. A.K. Sharma. A handbook of Organic Farming. 2004. Agrobios India.
4. A. Singh, A. Parmar and R.C.Kuhad. Bioaugmentation, Biostimulation and Biocontrol. Soil Biology Volume 28. Springer.
5. H. M. Gupta. Organic Farming and Sustainable Agriculture. 2005. ABD Publishers, Jaipur, India.

Practical: Plant, Agriculture and Animal Biotechnology

1. Preparation of Vermicompost and microbiological analysis of vermicompost
2. Isolation of organisms producing plant growth promoting substances
3. Production and estimation of plant growth promoting substances (any one)
4. Qualitative and quantitative study of Phosphate solubilizers

SELF STUDY

1. Report on a visit to Biofertilizer and biopesticide production plants
2. Assignment on Transgenic organelles in plants/ Uses of transgenic livestock

PSMB404 : MYCOLOGY, VIROLOGY & PROTOZOOLOGY

Learning Objective

The course is designed for learners to

- provide a broad background to some of the fastest developing areas in current fields of Mycology, Virology and Protozoa and study their potential importance in various areas other than Medical Microbiology
- understand the importance of environmental fungi, viruses and protozoa in the nutrient and chemical cycles needed to maintain life on Earth.

Learning Outcome –

At the end of this course the learner will

- Be familiar to contributions that show new applications, developments of well-established technology, novel research into new technology with reference to these three categories of microorganisms.
- have solid understanding of basic concepts in these fields and the knowledge gained will enable students to apply these concepts to problems in the different fields of Mycology, Virology and Protozoa.
- be able to predict the outcome of intervention measures both on the cellular as well as the population level.

Course Code	Unit	Subunit	Topics	Lectures	Credits
PSMB-404	Unit 1		Fungal technology	15	01
		1.1	Mycology a) A neglected Mega Science b) The diversity of fungi and fungus like organisms c) Fungal molecular taxonomy: An overview	02	
		1.2	Fungal Pigments and Mycotoxins a) Genetic basis of pigment production b) Factors affecting pigment production c) Fermentation for pigment synthesis d) Mycotoxins and their replacement e) Relevance of pigments in various fields	02	
		1.3	Fungal siderophores – structure, function and applications	02	
		1.4	Fungal Lipid production a) Oleaginous fungi b) Lipid production from lignocelluloses and crude glycerol	05	

			c) Production of specific chemicals and fuels derived from lipid metabolism		
		1.5	Fungal Metabolites a) Enzymes - Xylanase, Laccase, Galactosidase, Inulinase, Catalase and b). Flavours and Aroma c) Engineering of fungal biomolecules	04	
PSMB-404	Unit 2		Animal and Plant Virology	15	01
			(Study of virus with respect to Clinical Features and Epidemiology Pathogenesis, Diagnosis, Prevention, and Control) Veterinary and Zoonotic viruses a) Study of members of the genus Capripoxvirus – (Sheep pox Virus, Goat pox Virus, and Lumpy Skin disease virus) b) Study of Members of the Genus Asfarviridae African swine fever virus c) Marburg and Ebola disease viruses d) Members of the genus Influenza Virus A - Swine Influenza viruses and Avian influenza viruses e) Detection of viruses - Measurement of virus particles – Electron microscopy, f) Measurement of viral enzyme activity- serological method, virus neutralization, Hemagglutination, complement fixation, Protein detection, Immuno precipitation and Immunoblotting, ELISA, Green fluorescent probe, Nucleic acid detection, DNA microarray.	09	
		2.2	Plant virology a) Origin and Evolution of plant virus – history and descriptors used in virus taxonomy b) Disease symptoms and Economic losses- Economic losses due to plant virus, Macroscopic symptoms- Local and systemic c) Detection of plant viruses: Infectivity assays- Quantitative Assay Based on Local Lesions, Quantal Assay Based on Number of Individuals Infected. d) Use of plant viruses in industry.	06	
PSMB-404	Unit 3		Study of Bacteriophages and Algal Phages	15	01
		3.1	Intemperate and Temperate Bacteriophage		

			<p>a) Intemperate Bacteriophage – T2, T6, T1, T5, T3 and T7 Bacteriophages belonging to the Ff Group. Bacteriophages Infecting <i>Bacillus subtilis</i> - Bacteriophage SP01, Bacteriophage ϕ29</p> <p>b) Temperate Bacteriophage – Other Lambdoid Phages- Bacteriophage P22, Bacteriophage P2 and P4, Bacteriophage P1, Bacteriophage Mu, SSV1 and SSV2.</p> <p>c) Study of bacteriophages by one step growth curve</p>	9	
		3.2	Study of Mycobacteriophage -Phage therapy - therapeutic approach to Mycobacterial infections	2	
		3.3	Algal bloom viruses	2	
		3.4	Cultivation of viruses from Environment	2	
PSMB-404	Unit 4		Protozoology	15	01
		4.1	<p>Introduction to Protozoa</p> <p>a) Classification of Protozoa</p> <p>b) Processes in Protozoa: Motility, Nutrition, Reproduction</p> <p>c) Cultivation of Protozoa</p>	01	
		4.2	<p>Protozoa used in Wastewater Microbiology</p> <p>a) Sarcodina</p> <p>b) Flagellates</p> <p>c) Ciliates</p> <p>d) Sporozoa</p> <p>e) Rhizopoda</p>	02	
		4.3	<p>Importance of Protozoans in water and wastewater treatment</p> <p>a) Protozoa as indicators of wastewater treatment efficiency</p> <p>b) Types of Protozoans (Key groups)</p> <p>c) Activated sludge ecosystems</p> <p>d) Microfaunas as indicators</p>	04	
		4.4	Importance of Protozoans in Soil Bioremediation	03	
		4.5	<p>Protozoan Parasites</p> <p>a) <i>Giardia spp</i></p> <p>b) <i>Cryptosporidium</i></p>	05	

			<p><i>c) Microsporidia</i></p> <p><i>d) Toxoplasma</i></p> <p><i>e) Naegleria fowleri</i></p>		
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PRACTICALS FOR PSMB 404

1. Qualitative and quantitative estimation of fungal Laccase enzyme
2. Enrichment and Enumeration of bacteriophage.
3. Haemagglutination/ Haemagglutination Inhibition test for determination of titre of viruses
4. Demonstration of virus cultivation within chick embryo
5. Detection of viral enzyme activity /viruses by ELISA test
6. Cultivation of protozoa from natural environment

SELF STUDY

1. Report on Visit to virology institutes like NIV Pune, Veterinary college or any other relevant institute
2. Assignment on Emerging protozoa/fungal/viral diseases .

REFERENCES

Unit 1 – Applications of fungal technology

1. Applied Mycology by Mahendra Rai, Paul Dennis Bridge, 2009, CAB International.
2. Fungal Biology 4th ed. By J. W. Deacon ,2006, Blackwell Publishing.
3. Fungal Biomolecules – sources, Applications and Recent developments by Vijay kumar Gupta, Robert L. Mach, S. Sreenivasaprasad2015, Published by John Wiley & Sons .ltd.
4. Developments in Fungal Biology and Applied Mycology by TulsiSatyanarayana, Sunil K. Deshmukh, B. N. Johri2017, Springer.
5. Gunther Winkelmann (2007) “Ecology of siderophores with special reference to the fungi” *Biometals* , 20:379–392.
6. E. Ahmed* and S. J. M. Holmström (2014); “Siderophores in environmental research: roles and applications” *Microbial Biotechnology*, 7, 196–208. Published by John Wiley & Sons Ltd and Society for Applied Microbiology.
7. Biotechnology of Yeasts and Filamentous Fungi by Andriy A. Sibirny 2017, Springer International Publishing AG .
8. Radhika Deshmukh ,Anshuman A. Khardenavis and Hemant J. Purohit Review Article, *Indian J. Microbiology* (July–Sept 2016) 56(3):247–264.

Unit 2 – Animal and Plant Virology

1. Fenners Veterinary Biology - 4th edition, 2011, N.James Maclachlan & Edward J. Dubovi
2. Principles of Molecular virology- Allan J. Cahn. 6th edition, 2016.
3. Plant Virology ,Roger Hull

Unit 3 - Study of Bacteriophages and Algal Phages

1. Bacterial and Bacteriophage genetics - 5th edition, 2006, Edward A. Birge.
2. Advances in viral research. – Past, present and future. Said A. Ghabrial
3. Corina P. D. Brussaard and Joaquín Martínez Martínez, Algal bloom viruses Plant Viruses 2 (1), 1-13 ©2008 Global Science Books
4. Protozoal Viruses, Louis S.Diamond and Carl F.T.Mattern
5. Principles of Virology – Flint 2nd edition
6. Understanding Viruses – Teri Shors. Jones and Bartlett pub
7. <https://doi.org/10.2147/IDR.S218638>
8. <https://doi.org/10.1086/343812>
9. <https://www.researchgate.net/publication/23642149>
10. doi:10.1128/AEM.07175-11

Unit 4 – Protozoology

1. The handbook of water and waste water Microbiology by Duncan Mara and Nigel Horan,2003
 2. Wastewater Microbiology, 2nd edition by Bergey, D.H
 3. Wastewater Microbiology, 4th edition by Gabriel Bitton,2011
 4. Pauli W, Berger S, Protozoa in wastewater treatment: Function and Importance. Biodegradation and Persistence,2001,Pg 203-252.doi:10,1007/10508767_3
 5. Atlas of Medical Helminthology and Protozoology, 2001 Peter L. Chiodini, A.H.Moody, D.W.Manser
 6. Textbook of Medical Parasitology: Protozoology and Helminthology, 4th edition by S. C. Parija
 7. <https://www.sciencedirect.com/science/article/abs/pii/S1872203207600687>
 8. <https://www.nature.com/articles/ismej201320>
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5. Theory Evaluation :

Students appearing for the Revised MSc part 2 syllabi will be evaluated as per the 60:40 scheme wherein the term end exam will be of 60 marks while 40 marks will be through internal evaluation . There will be no internal evaluation for practical examination

A. Theory Internal Examination : 40%

a. CSR Component : 10 marks

Any one topic per paper can be selected by the student in which the candidate through a submitted report and actual observation by the teacher be graded for their involvement in

- Social outreach awareness of microbiology in daily life of villages , slum etc
- Teaching assistance
- Instrument maintenance of the dept
- Involvement in organization of conferences , workshops seminars etc
- Ecofriendly Green initiatives taken by dept like kitchen and garden waste disposal , vermin-composting etc

b. Technical Component : 30 marks

Any one topic per paper can be selected by the student from the following

- Patent writing on an selected microbiological innovation /technology
- Manuscript writing on a selected review based topic
- A report on case study
- Involvement in Scientific debate on a given topic quoting relevant scientific papers to emphases its pro and cons
- Poster preparation
- Attending a scientific conference and writing a report on it
- Visiting a lab/ biotechnology industry as observers and presenting a report on it
- Abstract writing
- Maintaining a register wrt to use of culture as per the biodiversity Act

Note : All reports presented will be checked by the Student for Absence of Plagiarism using the free Software like UrKund, Viper etc and attach a certificate of compliance for the same .

B. Theory -External examination -60% .

- Semester End Theory Assessment 60 marks
- The duration of these exam will be of 2.5 hrs
- The theory question paper will have 5 questions each of 12 marks .
- For each unit there will be one question and the fifth will be based on all the four units

- All questions shall be compulsory with internal choice within the questions such that each question will be set of 20-23 marks with options.
- Questions shall be subdivided into sub questions a, b, c, d, and e only and the allocation of marks will depend on the weight age of the topic

Practicals :

1. Each practical paper should have 1 major and 1 minor doable expts. The major expts should be exhaustive and should involve planning , obtaining the culture etc
2. The candidate will be given a choice of selecting the type of practicals they wish to perform . If students wish to take up project work then in Semester 3 they will have to submit their research proposal in the Mumbai university research grant format for its evaluation for 50 marks while in Semester 4 the candidate will submit his/her dissertation as a bound volume and present the work to the examiners through a presentation (oral/poster) for its evaluation for 100 marks
3. In lieu of this submission , the candidate will be allow to appear for practicals of Semester 3 only for three papers i.e PSMB 302, 303 and 304 instead of the usual four papers. In Semester 4 the candidate will appear for their Practical exam in only two papers i.e PSMB 401, and 403 instead of the usual four papers.
5. If the students does not wish to take up Project work then the practical exam will be held on the expts of all the four papers in both Semester 3 and Semester 4.
5. To make our students knowledgeable in various technique, college are requested to form themselves in small groups based on location convenience and make arrangements to send their students to various institutes where expts that are expensive can be demonstrated.

Practical Examination Pattern

Semester 3

Practical Course	Major Technique	Minor Technique	Journal	Viva	Spots	Total
PSMB 301	25 marks	10 marks	5 marks	5 marks	5 marks	50 marks
PSMB302	25 marks	10 marks	5 marks	5 marks	5 marks	50 marks
PSMB303	25 marks	10 marks	5 marks	5 marks	5 marks	50 marks
PSMB304	25 marks	10 marks	5 marks	5 marks	5 marks	50 marks

OR

Practical Course	Major Technique	Minor Technique	Journal	Viva	Spots	Total
PSMB302	25 marks	10 marks	5 marks	5 marks	5 marks	50 marks
PSMB303	25 marks	10 marks	5 marks	5 marks	5 marks	50 marks
PSMB304	25 marks	10 marks	5 marks	5 marks	5 marks	50 marks
Research proposal in the Mumbai university research grant format and present the proposal to the examiners through oral/poster						50 marks

Semester 4

Practical Course	Major Technique	Minor Technique	Journal	Viva	Spots	Total
PSMB 401	25 marks	10 marks	5 marks	5 marks	5 marks	50 marks
PSMB402	25 marks	10 marks	5 marks	5 marks	5 marks	50 marks
PSMB403	25 marks	10 marks	5 marks	5 marks	5 marks	50 marks
PSMB404	25 marks	10 marks	5 marks	5 marks	5 marks	50 marks

OR

Practical Course	Major Technique	Minor Technique	Journal	Viva	Spots	Total
PSMB401	25 marks	10 marks	5 marks	5 marks	5 marks	50 marks
PSMB403	25 marks	10 marks	5 marks	5 marks	5 marks	50 marks
Research dissertation submitted as a bound volume and present the work to the Examiners through a presentation (oral/poster) for its evaluation						100marks