



**R.P. Gogate College of Arts & Science and R.V.  
Jogalekar College of Commerce, Ratnagiri  
(Autonomous)**

**Master of Science (M.Sc.) Microbiology**

**M.Sc. Part -2 [Sem III & IV]**

***Course Structure***

**Under Choice Based Credit System (CBCS)**

**To be implemented from Academic Year- 2024-2025**

<b>Name of Program</b>	<b>M.Sc.</b>
<b>Level</b>	PG
<b>No of Semesters</b>	04
<b>Year of Implementation</b>	<b>2024-25</b>
<b>Program Specific Outcomes (PSO)</b>	<ol style="list-style-type: none"> <li>1] Learner shall know the advanced tools and techniques in Microbiology.</li> <li>2] Learner shall get insights and in depth knowledge of applied Microbiology which includes bioremediation, diagnostics, therapeutics and novel uses of microorganisms.</li> <li>3] Learner shall gain the knowledge of industrial and food microbiology techniques.</li> <li>4] Learner shall know the advancement in the field of animal and agricultural biotechnology.</li> <li>5] Learner shall able to run industry based assays in the fields related to cell biology, food microbiology, pharmaceutical microbiology and cosmetic microbiology.</li> <li>6] Learners shall become aware about IPR and bioethics.</li> <li>7] Learner shall able to carry out simple research projects and apply knowledge of biostatistics for research purpose.</li> </ol>
<b>Relevance of PSOs to the local, regional, national, and global developmental needs</b>	<p>Microbiology is the study of microorganisms. At the postgraduate level this discipline needs a more advanced and updated knowledge of microbiology. Therefore the said curriculum is designed in such a way that learner should get the knowledge of advanced techniques in microbiology. At local to global level research and innovation is the key to success. These research abilities will be inculcated by simple research projects. Globally the demand of skilled microbiologist is increasing so the keen knowledge of industrial, food and pharmaceutical microbiology techniques is essential. The Covid 19 pandemic has established the global threat of communicable diseases. In such situation control strategy should not limit at local level. The vaccines produced by animal cell culture technique has remarkable role in fight against such global problem. The current curriculum provides the knowledge of such animal cell culture techniques. The pharmaceutical industries needs a skilled microbiologist accompanied with the knowledge of industrial product assays. The said curriculum provides in depth knowledge about such assay methods.</p> <p>Summarizing, Post graduates of MSc. Microbiology program will be informed citizens who can understand and evaluate impact of new research and innovation in Life sciences and will be able to pursue wide range of careers including biological and life science research in higher educational institutions as well as careers in public health, clinical research, food, pharmaceutical and biotechnological industries.</p>

The performance of the learners shall be evaluated into two parts. The learner's performance shall be assessed by Internal Assessment with 40% marks in the first part and by conducting the Semester End Examinations with 60% marks in the second part. The allocation of marks for the Internal Assessment and Semester End Examinations are as shown below-

**A) Internal Assessment: 40 % (40 Marks)**

Sr.No.	Particulars	4 credit subjects Marks	2 credit subjects Marks
01	One Class Test / Online Examination to be conducted in the given semester [Duration: 40 Minutes] [Duration: 20 Minutes]  Question Paper Pattern for Periodical Class Test <b>Maximum Marks: 20 (4 Credit Subjects)</b> Duration: 40 Minutes Match the Column / Fill in the Blanks / Multiple Choice Questions/ True or False / Answer in One or Two Lines (Concept based Questions) (1 Marks each X 5 Que. = 05 Marks) Descriptive Questions – 5 marks each X 3 Que. = 15 Marks  <b>Maximum Marks: 10 (2 Credit Subjects)</b> Duration: 20 Minutes Descriptive Questions – 5 marks each X 2 Que. = 10 Marks	20	10
02	Assignments	10	05
03	Active participation in routine class instructional deliveries and overall conduct as a responsible learner, mannerism and articulation and exhibit of leadership qualities in organizing related academic activities	10	05
	<b>Total</b>	<b>40</b>	<b>20</b>

**B) Semester End Examination: 60% of 100 (60 Marks) or 60% of 50 (30 Marks)**

**For 4 credit course – 60 Marks**

The examination shall be of 2 hours duration.

Question No	Unit	Type of Question	Marks Distribution
Q1	I	Short Note (12)	6 marks each X 2 Que. [out of 4] = 12 Marks
Q2	II	Short Note (12)	6 marks each X 2 Que. [out of 4] = 12 Marks
Q3	III	Short Note (12)	6 marks each X 2 Que. [out of 4] = 12 Marks
Q4	IV	Short Note (12)	6 marks each X 2 Que. [out of 4] = 12 Marks
Q5	I, II, III, IV	Objective (12)	Match the Column / Fill in the Blanks / Multiple Choice Questions/ True or False / Answer in One or Two Lines (Concept based Questions) (1 Marks each X 12 Que. = 12 Marks)

**For 2 credit course – 30 Marks**

The examination shall be of 1 hour

Question No	Unit	Type of Question	Marks Distribution
Q1	I	Short Note (12)	6 marks each X 2 Que. [out of 4] = 12 Marks
Q2	II	Short Note (12)	6 marks each X 2 Que. [out of 4] = 12 Marks
Q3	I and II	Objective (06)	Match the Column / Fill in the Blanks / Multiple Choice Questions/ True or False / Answer in One or Two Lines (Concept based Questions) (1 Marks each X 6 Que. = 6 Marks)

**Standard of Passing**

The learner to pass a course shall have to obtain a minimum of 40% marks in aggregate for each course where the course consists of Internal Assessment & Semester End Examination. The learner shall obtain minimum of 40% marks (i.e. 16 out of 40 or 8 out of 20) in the Internal Assessment and 40% marks in Semester End Examination (i.e. 24 out of 60 or 12 out of 30) separately, to pass the course and minimum of Letter Grade “P” in the project component, wherever applicable to pass a particular semester. A learner will be said to have passed the course if the learner passes the Internal Assessment & Semester End Examination together.

**Performance Grading:  
Letter Grades and Grade Points**

<b>Semester GPA/ Program CGPA Semester/Program</b>	<b>% of Marks</b>	<b>Alpha-Sign/ Letter Grade Result</b>
9.00-10.00	90.0 -100	O (Outstanding)
$8.00 \leq 9.00$	$80.0 \leq 90.0$	A+ (Excellent)
$7.00 \leq 8.00$	$70.0 \leq 80.0$	A (Very Good)
$6.00 \leq 7.00$	$60.0 \leq 70.0$	B+ (Good)
$5.50 \leq 6.00$	$55.0 \leq 60.0$	B (Above Average)
$5.00 \leq 5.50$	$50.0 \leq 55.0$	C (Average)
$4.00 \leq 5.00$	$40.0 \leq 50.0$	P (Pass)
Below 4.00	Below 40	F (Fail)
Ab (Absent)	-	Absent

Master of Science (M.Sc.) Programme  
Under Choice Based Credit System (CBCS)  
Course Structure

M.Sc. II [Microbiology]

(To be implemented from Academic Year 2024-25)

No. of Courses	Semester III	Credits	No. of Courses	Semester IV	Credits		
<b>Major Mandatory</b>				<b>Major Mandatory</b>			
PSMB301	Tools And Techniques In Microbiology	4	PSMB401	Industrial And Food Microbiology	4		
PSMB302	Pharmaceutical And Cosmetic Microbiology	4	PSMB402	Applied Microbiology	4		
PSMB303	Practical's of PSMB301 and PSMB302	4	PSMB403	Practical's of PSMB401 and PSMB402	4		
PSMB304	IPR and Bioethics	2					
<b>Major Electives</b>				<b>Major Electives</b>			
PSMB305	Cell Biology	2	4	PSMB404	Advances in biotechnology	2	4
PSMB306	Practical's of PSMB305	2		PSMB405	Practical's of PSMB404	2	
<b>OR</b>				<b>OR</b>			
PSMB307	Animal and Agricultural Biotechnology	2		PSMB406	Mycology and Protozoology	2	
PSMB308	Practical's of PSMB307	2		PSMB407	Practical's of PSMB406	2	
PSMB309	Research Project	4	PSMB408	Research Project	6		
<b>Total Credits</b>		<b>22</b>	<b>Total Credits</b>		<b>22</b>		

## Syllabus for M.Sc. II Microbiology Semester III

From the year 2024-25

No. of Courses	Semester III		Credits
<b>Major Mandatory</b>			
PSMB301	Tools And Techniques In Microbiology		4
PSMB302	Pharmaceutical And Cosmetic Microbiology		4
PSMB303	Practical's of PSMB301 and PSMB302		4
PSMB304	IPR and Bioethics		2
<b>Major Electives</b>			
PSMB305	Cell Biology	2	4
PSMB306	Practical's of PSMB305	2	
<b>OR</b>			
PSMB307	Animal and Agricultural Biotechnology	2	
PSMB308	Practical's of PSMB307	2	
PSMB309	Research Project		4
<b>Total Credits</b>			<b>22</b>

<b>Name of the Course</b>	Tools and Techniques in Microbiology
<b>Course Code</b>	PSMB301
<b>Class</b>	M.Sc. II
<b>Semester</b>	III
<b>No of Credits</b>	04
<b>Nature</b>	Theory
<b>Type</b>	Major: Mandatory
<b>Highlight revision specific to employability/ entrepreneurship/ skill development</b>	Developing expertise in sample preparation techniques for phytopharmaceutical analysis, microscopy, chromatography and spectroscopy enhances your employability in various industries such as pharmaceuticals, research, and quality control. Proficiency in fluorescence microscopy is beneficial for careers in cell biology, neuroscience, and diagnostics. Expertise in advanced analytical techniques like Mass Spectrometry, NMR Spectroscopy is sought after in pharmaceuticals, biotechnology, and environmental monitoring. Understanding microbial analysis and genomics is valuable in fields like microbiology, biotechnology, and medical research. Skill development includes precision, attention to detail, and adherence to safety protocols during lab & research work. Entrepreneurs can offer microbial identification services or develop novel DNA extraction kits. They also can establish microscopy training workshops or consulting services for image analysis.

## PSMB301 - Tools and Techniques In Microbiology Modules at a Glance

Sr. No.	Modules	No. of Lectures
I	Biological sample preparation and Modified analytical techniques	15
II	Advanced Microscopy Techniques	15
III	Spectroscopic and Chromatography Techniques: Principle, working and applications	15
IV	Identification methods in microbiology	15
<b>Total</b>		<b>60</b>



## Course Outcomes:

### 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
- 4) Be able to understand concept of genome sequencing, analysis and its applications

## Curriculum:

<b>PSMB301 - Tools and Techniques in Microbiology</b>			
<b>Unit</b>	<b>Title</b>	<b>Learning Points</b>	<b>No of Lectures</b>
I	Biological sample preparation and Modified analytical techniques	1.1 Sample preparation: An analytical perspective 1.2 General sample preparation for analysis of Phyto pharmaceuticals 1.3 Preparation of sample and staining for SEM, TEM, Atomic force Microscopy, Confocal Microscopy. 1.4 Preparation of sample and general principle of chromatography and spectroscopic techniques 1.5 Combination procedures for analysis with relevant examples/case studies : a) TLC and HPLC b) HPTLC and MS c) TLC and FTIR d) TLC and Raman spectroscopy	15 (1)

II	Advanced Microscopy Techniques	<p>2.1 Principle and working of</p> <ol style="list-style-type: none"> <li>a. TEM &amp; SEM</li> <li>b. Confocal Microscopy</li> <li>c. AFM</li> </ol> <p>2.2 Principle &amp; Working of</p> <ol style="list-style-type: none"> <li>a. Fluorescence Microscopy,</li> <li>b. High Resolution Fluorescent Microscope,</li> </ol> <p>Concept Understanding of Fluorescence recovery after photobleaching (FRPA), and Forster Resonance Energy Transfer (FRET)</p>	15 (1)
III	Spectroscopic and Chromatography Techniques: Principle, working and applications	<p>3.1 Mass Spectroscopy : ESI-MS and MALDIMS</p> <p>3.2 NMR spectroscopy</p> <p>3.3 FTIR</p> <p>3.4 Ion exchange chromatography</p> <p>3.5 Gel filtration chromatography</p>	15 (1)
IV	Identification methods in microbiology	<p>4.1 Introduction of microbial systematic Phylogeny: Overview of phylogeny and Phylogenetic trees</p> <p>4.2 i) Culture dependent analysis of microbial communities: Laser Tweezer Flow cytometry</p> <p>ii) For classification &amp; identification through Phenotypic analysis using VITEK , API 20, FAME.</p> <p>4.3 Culture independent methods</p> <p>i) Methods for DNA / RNA extraction</p> <p>ii) Gene sequence analysis</p> <ol style="list-style-type: none"> <li>1. Amplification of 16S rRNA gene for prokaryotes and SSU, LSU, ITS.</li> <li>2. Multi-locus sequence typing</li> <li>3. Genome fingerprinting (Multi gene and whole genome)– Ribotyping</li> </ol> <p>iii) Sequencing genomes</p> <ul style="list-style-type: none"> <li>• First generation - Sanger sequencing and sequence analysis using different tools (Chromas – Pro, SeqMan)</li> <li>• Shotgun – genomic library</li> <li>• Second generation – Amplicon sequencing Illumina</li> <li>• Third and fourth generation Heliscope and Ion torrent Oxford nanopore</li> </ul> <p>iv) Environmental genomics An introduction to meta-genomics, meta transcriptomes and Meta-proteomics</p>	15 (1)

## Learning Resources recommended:

- 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)
- 15) Applied NMR Spectroscopy for Chemists and Life Scientists by Oliver Zerbe and Simon Jurt, (2014)
- 16) Techniques and Instrumentation in Analytical Chemistry Volume 18, 1997
- 17) High-Performance Thin-Layer Chromatography (HPTLC) by Man Mohan Srivastava. 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 14<sup>th</sup> ed.
- 20) Molecular cloning : a lab manual, Green and Sambrook vol. 1 4<sup>th</sup> ed.
- 21) <https://www.olympus-lifescience.com/en/microscoperesource/primer/techniques/confocal/confocalintro/>
- 22) <http://www.ammr.org.au/myscope/pdfs/tem.pdf>
- 23) <https://www.olympuslifescience.com/en/microscoperesource/primer/techniques/confocal/applications/fretintro/>

## Teaching Plan

Unit No.	Unit Title	Teaching Methods	No. of Lectures
I	Biological sample preparation and Modified analytical techniques	Chalk & Board, ICT	15
II	Advanced Microscopy Techniques	Chalk & Board, ICT	15
III	Spectroscopic and Chromatography Techniques: Principle, working and applications	Chalk & Board, ICT	15
IV	Identification methods in microbiology	Chalk & Board, ICT	15

## Evaluation Pattern

### A. Internal Evaluation

Method	Marks
Class test	20
Assignment	15
Class performance	05
<b>Total</b>	<b>40</b>

### B. Semester End Evaluation (Paper Pattern)

Question No	Unit	Type of Questions (Marks)
Q1	I	Short Note (12)
Q2	II	Short Note (12)
Q3	III	Short Note (12)
Q4	IV	Short Note (12)
Q5	I, II, III, IV	Objective (12)
<b>Total</b>		<b>60</b>

<b>Name of the Course</b>	Pharmaceutical And Cosmetic Microbiology
<b>Course Code</b>	PSMB302
<b>Class</b>	M.Sc. II
<b>Semester</b>	III
<b>No of Credits</b>	04
<b>Nature</b>	Theory
<b>Type</b>	Major: Mandatory
<b>Highlight revision specific to employability/ entrepreneurship/ skill development</b>	<p>Strong understanding of microbiology in pharmaceuticals enhances employability in quality control, research, and regulatory roles. Proficiency in Good Manufacturing Practices (GMP) is vital for roles involving compliance and quality assurance. Expertise in assessing water systems and endotoxin/pyrogen testing is crucial for product safety.</p> <p>Knowledge of cleaning, disinfection, and clean room practices is valuable for maintaining aseptic environments. Skill development includes risk assessment, audit procedures, and knowledge of relevant ISO standards. It also involves knowledge of cosmetic formulation, preservation techniques, and microbial testing protocols along with in-depth understanding of GMP principles, audit procedures, and quality management systems. Entrepreneurs can offer consulting services for water, pharmaceutical &amp; cosmetic product analysis.</p>

## **PSMB302 - Pharmaceutical and Cosmetic Microbiology**

### **Modules at a Glance**

Sr. No.	Modules	No. of Lectures
I	Introduction to Pharmaceutical Microbiology	15
II	Pharmaceutical Analysis & Regulation	15
III	Cosmetic Microbiology	15
IV	Audit, Validation & documentation	15
<b>Total</b>		<b>60</b>

## Course Outcomes:

### At the end of the course learners will be

1. Be able to understand the different process and work culture in the Pharmaceutical & Cosmetic Industry
2. Equipped with in-depth knowledge w. r. t. regulations and audit procedures carried out in an industry
3. Equipped with risk assessment tools and process understanding to make them skilled and competent as per job requirement.

## Curriculum:

<b>PSMB302 - Pharmaceutical And Cosmetic Microbiology</b>			
<b>Unit</b>	<b>Title</b>	<b>Learning Points</b>	<b>No of Lectures</b>
I	Introduction to Pharmaceutical Microbiology	1.1 Role of Microbiology for pharmaceuticals industries 1.2 GMP and Regulations 1.3 Laboratory management and design 1.4 Microbiological culture media & Microbiology laboratory techniques 1.5 Bio burden determination 1.6 Specified and objectionable microorganisms 1.7 Guidelines for preparing a laboratory information file	15 (1)
II	Pharmaceutical Analysis & Regulation	2.1 Assessment of pharmaceutical water systems and Endotoxin and pyrogen testing 2.2 Sterilization and sterility assurance. Use of Biological indicators for measuring sterilization 2.3 Cleaning and disinfection Use of Antibiotics and preservatives ,Clean rooms and environmental monitoring 2.4 Rapid microbiological methods 2.5 Risk assessment and microbiology 2.6 Good practices for pharmaceutical quality control laboratories 2.7 Good manufacturing practices for pharmaceutical Products.	15 (1)

III	Cosmetic Microbiology	3.1 History of cosmetic Microbiology ,Preservation of cosmetics 3.2 Antimicrobial preservative efficacy & microbial content testing 3.3 Microbiology Laboratory methods in support of sterility Assurance System 3.4 Bio burden testing & Environmental monitoring 3.5 Sampling: Principles and Practice	15 (1)
IV	Audit, Validation & documentation	4.1 Microbiological hazard analysis & audit Validation 4.2 IS and ISO standards: 9001/14001. 4.3 Introduction to Validation and documentation 4.4 Auditing sterilization processes and facilities	15 (1)

### Learning Resources recommended:

1. Pharmaceutical Microbiology by Tim Sandle
2. WHO Guidelines for preparing a laboratory information file
3. WHO Good practices for pharmaceutical microbiology laboratories
4. WHO-GMP for pharmaceutical products
5. Cosmetic Microbiology: A practical Approach, 2nd edition. Philip A Geiss. Taylor& Francis group
6. Handbook of Microbiological Quality Control for Pharmaceuticals and Medical Devices, Rosamund M. Baird, Stephen P. Denyer, Norman Hodges

### Teaching Plan

Unit No.	Unit Title	Teaching Methods	No. of Lectures
I	Introduction to Pharmaceutical Microbiology	Chalk & Board, ICT	15
II	Pharmaceutical Analysis & Regulation	Chalk & Board, ICT	15
III	Cosmetic Microbiology	Chalk & Board, ICT	15
IV	Audit, Validation & documentation	Chalk & Board, ICT	15

## Evaluation Pattern

### A. Internal Evaluation

Method	Marks
Class test	20
Assignment	15
Class performance	05
<b>Total</b>	<b>40</b>

### B. Semester End Evaluation (Paper Pattern)

Question No	Unit	Type of Question (Marks)
Q1	I	Short Note (12)
Q2	II	Short Note (12)
Q3	III	Short Note (12)
Q4	IV	Short Note (12)
Q5	I, II, III, IV	Objective (12)
<b>Total</b>		<b>60</b>



<b>Name of the Course</b>	Practical's of PSMB301 and PSMB302
<b>Course Code</b>	PSMB303
<b>Class</b>	M.Sc. II
<b>Semester</b>	III
<b>No of Credits</b>	04
<b>Nature</b>	Practical
<b>Type</b>	Major: Mandatory
<b>Highlight revision specific to employability/ entrepreneurship/ skill development</b>	<p>Developing expertise in sample preparation techniques for phytopharmaceutical analysis, microscopy, chromatography and spectroscopy enhances your employability in various industries such as pharmaceuticals, research, and quality control. Proficiency in fluorescence microscopy is beneficial for careers in cell biology, neuroscience, and diagnostics. Expertise in advanced analytical techniques like Mass Spectrometry, NMR Spectroscopy is sought after in pharmaceuticals, biotechnology, and environmental monitoring. Understanding microbial analysis and genomics is valuable in fields like microbiology, biotechnology, and medical research. Skill development includes precision, attention to detail, and adherence to safety protocols during lab &amp; research work. Entrepreneurs can offer microbial identification services or develop novel DNA extraction kits. They also can establish microscopy training workshops or consulting services for image analysis.</p> <p>The strong understanding of microbiology in pharmaceuticals enhances employability in quality control, research, and regulatory roles. Expertise in assessing water systems and endotoxin/pyrogen testing is crucial for product safety. Knowledge of cleaning, disinfection, and clean room practices is valuable for maintaining aseptic environments. Skill development includes risk assessment, audit procedures, and knowledge of relevant ISO standards. It also involves knowledge of cosmetic formulation, preservation techniques, and microbial testing protocols along with in-depth understanding of GMP principles, audit procedures, and quality management systems. Entrepreneurs can offer consulting services for water, pharmaceutical &amp; cosmetic product analysis.</p>

**PSMB303 - Practical's of PSMB301 and PSMB302**  
**Modules at a Glance**

Sr. No.	Modules	No. of Lectures
I	Practicals of PSMB301 (Tools and Techniques in Microbiology Practicals)	60
II	Practicals of PSMB302 (Pharmaceutical And Cosmetic Microbiology Practicals)	60
<b>Total</b>		<b>120</b>

**Course Outcomes:**

**At the end of the course learners will be**

1. Generate a phylogenetic tree
2. Perform extraction and separation of pigments and phyto-chemicals
3. Perform DNA extraction and agarose electrophoresis
4. Know the different process and work culture in the Pharmaceutical & Cosmetic Industry.
5. Perform variety of tests carried out in pharmaceutical and cosmetic industry
6. Understand in-depth knowledge w. r. t. regulations and audit procedures carried out in an industry

<b>PSMB303 - Practical's of PSMB301 and PSMB302</b>		
<b>Title</b>	<b>Learning Points</b>	<b>No of Lectures</b>
Practicals of PSMB301 (Tools and Techniques in Microbiology Practicals)	<p><b>PRACTICALS</b></p> <ol style="list-style-type: none"> <li>1. Extraction and Qualitative detection of different phyto-chemicals using chemical methods.</li> <li>2. Extraction and separation of different pigments using TLC</li> <li>3. Spectrum analysis of pigments using UV spectrophotometer.</li> <li>4. Generation of phylogenetic tree.</li> <li>5. Extraction of DNA from soil and checking its purity using agarose electrophoresis and UV260/280 ratio</li> </ol> <p><b>SELF STUDY</b></p> <ol style="list-style-type: none"> <li>1. Determination of purity of extracted DNA using Qubit</li> <li>2. Study the working of TEM, SEM, Fluorescence and Confocal microscopy /Nuclear magnetic resonance spectroscopy and evaluation of simple <sup>1</sup>H NMR spectra of select organic compounds / Determination of Molar Mass of Simple Compounds Using Mass Spectroscopy using virtual lab</li> <li>3. Assignment on “Application of advanced electron microscopy”./ protocol for culture submission to NCBI database</li> <li>4. Use of VITEK (Demonstration)</li> </ol>	60 (2)
Practicals of PSMB302 (Pharmaceutical And Cosmetic Microbiology Practicals)	<p><b>PRACTICALS</b></p> <ol style="list-style-type: none"> <li>1) Perform an audit of any test.</li> <li>2) Preservative efficacy test as per ISO 11930</li> <li>3) Bio burden test</li> <li>4) Quality control of microbial content of cosmetics</li> <li>5) MIC of an antibiotic by tube method using Indian pharmacopeia protocol</li> </ol> <p><b>SELF-STUDY :</b></p> <ol style="list-style-type: none"> <li>1. Market survey of 5 cosmetic products and the Common cosmetic preservatives used</li> <li>2. HACCP of College canteen or home kitchen wrt a food preparation.</li> </ol>	60 (2)

## Learning Resources recommended:

### Practicals of PSMB301

1. Handbook from Anchrom laboratory
2. Molecular cloning : a lab manual, Green and Sambrook vol. 1 4<sup>th</sup> edn
3. Techniques and Instrumentation in Analytical Chemistry Volume 18, 1997
4. Handbook of TEM by Ayache J., Beaunier L., Boomendil J., Ehret G.
5. <https://www.olympusifescience.com/en/microscoperesource/primer/techniques/confocal/confocalintro/>
6. <http://www.ammrif.org.au/myscope/pdfs/tem.pdf>
7. <https://www.olympusifescience.com/en/microscoperesource/primer/techniques/confocal/applications/fretintro/>
8. <https://www.microscopyu.com/techniques/fluorescence/introduction-to-fluorescencemicroscopy>

### Practicals of PSMB302

1. WHO Guidelines for preparing a laboratory information file
2. WHO Good practices for pharmaceutical microbiology laboratories
3. WHO-GMP for pharmaceutical products
4. Cosmetic Microbiology: A practical Approach, 2nd edition. Philip Taylor & Francis

## Teaching Plan

Sr. No.	Practical Title	Teaching Methods	No. of Lectures
I	Tools and Techniques in Microbiology Practicals	Practical & Demonstration	60
II	Pharmaceutical And Cosmetic Microbiology Practicals	Practical & Demonstration	60

## Evaluation Pattern –

Practical Course	External		Internal			Total
	Major techniques	Minor Techniques	Journal	Viva	Spots / Quiz/ Lab	
PSMB303	40 Marks	20 Marks	10 Marks	10 Marks	20 Marks	100 Marks

<b>Name of the Course</b>	IPR and Bioethics
<b>Course Code</b>	PSMB304
<b>Class</b>	M.Sc. II
<b>Semester</b>	III
<b>No of Credits</b>	02
<b>Nature</b>	Theory
<b>Type</b>	Major: Mandatory
<b>Highlight revision specific to employability/ entrepreneurship/ skill development</b>	Understanding intellectual property rights (IPR) is crucial for career opportunities in biotechnology companies and research institutions. Proficiency in biotech patents is essential for research protection and technology transfer roles. Proficiency in ethical guidelines is vital for careers involving human subject's research and clinical trials. Proficiency in nanotechnology applications in biotech fields enhances employability in materials science, medicine, and agriculture. Entrepreneurs can establish IPR consulting services to help biotech startups protect their innovations. Skill development includes knowledge of patent laws, patent filing procedures, and patent infringement issues.

## PSMB304 - IPR and Bioethics

### Modules at a Glance

Sr. No.	Modules	No. of Lectures
I	IPR and Biodiversity Law	15
II	Bioethics	15
<b>Total</b>		<b>30</b>

### Course Outcomes:

#### At the end of the course students will:

1. Understand the protection of intellectual property in the context of life sciences
2. Reflect on the need and implications of patents in Biotechnology
3. Understand the biodiversity law
4. Learn the bioethical guidelines and their considerations in biotechnological advancements.

**Curriculum:**

<b>PSMB304 - IPR and Bioethics</b>			
<b>Unit</b>	<b>Title</b>	<b>Learning Points</b>	<b>No of Lectures</b>
I	IPR and Biodiversity Law	1.1 Need for IPR in Biotechnology 1.2 Patents for Biotechnology 1.3 Case Studies- Basmati Rice Issue- Turmeric Patent- Agriculture Neem Patent- Chakraborty case- Corn genetically engineered with an insecticide 1.4 Biodiversity law: introduction, Development, International and National Biodiversity laws	15 (1)
II	Bioethics	2.1 The goals of biotechnology, Challenging characteristics of biotechnology 2.2 Bioethics and microbiology Ethical issues and Perspectives in the Discipline of Microbiology Ethics Perspectives from India Bioethics, bioweapons and the microbiologist 2.3 Ethical guidelines for Biomedical research on Human subjects 2.4 Case study –Infectious disease -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, - 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 consideration	15 (1)

## Learning Resources recommended:

### 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

### 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. Ethical guidelines For Biomedical research on Human subjects .National Institute of Tuberculosis and Respiratory Diseases. Based on ICMR, CDSCO, GCP & International Ethical Guidelines.
6. 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
7. Case study: Public health - ethical issues, Nuffield Council on Bioethics, Chapter 4 page no.51- 77.

## Teaching Plan

Unit No.	Unit Title	Teaching Methods	No. of Lectures
I	IPR and Biodiversity Law	Chalk & Board, ICT	15
II	Bioethics	Chalk & Board, ICT	15

## Evaluation Pattern

### A. Internal Evaluation

Method	Marks
Class test	10
Assignment	05
Class performance	05
<b>Total</b>	<b>20</b>

### B. Semester End Evaluation (Paper Pattern)

Question No	Unit	Type of Question (Marks)
Q1	I	Short Note (12)
Q2	II	Short Note (12)
Q3	I, II	Objective (06)
<b>Total</b>		<b>30</b>



<b>Name of the Course</b>	Cell Biology
<b>Course Code</b>	PSMB305
<b>Class</b>	M.Sc. II
<b>Semester</b>	III
<b>No of Credits</b>	02
<b>Nature</b>	Theory
<b>Type</b>	Major: Elective
<b>Highlight revision specific to employability/ entrepreneurship/ skill development</b>	A strong foundation in cell biology is essential for roles in research, biotechnology, and medical fields. Proficiency in understanding membrane structure is valuable in drug delivery, biophysics, and bioengineering. Understanding cell division mechanisms is crucial in cancer research, drug development, and regenerative medicine. Mastery of cell and developmental biology concepts is essential in regenerative medicine, genetics, and biotechnology. Skill development includes understanding model organism development, genetic regulation, and morphogenesis as well as encompasses knowledge of lipid bilayer, membrane proteins, and their interactions. Entrepreneurs can develop novel therapeutics and diagnostics based on cell biology insights and can participate in the evolving field of regenerative medicine.

## PSMB305 - Cell Biology Modules at a Glance

Sr. No.	Modules	No. of Lectures
I	Introduction To Cell Biology	15
II	Cell Division, Cell Cycle, Cell Communication and Signaling	15
<b>Total</b>		<b>30</b>

### Course Outcomes:

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

1. Understand the structure and compartmentalization of organelles, protein export, protein sorting
2. Understand the events of cell cycle and its regulation
3. Explain the communications of cells with other cells and to the environment
4. Explain the process of development in general

**Curriculum:**

<b>PSMB305 - Cell Biology</b>			
<b>Unit</b>	<b>Title</b>	<b>Learning Points</b>	<b>No of Lectures</b>
I	Introduction To Cell Biology	<p>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</p> <p>1.2 Membrane structure : Cell membrane structure: Lipid bilayer, membrane proteins, Spectrins, Glycophorin, Multipass membrane proteins Bacteriorhodopsin</p> <p>1.3 Membrane Transport: Principles of membrane transport, ion channels and electrical properties of membranes. protein transport, post translation transport and co translation transport.</p> <p>1.4 Intracellular Compartments and protein sorting: Compartmentalization of cells, transport of molecules between the nucleus and cytosol, peroxisomes, Endoplasmic reticulum, transport of proteins into mitochondria and chloroplasts</p> <p>1.5 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 etc.</p>	15 (1)
II	Cell Division, Cell Cycle, Cell Communication and Signaling	<p>3.1 Mechanism of cell division: M-phase, Mitosis, Cytokinesis.</p> <p>3.2 Cell cycle and Programmed cell death: Control system, intracellular control of cell cycle events, Apoptosis, extracellular control of cell growth and apoptosis.</p> <p>3.3 Cell communication and Signaling: General principles of cell communication (Nitric oxide gas signal and nuclear receptors, Three classes surface receptors), Signaling through G-protein linked cell surface receptors, Signalling through enzyme linked cell surface receptors: Tyrosine kinase, Docking sites, Ras, MAP kinase, PI3 kinase, TGF-<math>\beta</math>, Signaling pathways by regulated proteolysis.</p>	15 (1)

## Learning Resources recommended:

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

## Teaching Plan

Unit No.	Unit Title	Teaching Methods	No. of Lectures
I	Introduction To Cell Biology	Chalk & Board, ICT	15
II	Cell Division, Cell Cycle, Cell Communication and Signaling	Chalk & Board, ICT	15

## Evaluation Pattern

### A. Internal Evaluation

Method	Marks
Class test	10
Assignment	05
Class performance	05
<b>Total</b>	<b>20</b>

### B. Semester End Evaluation (Paper Pattern)

Question No	Unit	Type of Question (Marks)
Q1	I	Short Note (12)
Q2	II	Short Note (12)
Q3	I, II	Objective (06)
<b>Total</b>		<b>30</b>

<b>Name of the Course</b>	Practicals of PSMB305
<b>Course Code</b>	PSMB306
<b>Class</b>	M.Sc. II
<b>Semester</b>	III
<b>No of Credits</b>	02
<b>Nature</b>	Practical
<b>Type</b>	Major: Elective
<b>Highlight revision specific to employability/ entrepreneurship/ skill development</b>	A strong foundation in cell biology is essential for roles in research, biotechnology, and medical fields. Proficiency in understanding membrane structure is valuable in drug delivery, biophysics, and bioengineering. Understanding cell division mechanisms is crucial in cancer research, drug development, and regenerative medicine. Mastery of developmental biology concepts is essential in regenerative medicine, genetics, and biotechnology. Skill development includes understanding model organism development, genetic regulation, and morphogenesis as well as encompasses knowledge of lipid bilayers, membrane proteins, and their interactions. Impart skills such as SDS PAGE & cell viability analysis. Entrepreneurs can develop tools for developmental biology research or offer services for model organism analysis.

### **PSMB306 - Practicals of PSMB305**

#### **Modules at a Glance**

Sr. No.	Modules	No. of Lectures
I	Practicals of PSMB305 (Cell Biology Practicals)	60
<b>Total</b>		<b>60</b>

**Course Outcomes: At the end of the course learners will be able to**

1. Perform SDS PAGE using protein separation
2. Perform cell viability assays using different techniques
3. Perform isolation of cell organelles

## Curriculum:

<b>PSMB306 - Practicals of PSMB305</b>		
<b>Title</b>	<b>Learning Points</b>	<b>No of Lectures</b>
Practicals of PSMB305 (Cell Biology Practicals)	<b>PRACTICALS</b> 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 neutral red uptake assay 4. Comparison of various cell viability techniques 5. Isolation of mitochondria 6. Isolation of chloroplast and checking photophosphorylation	60 (2)

## Learning Resources recommended:

1. Molecular cloning: a lab manual, Green and Sambrook vol. 1 4<sup>th</sup> ed.
2. Cell Viability Assays; Terry L Riss, PhD, Richard A Moravec, BS, Andrew L Niles, MS, Sarah Duellman, PhD, Hélène A Benink, PhD, Tracy J Worzella, MS, and Lisa Minor. (<https://www.ncbi.nlm.nih.gov/books/NBK144065/>)
3. Cell Biology Laboratory Manual by William H. Heidcamp

## Teaching Plan

<b>Sr. No.</b>	<b>Practical Title</b>	<b>Teaching Methods</b>	<b>No. of Lectures</b>
I	Cell Biology Practicals	Practical & Demonstration	60

## Evaluation Pattern –

<b>Practical Course</b>	<b>External</b>		<b>Internal</b>			<b>Total</b>
	<b>Major techniques</b>	<b>Minor Techniques</b>	<b>Journal</b>	<b>Viva</b>	<b>Spots / Quiz/ Lab</b>	
PSMB306	20 Marks	10 Marks	05 Marks	05 Marks	10 Marks	50 Marks

<b>Name of the Course</b>	Animal and Agriculture Biotechnology
<b>Course Code</b>	PSMB307
<b>Class</b>	M.Sc. II
<b>Semester</b>	III
<b>No of Credits</b>	02
<b>Nature</b>	Theory
<b>Type</b>	Major: Elective
<b>Highlight revision specific to employability/ entrepreneurship/ skill development</b>	Proficiency in transgenic plant traits and applications is valuable in agricultural innovation and biotech research. Expertise in sustainable agriculture practices enhances employability in farming, agribusiness, and environmental roles. Proficiency in biological pest control methods is crucial in integrated pest management and agricultural sustainability. Skill development includes knowledge of transformation methods, gene delivery techniques, and manipulation of genomes. It also includes understanding nutrient management. Entrepreneurs can establish organic farming ventures or offer consulting on sustainable practices. They can also develop biopesticides or offer pest management consulting to farmers.

## PSMB307 - Animal and Agriculture Biotechnology Modules at a Glance

Sr. No.	Modules	No. of Lectures
I	Animal Biotechnology	15
II	Bio-control in Agriculture	15
<b>Total</b>		<b>30</b>

**Course Outcomes:** By the end of the course, the learner will be able to: -

1. Comprehend the different methods of obtaining Transgenic animals and their applications.
2. Assess the importance of Vermicomposting and Biofertilizers in agriculture.
3. Understand the role of microbiologist in Organic farming and its scope.
4. Critically evaluate the need for the use of Biocontrol agents in the field of agriculture.

**Curriculum:**

<b>PSMB307 - Animal and Agriculture Biotechnology</b>			
<b>Unit</b>	<b>Title</b>	<b>Learning Points</b>	<b>No of Lectures</b>
I	Animal Biotechnology	<p>1.1 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.</p> <p>1.2 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</p>	15 (1)
II	Bio-control in Agriculture	<p>2.1 Biological control of Pests: Biological Control agent, mechanism of biocontrol, biopesticide, bioinsecticide, bioherbicide</p> <p>2.2 Induced systemic resistance in Biocontrol of Plant diseases:</p> <p>a) Induction of systemic resistance by Pseudomonas, Bacillus, Trichoderma, Fungi and others.</p> <p>b) Mechanism of Induced systemic resistance</p> <p>2.3 Microbial control strategies: Postharvest diseases of Fruits, Vegetables, Roots and Tubers</p> <p>a) Mode of action of biocontrol agents</p> <p>b) Extensive of use of biocontrol agents</p> <p>c) Enhancing biocontrol efficacy of Microbial Antagonist</p> <p>d) Biotechnological Approach</p>	15 (1)

## Learning Resources recommended:

1. B.R. Glick, J.J. Pasternak and C.L. Patten. Molecular Biotechnology: Principles and Applications of Recombinant DNA. 4<sup>th</sup> Edition. ASM Press, Washington D.C.
2. J.D. Watson, M. Gilman, J. Witkowski and M. Zoller. Recombinant DNA. 2<sup>nd</sup> 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.

## Teaching Plan

Unit No.	Unit Title	Teaching Methods	No. of Lectures
I	Animal Biotechnology	Chalk & Board, ICT	15
II	Bio-control in Agriculture	Chalk & Board, ICT	15

## Evaluation Pattern

### A. Internal Evaluation

Method	Marks
Class test	10
Assignment	05
Class performance	05
<b>Total</b>	<b>20</b>

### B. Semester End Evaluation (Paper Pattern)

Question No	Unit	Type of Question (Marks)
Q1	I	Short Note (12)
Q2	II	Short Note (12)
Q3	I, II	Objective (06)
<b>Total</b>		<b>30</b>



<b>Name of the Course</b>	Practicals of PSMB307
<b>Course Code</b>	PSMB308
<b>Class</b>	M.Sc. II
<b>Semester</b>	III
<b>No of Credits</b>	02
<b>Nature</b>	Practical
<b>Type</b>	Major: Elective
<b>Highlight revision specific to employability/ entrepreneurship/ skill development</b>	Proficiency in transgenic plant traits and applications is valuable in agricultural innovation and biotech research. Expertise in sustainable agriculture practices enhances employability in farming, agribusiness, and environmental roles. Proficiency in biological pest control methods is crucial in integrated pest management and agricultural sustainability. Skill development includes knowledge of transformation methods, gene delivery techniques, and manipulation of genomes. Entrepreneurs can establish organic farming ventures or offer consulting on sustainable practices. They can also develop biopesticides or offer pest management consulting to farmers.

### **PSMB308 - Practical of PSMB307**

#### **Modules at a Glance**

Sr. No.	Modules	No. of Lectures
I	Practicals of PSMB307 (Animal and Agriculture Biotechnology Practicals)	60
<b>Total</b>		<b>60</b>

**Course Outcomes:** At the end of the course the learner will be able to

1. Prepare and analyze vermicompost
2. Isolate plant growth promoting bacteria & estimate PGP substances
3. Perform qualitative and quantitative analysis of phosphate solubilizers

## Curriculum:

PSMB308 - Practicals of PSMB307		
Title	Learning Points	No of Lectures
Practicals of PSMB307 (Animal and Agriculture Biotechnology Practicals)	<b>PRACTICALS</b> 1. Preparation of biofertilizer/ biopesticide/bioinsecticide/bioherbicide 2. Determination of effectiveness of various biocontrol agents used in agriculture. 3. Isolation of organisms producing plant growth promoting substances 4. Production and estimation of plant growth promoting substances (any one) 5. Determination of mode of action of biocontrol agents. <b>SELF STUDY</b> 1. Report on a visit to Biofertilizer and biopesticide production plants 2. Assignment on Transgenic livestock, Transgenic poultry and Transgenic fish.	60 (2)

## Learning Resources recommended:

1. H. M. Gupta. Organic Farming and Sustainable Agriculture. 2005. ABD Publishers, Jaipur, India.
2. A.K. Sharma. A handbook of Organic Farming. 2004. Agrobios India.
3. [https://www.scielo.cl/scielo.php?script=sci\\_arttext&pid=S0718-95162013000300011](https://www.scielo.cl/scielo.php?script=sci_arttext&pid=S0718-95162013000300011)

## Teaching Plan

Sr. No.	Practical Title	Teaching Methods	No. of Lectures
I	Animal and Agriculture Biotechnology Practicals	Practical & Demonstration	60

## Evaluation Pattern –

Practical Course	External		Internal			Total
	Major technique	Minor Technique	Journal	Viva	Spots / Quiz/ Lab	
PSMB308	20 Marks	10 Marks	05 Marks	05 Marks	10 Marks	50 Marks

<b>Name of the Course</b>	Research Project
<b>Course Code</b>	PSMB309
<b>Class</b>	M.Sc. II
<b>Semester</b>	III
<b>No of Credits</b>	04
<b>Nature</b>	Research Project
<b>Type</b>	Major: Mandatory
<b>Highlight revision specific to employability/ entrepreneurship/ skill development</b>	Engaging in a research project can develop a wide range of skills that are highly valuable in terms of employability, entrepreneurship, and skill development. Research projects require you to critically evaluate information, synthesize findings, and draw logical conclusions. This skill is invaluable for problem-solving in both employment and entrepreneurial contexts. Conducting research involves analyzing data, identifying patterns, and interpreting results. These analytical skills are crucial for making informed decisions in various professional settings. Depending on the nature of the research project, individuals may need to acquire technical skills related to data analysis, research methodologies, or specific tools/software. These technical proficiencies enhance employability and provide a competitive edge in the job market or entrepreneurial landscape.

Inclusion of project work in the course curriculum of the M.Sc. programme is one of the ambitious aspects in the programme structure. The main objective of inclusion of project work is to inculcate the element of research work challenging the potential of learner as regards to his/her eager to enquire and ability to interpret particular aspect of the study in his/her own words. It is expected that the guiding teacher should undertake the counselling sessions and make the awareness among the learners about the methodology of formulation, preparation and evaluation pattern of the project work.

## **Course Outcomes**

1. Students will be able to identify the research problem and formulate objectives
2. Students will be able to critically evaluate existing literature in their field of study to identify gaps, inconsistencies, and areas for further investigation.
3. Students will demonstrate the ability to develop a comprehensive research proposal, including clear research questions, appropriate methodologies, and feasible timelines.
4. Students will enhance their written and oral communication skills through the creation and presentation of a well-structured research proposal.
5. Students will gain practical experience in budget planning and resource allocation for research projects, including identifying potential funding sources and justifying expenses.
6. Students will learn project management techniques and strategies to effectively plan, execute, and monitor research projects, ensuring timely completion and adherence to budget constraints.

## **Guidelines for preparation of Research Proposal**

1. Research Proposal can be undertaken on any Major subject.
2. The Research Proposal should be prepared under the guidance of the Project Guide.
3. The Research Proposal shall contain the chapters as follows:
  - Chapter I: Introduction
  - Chapter II: Aim and Objectives
  - Chapter III: Literature Review
  - Chapter IV: Materials and Methods
  - Chapter V: Expected Results
  - Chapter VI: Budget and Time Schedule of activities
  - Chapter VII: Facilities available
  - Chapter VIII: References
  - Chapter IX: CV of applicant
4. Research Proposal should be prepared by the student individually.
5. The Research Proposal shall consist of 40 to 60 Pages.
6. All students should prepare a PowerPoint presentation of research proposal which they have to present during the practical and/or internal examination.
7. All P.G. Teachers under the Faculty of Science are eligible to work as Project Guide.
8. The Responsibility of guiding the projects will be shared by all P.G.Teachers in proportion.
9. Proposal viva shall be conducted by the panel of examiners.

**Assessment of the research proposal:**

Total Marks: 100

Credits: 4

**1. Research Proposal: 60 Marks**

Student should prepare and submit printed (one sided), spiral bound research proposal of around 40 to 60 pages (Marks distribution – Chapter I and II – 12 Marks, Chapter III – 12 Marks, Chapter IV and V – 12 Marks, Chapter VI and VII – 12 Marks, and Chapter VIII and IX – 12 Marks)

**2. Research Proposal Presentation: 30 Marks**

Student should prepare a PowerPoint presentation based on the research proposal, which he or she has to present during the practical and/or internal examination. (Marks distribution – Presentation (Slides) preparation – 15 Marks and Presentation skill and delivery – 15 Marks)

**3. Research Proposal Viva: 10 Marks**

## Syllabus for M.Sc. II Microbiology Semester IV

From the year 2024-25

No. of Courses	Semester IV		Credits
	<b>Major Mandatory</b>		
PSMB401	Industrial And Food Microbiology		4
PSMB402	Applied Microbiology		4
PSMB403	Practical's of PSMB401 and PSMB402		4
	<b>Major Electives</b>		
PSMB404	Advances in biotechnology	2	4
PSMB405	Practical's of PSMB404	2	
	<b>OR</b>		
PSMB406	Mycology and Protozoology	2	
PSMB407	Practical's of PSMB406	2	
PSMB408	Research Project		6
<b>Total Credits</b>			<b>22</b>

<b>Name of the Course</b>	Industrial and Food Microbiology
<b>Course Code</b>	PSMB401
<b>Class</b>	M.Sc. II
<b>Semester</b>	IV
<b>No of Credits</b>	04
<b>Nature</b>	Theory
<b>Type</b>	Major: Mandatory
<b>Highlight revision specific to employability/ entrepreneurship/ skill development</b>	Understanding starter cultures enhances employability in food industry roles, such as food technologist or quality control specialist. Proficiency in fermented food production is valuable in food technology and culinary industries. Proficiency in advanced detection methods enhances employability in food safety and quality assurance. Expertise in microbial metabolite production is valuable in biotechnology and pharmaceutical industries. Skill development involves implementing quality control measures, adhering to standards, and risk assessment. Apart from this mastering sampling technique, understanding detection principles, and data interpretation is also covered. Course also encompasses knowledge of fermentation techniques, controlling microbial growth, and optimizing flavor profiles. Entrepreneurs can establish testing labs specializing in rapid and sensitive microorganism detection & can offer quality assurance consulting services to food companies.

## **PSMB401 - Industrial and Food Microbiology Modules at a Glance**

Unit No.	Modules	No. of Lectures
I	Applications of Microbial technology in food processing	15
II	Food Preservation & Food safety	15
III	Strain improvement: Modern methods	15
IV	Fermentations of Microbial products for commercial use	15
<b>Total</b>		<b>60</b>

## Course Outcomes:

### At the end of the course the learner will be able

1. To develop employable skills concurrently with an understanding of various fermentation processes.
2. Understand the basic knowledge of food fermentation, along with advanced methods of food preservation, food analysis and food safety.
3. To develop the skill for production & assessment of probiotic microbes
4. To acquire knowledge about probiotics and prebiotics and their applications
5. To understand the high throughput screening techniques used for fermentation.

## Curriculum:

<b>PSMB401 - Industrial and Food Microbiology</b>			
<b>Unit</b>	<b>Title</b>	<b>Learning Points</b>	<b>No of Lectures</b>
I	Applications of Microbial technology in food processing	1.1 Starter culture of bacteria , yeast & mold used in food fermentation 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 1.3 Prebiotic & Probiotic 1.3.1 Probiotics 1.3.2 Screening of Potential Probiotics 1.3.3 Industrial Aspects of Probiotic Production 1.3.4 Prebiotics	15 (1)



II	Food Preservation & Food safety	<p>2.1 Advanced methods of food preservation Microwave Processing, Ohmic Heating, High-Pressure Processing, Pulsed Electric Fields, Pulsed Light Technology Magnetic Fields, Ultrasound, Pulsed X-Rays, Ozone, Antimicrobial Edible Films</p> <p>2.2 Advanced methods of detection of microorganisms in food Sampling plans and sample preparation, physical methods, chemical methods.</p> <p>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</p>	15 (1)
III	Strain improvement: Modern methods	<p>3.1 Screening methods and high throughput screening</p> <p>3.2 Return of natural products</p> <p>3.3 Broadening the base of the discovery process and increasing the gene expression</p> <p>3.4 Post genomics era- the influence of genomics, transcriptomics and fluxomics on the improvement of primary metabolite producers</p> <p>3.5 Use of recombination systems for the improvement of secondary metabolite production. A) The application of parasexual cycle B) Protoplast fusion C) Recombinant DNA technology.</p>	15 (1)
IV	Fermentations of Microbial products for commercial use	<p>4.1 Microbial production of Rosmeric acid &amp; Caffeic acid</p> <p>4.2 Production of bacterial polysaccharide &amp; Commercially produced Polysaccharides</p> <p>4.3 Microbial Production of Riboflavin</p> <p>4.4 Microbial Production of Antibiotic :- Cephalosporin , Tetracycline</p>	15 (1)

### Learning Resources recommended:

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 Erkmen, 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

## Teaching Plan

Unit No.	Unit Title	Teaching Methods	No. of Lectures
I	Applications of Microbial technology in food processing	Chalk & Board, ICT	15
II	Food Preservation & Food safety	Chalk & Board, ICT	15
III	Strain improvement: Modern methods	Chalk & Board, ICT	15
IV	Fermentations of Microbial products for commercial use	Chalk & Board, ICT	15

## Evaluation Pattern

### A. Internal Evaluation

Method	Marks
Class test	20
Assignment	15
Class performance	05
<b>Total</b>	<b>40</b>

### B. Semester End Evaluation (Paper Pattern)

Question No	Unit	Type of Question (Marks)
Q1	I	Short Note (12)
Q2	II	Short Note (12)
Q3	III	Short Note (12)
Q4	IV	Short Note (12)
Q5	I, II, III, IV	Objective (12)
<b>Total</b>		<b>60</b>

<b>Name of the Course</b>	Applied Microbiology
<b>Course Code</b>	PSMB402
<b>Class</b>	M.Sc. II
<b>Semester</b>	IV
<b>No of Credits</b>	04
<b>Nature</b>	Theory
<b>Type</b>	Major: Mandatory
<b>Highlight revision specific to employability/ entrepreneurship/ skill development</b>	Understanding bioremediation strategies enhances employability in environmental science, waste management, and consulting roles. Proficiency in ecosystem-specific bioremediation techniques is valuable in addressing pollution across diverse environments. Understanding enzyme applications enhances employability in food technology, pharmaceuticals, and industrial sectors. Expertise in biotech applications in medicine is sought after in pharmaceutical research and healthcare. Skill development involves designing in situ bioremediation strategies, monitoring microbial activity, and assessing ecological impact. Besides this it includes optimizing biosensor technologies, understanding microbial contributions to climate change, and developing sustainable bioproducts. Entrepreneurs can offer services in molecular diagnostics, vaccine development, or biopharmaceutical production. They can develop enzyme-based products for food processing, cosmetics, and industrial processes.

## PSMB402 - Applied Microbiology Modules at a Glance

Unit No.	Modules	No. of Lectures
I	Applications of Microbiology in bioremediation & pollution control	15
II	Applications of Enzymes	15
III	Microbial bio-molecules in diagnostics and therapeutics	15
IV	Novel uses of microorganisms and microbial products	15
<b>Total</b>		<b>60</b>

## Course Outcomes:

At the end of the course the learner will be able

1. To understand and explain different applications of Microbiology
2. To explain the role of microbial bio molecules in diagnostic and therapeutic industry
3. To understand the role of microbiology in pollution control and remediation
4. To assess and apply the novel uses of microorganisms and microbial products.

## Curriculum:

<b>PSMB402 - Applied Microbiology</b>			
<b>Unit</b>	<b>Title</b>	<b>Learning Points</b>	<b>No of Lectures</b>
I	Applications of Microbiology in bioremediation & pollution control	1.1 Introduction to Bioremediation strategies for synthetic compounds, petrochemicals, inorganic waste. 1.2 Bioremediation strategies and techniques in situ and testing its efficacy and side effects 1.3 Bioremediation of metals & gaseous ex situ. Environment modification for bioremediation 1.4 Approaches to bioremediation : Microbial seeding & bioengineering using rDNA technology 1.5 Bioremediation of various ecosystems-Soil, marine, air	15 (1)
II	Applications of Enzymes	2.1 Enzymes as analytical tool for the assessment of food quality, safety, and monitoring food processing 2.2 Applications of enzymes in food : Baking, fruit juice production, processing, brewing, and dairy. Applications of nonfood enzymes in detergents, Textiles, medical. 2.3 New industrial enzyme applications: Cosmetics, enzymes for preservation. Hard surface cleaning, oil field application, waste water treatment.	15 (1)

III	Microbial bio-molecules in diagnostics and therapeutics	3.1 Protein therapeutics: Pharmaceuticals, monoclonal antibodies. Enzymes (Dnase I, Alginate lyase, Glycosidase) 3.2 Nucleic acid as a therapeutic agent – antisense RNA, ribozymes and Nucleic acid delivery. 3.3 Vaccines – Subunit and Peptide vaccines. 3.4 Molecular diagnosis of genetic diseases.	15 (1)
IV	Novel uses of microorganisms and microbial products	4.1 Biosensors, microbial concrete, Bioleaching, Enhanced oil recovery, Biofuels 4.2 Biotech of the marine environment, microbial contribution of climate change 4.3 Biopolymers, Bio surfactants	15 (1)

### Learning Resources recommended:

1. Environmental Biotechnology by Alan Scragg 2<sup>nd</sup> edition
2. Wolfgang Aehle, Enzyme in industry
3. Muthuswamy --Enzymes in Food and Beverage Processing Edited by Muthusamy Chandrasekaran, CRC Press-
4. Medical Biotechnology –Pratibha Nallari –
5. Comprehensive Biotechnology-Ramawat 4th Edition.
6. Glick: Molecular Biotechnology - Principles and Applications of Recombinant DNA (3rd, Third Edition) By Bernard R. Glick Nallari
7. Alan Scragg, Environmental Biotechnology by Alan Scragg B. D. Singh Kalyani Publishers, 2010 - Biotechnology -

### Teaching Plan

Unit No.	Unit Title	Teaching Methods	No. of Lectures
I	Applications of Microbiology in bioremediation & pollution control	Chalk & Board, ICT	15
II	Applications of Enzymes	Chalk & Board, ICT	15
III	Microbial bio-molecules in diagnostics and therapeutics	Chalk & Board, ICT	15
IV	Novel uses of microorganisms and microbial products	Chalk & Board, ICT	15

## Evaluation Pattern

### A. Internal Evaluation

Method	Marks
Class test	20
Assignment	15
Class performance	05
<b>Total</b>	<b>40</b>

### B. Semester End Evaluation (Paper Pattern)

Question No	Unit	Type of Question (Marks)
Q1	I	Short Note (12)
Q2	II	Short Note (12)
Q3	III	Short Note (12)
Q4	IV	Short Note (12)
Q5	I, II, III, IV	Objective (12)
<b>Total</b>		<b>60</b>

<b>Name of the Course</b>	Practicals of PSMB401 and PSMB402
<b>Course Code</b>	PSMB403
<b>Class</b>	M.Sc. II
<b>Semester</b>	IV
<b>No of Credits</b>	04
<b>Nature</b>	Practical
<b>Type</b>	Major: Mandatory
<b>Highlight revision specific to employability/ entrepreneurship/ skill development</b>	<p>Understanding starter cultures enhances employability in food industry roles, such as food technologist or quality control specialist. Proficiency in fermented food production is valuable in food technology and culinary industries. Proficiency in advanced detection methods enhances employability in food safety and quality assurance. Expertise in microbial metabolite production is valuable in biotechnology and pharmaceutical industries. Skill development involves implementing quality control measures, adhering to standards, and risk assessment. Apart from this mastering sampling technique, understanding detection principles, and data interpretation is also covered. Course also encompasses knowledge of fermentation techniques, controlling microbial growth, and optimizing flavor profiles. Entrepreneurs can establish testing labs specializing in rapid and sensitive microorganism detection &amp; can offer quality assurance consulting services to food companies.</p> <p>Proficiency in Good Manufacturing Practices (GMP) is vital for roles involving compliance and quality assurance. Expertise in assessing water systems and endotoxin/pyrogen testing is crucial for product safety.</p> <p>Knowledge of cleaning, disinfection, and clean room practices is valuable for maintaining aseptic environments. Skill development includes risk assessment, audit procedures, and knowledge of relevant ISO standards. It also involves knowledge of cosmetic formulation, preservation techniques, and microbial testing protocols along with in-depth understanding of GMP principles, audit procedures, and quality management systems. Entrepreneurs can offer consulting services for water, pharmaceutical &amp; cosmetic product analysis.</p>

## PSMB403 - Practicals of PSMB401 and PSMB402

### Modules at a Glance

Sr. No.	Modules	No. of Lectures
I	Practicals of PSMB401 (Industrial and Food Microbiology Practicals)	60
II	Practicals of PSMB402 (Applied Microbiology Practicals)	60
<b>Total</b>		<b>120</b>

### Course Outcomes:

At the end of the course the learner will be able to

1. Perform bioassay of antibiotics
2. Preparation and analysis of sauerkraut
3. Isolate and characterize the probiotic producing microorganisms
4. Isolate pigments and biopolymer producing bacteria from environmental samples
5. Isolate & characterize agarase producing bacteria
6. Perform residual starch degradation

### Curriculum:

<b>PSMB403 - Practicals of PSMB401 and PSMB402</b>		
Title	Learning Points	No of Lectures
Practicals of PSMB401 (Industrial and Food Microbiology Practicals)	<p><b>Practicals</b></p> <ol style="list-style-type: none"> <li>1. Isolation &amp; Characterization of organisms with probiotic potential from food samples</li> <li>2. Effect of prebiotic on probiotic culture</li> <li>3. Sauerkraut preparation and Microbiological analysis</li> <li>4. Production of antibiotic and assay</li> </ol> <p><b>Assignments</b></p> <ol style="list-style-type: none"> <li>1. Detection of microorganism in food by any one Novel method.</li> <li>2. BIS methods to study different adulterants in foods</li> </ol>	60 (2)



Practicals of PSMB402 (Applied Microbiology Practicals)	<p><b>PRACTICALS</b></p> <p>1) Enrichment and isolation of Agarase producing bacteria</p> <p>2) Isolation of pigment producing bacteria from marine environment and extraction of pigments through solvent extraction procedures</p> <p>3) Removal of blood stains by using proteases/detergents.</p> <p>4) Residual starch degradation by amylase</p> <p><b>SELF STUDY</b></p> <p>1. Report on an visit to an relevant industry/institute</p>	60 (2)
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### Learning Resources recommended:

1. Petra Foerst, Chalat Santivarangkna 2016 Advances in Probiotic Technology ,CRC Press A Science Publishers Book
2. Robert E.C. , Wildman 2<sup>nd</sup> Ed. “ Handbook of Nutraceuticals & Functional Foods “ CRC Press A SCIENCE PUBLISHERS BOOK
3. [https://www.researchgate.net/publication/351692943\\_Isolation\\_and\\_Characterization\\_of\\_Probiotics\\_from\\_Different\\_Curd\\_Samples](https://www.researchgate.net/publication/351692943_Isolation_and_Characterization_of_Probiotics_from_Different_Curd_Samples)
4. [https://www.academia.edu/7844126/Isolation\\_and\\_characterization\\_of\\_probiotic\\_lactic\\_Acid\\_bacteria\\_from\\_milk\\_and\\_curd\\_samples](https://www.academia.edu/7844126/Isolation_and_characterization_of_probiotic_lactic_Acid_bacteria_from_milk_and_curd_samples)
5. Bibek Ray and Arun Bhunia (2008) Fundamental Food Microbiology. 4<sup>th</sup> Ed. CRC Press.
6. Comprehensive Biotechnology-Ramawat 4<sup>th</sup> Edition.
7. [https://link.springer.com/chapter/10.1007/978-3-642-24520-6\\_2](https://link.springer.com/chapter/10.1007/978-3-642-24520-6_2)
8. Wolfgang Aehle ,Enzyme in industry
9. <https://www.sciencedirect.com/science/article/abs/pii/S2352554121002096>

### Teaching Plan

Sr. No.	Unit Title	Teaching Methods	No. of Lectures
I	Industrial and Food Microbiology Practicals	Practical & Demonstration	60
II	Applied Microbiology Practicals	Practical & Demonstration	60

### Evaluation Pattern –

Practical Course	External		Internal			Total
	Major techniques	Minor Techniques	Journal	Viva	Spots / Quiz/ Lab	
PSMB403	40 Marks	20 Marks	10 Marks	10 Marks	20 Marks	100 Marks

<b>Name of the Course</b>	Advances in Biotechnology
<b>Course Code</b>	PSMB404
<b>Class</b>	M.Sc. II
<b>Semester</b>	IV
<b>No of Credits</b>	02
<b>Nature</b>	Theory
<b>Type</b>	Major: Elective
<b>Highlight revision specific to employability/ entrepreneurship/ skill development</b>	Understanding principles of nanoscale materials, applications in medicine, and ethical considerations are important with respect to various careers in biotechnology. Proficiency in nanotechnology applications in biotech fields enhances employability in materials science, medicine, and agriculture. Entrepreneurs can develop algal-based products for sustainable food, energy, and cosmetics markets. The knowledge of algae cultivation, biofuel production and environmental implications offer opportunities for employment in research, development and application of advanced technologies. Other skills such as understanding nanomaterial properties, biosynthesis, and applications in various sectors are also imparted.

## PSMB404 - Advances in Biotechnology Modules at a Glance

Sr. No.	Modules	No. of Lectures
I	Nano Biotechnology	15
II	Algal Biotechnology	15
<b>Total</b>		<b>30</b>

### Course Outcomes:

#### At the end of the course students will:

1. Comprehend the fundamental principles of nanoscale materials, their properties and potential applications in various industries.
2. Demonstrate the ability to design and synthesize nanomaterials with specific properties for targeted biomedical or industrial applications.

3. Demonstrate proficiency in algal biomass production and processing techniques for application in biofuel production and sustainable resource management.
4. Apply knowledge of algal biotechnology to develop innovative solutions for environmental challenges.

**Curriculum:**

<b>PSMB404 - Advances in Biotechnology</b>			
<b>Unit</b>	<b>Title</b>	<b>Learning Points</b>	<b>No of Lectures</b>
I	Nano Biotechnology	1.1 Basics of Nanotechnology - Types of nano materials - Properties of nano materials 1.2 Fundamentals of Bio-nanotechnology - nanomotors of biological systems – ATP synthase: a nanoturbine - Flagellar motors in bacteria -Linear molecular motors 1.3 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, Algae as nanotechnologists 1.4 DNA and proteins as templates for molecular Nanotechnology and nano electronics 1.5 Applications of nanotechnology – Nanomedicine, nano bio-devices, nano implants, applications in agriculture, food and cosmetics	15 (1)
II	Algal Biotechnology	2.1 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. 2.2 Culturing microalgae in Photo bioreactors, Fermentor and Outdoor ponds: Variation in design, culture conditions, scale up, advantages and disadvantages 2.3 Applications of Algal Biotechnology: Food Supplements and fertilizers, Bioactive compounds and cosmetics, Biofuel, Bioplastics.	15 (1)

## Learning Resources recommended:

### Unit 1

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

### Unit 2

1. Bellinger, E. G. and Sigee, 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,

## Teaching Plan

Unit No.	Unit Title	Teaching Methods	No. of Lectures
I	Nano Biotechnology	Chalk & Board, ICT	15
II	Algal Biotechnology	Chalk & Board, ICT	15

## Evaluation Pattern

### A. Internal Evaluation

Method	Marks
Class test	10
Assignment	05
Class performance	05
<b>Total</b>	<b>20</b>

### B. Semester End Evaluation (Paper Pattern)

Question No	Unit	Type of Question (Marks)
Q1	I	Short Note (12)
Q2	II	Short Note (12)
Q3	I, II	Objective (06)
<b>Total</b>		<b>30</b>

<b>Name of the Course</b>	Practicals of PSMB404
<b>Course Code</b>	PSMB405
<b>Class</b>	M.Sc. II
<b>Semester</b>	IV
<b>No of Credits</b>	02
<b>Nature</b>	Practical
<b>Type</b>	Major: Elective
<b>Highlight revision specific to employability/ entrepreneurship/ skill development</b>	Proficiency in nanotechnology applications in biotech fields enhances employability in materials science, medicine, and agriculture. Entrepreneurs can develop algal-based products for sustainable food, energy, and cosmetics markets. They can also understand and navigate regulatory framework related to nanoparticle products. Skill development includes understanding nanomaterial properties, biosynthesis, and innovating new nanotechnology based products considering market needs.

### **PSMB405 - Practical of PSMB404 Modules at a Glance**

Sr. No.	Modules	No. of Lectures
I	Practicals of PSMB404 (Advances in Biotechnology Practicals)	60
<b>Total</b>		<b>60</b>

#### **Course Outcomes:**

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

1. Synthesize silver nanoparticles and determine its antibacterial activity
2. Prepare growth culture medium for algae
3. Cultivate microalgae from freshwater environments

## Curriculum:

PSMB405 - Practicals of PSMB404		
Title	Learning Points	No of Lectures
Practicals of PSMB404 (Advances in Biotechnology Practicals)	<b>PRACTICALS</b> <ol style="list-style-type: none"><li>1. Preparation and characterization of Silver Nanoparticles</li><li>2. Survival Curve and antibacterial activity of nano silver particles</li><li>3. Study of nano silver coated gauze / textiles for antimicrobial effect on different bacteria.</li><li>4. Preparation of growth culture medium for fresh water algae and study its diversity with respect to its type count and morphology.</li><li>5. Counting algal Cells in Cultures with the Light Microscope.</li></ol> <b>SELF STUDY</b> <ol style="list-style-type: none"><li>1. Assignment on Measurement of Chlorophyll a and Carotenoids Concentration in Cyanobacteria</li><li>2. Study various types of microalgae and its role in climate change</li></ol>	60 (2)

## Learning Resources recommended:

1. Andersen, R. A. (2005). Algal culturing techniques. Elsevier Academic Press
2. 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
3. Richmond, A. and Hu, Q. (2013). Handbook of Microalgal Culture: Applied Phycology and Biotechnology, 2ed. John Wiley & Sons, Ltd.

## Teaching Plan

Sr. No.	Practical Title	Teaching Methods	No. of Lectures
I	Advances in Biotechnology Practical	Practical & Demonstration	60

## Evaluation Pattern –

Practical Course	External		Internal			Total
	Major technique	Minor Technique	Journal	Viva	Spots / Quiz/ Lab	
PSMB405	20 Marks	10 Marks	05 Marks	05 Marks	10 Marks	50 Marks

<b>Name of the Course</b>	Mycology and Protozoology
<b>Course Code</b>	PSMB406
<b>Class</b>	M.Sc. II
<b>Semester</b>	IV
<b>No of Credits</b>	02
<b>Nature</b>	Theory
<b>Type</b>	Major: Elective
<b>Highlight revision specific to employability/ entrepreneurship/ skill development</b>	Understanding mycology and protozoology enhances employability in biotechnology, pharmaceuticals, and ecology roles. Proficiency in fungal pigments, mycotoxins, and lipid production is valuable in food, cosmetics, and bioproduction industries. Skills such as protozoan classification, culturing techniques, and understanding their ecological significance are also being imparted. Expertise in identifying pathogenic protozoa, valuable in clinical settings for diagnosing and managing infectious diseases. Capability to assess the ecological impact of protozoa and fungi in various ecosystems, will help the students to contribute to environmental monitoring and biodiversity studies.

## PSMB406 - Mycology and Protozoology Modules at a Glance

Sr. No.	Modules	No. of Lectures
I	Fungal technology	15
II	Protozoology	15
<b>Total</b>		<b>30</b>

### Course Outcomes:

**At the end of this course the learner will**

1. Be familiar to contributions that show new applications, developments of well-established technology, novel research into new technology with reference to these two categories of microorganisms.
2. 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 and Protozoology.



**Curriculum:**

<b>PSMB406 - Mycology and Protozoology</b>			
<b>Unit</b>	<b>Title</b>	<b>Learning Points</b>	<b>No of Lectures</b>
I	Fungal technology	1.1 Mycology a) A neglected Mega Science b) The diversity of fungi and fungus like organisms c) Fungal molecular taxonomy: An overview 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 1.3 Fungal siderophores – structure, function and applications 1.4 Fungal Lipid production a) Oleaginous fungi b) Lipid production from lignocelluloses and crude glycerol 1.5 Fungal Metabolites a) Enzymes - Xylanase, Laccase, Galactosidase, Inulinase, Catalase and b). Flavors and Aroma c) Engineering of fungal biomolecules	15 (1)

II	Protozoology	<p>2.1 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> <p>2.2 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> <p>2.3 Importance of Protozoans in water and wastewater treatment</p> <p>a) Protozoa as indicators of wastewater treatment efficiency</p> <p>b) Activated sludge ecosystems</p> <p>c) Microfaunas as indicators</p> <p>2.4 Importance of Protozoans in Soil bioremediation</p> <p>2.5 Protozoan Parasites</p> <p>a) Giardia spp</p> <p>b) Microsporidia</p> <p>c) Toxoplasma</p>	15 (1)
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### Learning Resources recommended:

#### Unit 1 – Fungal technology

1. Applied Mycology by Mahendra Rai, Paul Dennis Bridge, 2009, CAB International.
2. Fungal Biology 4<sup>th</sup>ed. By J. W. Deacon, 2006, Blackwell Publishing.
3. Fungal Biomolecules – sources, Applications and Recent developments by Vijay kumar Gupta, Robert L. Mach, S. Sreenivasaprasad 2015, Published by John Wiley & Sons .ltd.
4. Developments in Fungal Biology and Applied Mycology by Tulsi Satyanarayana, Sunil K. Deshmukh, B. N. Johri 2017, 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.

## Unit 2 – Protozoology

1. The handbook of water and waste water Microbiology by Duncan Mara and Nigel Horan,2003
2. Wastewater Microbiology, 2<sup>nd</sup> edition by Bergey, D.H
3. Wastewater Microbiology, 4<sup>th</sup> 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, 4<sup>th</sup> edition by S. C. Parija
7. <https://www.sciencedirect.com/science/article/abs/pii/S1872203207600687>
8. <https://www.nature.com/articles/ismej201320>

## Teaching Plan

Unit No.	Unit Title	Teaching Methods	No. of Lectures
I	Fungal technology	Chalk & Board, ICT	15
II	Protozoology	Chalk & Board, ICT	15

## Evaluation Pattern

### A. Internal Evaluation

Method	Marks
Class test	10
Assignment	05
Class performance	05
<b>Total</b>	<b>20</b>

### B. Semester End Evaluation (Paper Pattern)

Question No	Unit	Type of Question (Marks)
Q1	I	Short Note (12)
Q2	II	Short Note (12)
Q3	I, II	Objective (06)
<b>Total</b>		<b>30</b>

<b>Name of the Course</b>	Practicals of PSMB406
<b>Course Code</b>	PSMB407
<b>Class</b>	M.Sc. II
<b>Semester</b>	IV
<b>No of Credits</b>	02
<b>Nature</b>	Practical
<b>Type</b>	Major: Elective
<b>Highlight revision specific to employability/ entrepreneurship/ skill development</b>	Understanding mycology enhances employability in biotechnology, pharmaceuticals, and ecology roles. Proficiency in fungal pigments, mycotoxins, and lipid production is valuable in food, cosmetics, and bioproduction industries. Understanding virology and viral detection enhances employability in healthcare, research, and diagnostics roles. Expertise in bacteriophages and phage therapy enhances employability in microbiology and medical research. Skill development includes understanding disease symptoms, virus detection techniques, and economic losses due to viral infections, microscopy, serological methods, nucleic acid detection, and virus neutralization. Other skills such as protozoan classification, culturing techniques, and understanding their ecological significance are also being imparted. Entrepreneurs can establish viral diagnostic labs; wastewater treatment consulting and can also offer plant virus detection services to farmers or develop disease-resistant crops.

## PSMB407 – Practical of PSMB406

### Modules at a Glance

Sr. No.	Modules	No. of Lectures
I	Practicals of PSMB406 (Mycology and Protozoology Practicals)	60
<b>Total</b>		<b>60</b>

**Course Outcomes:** At the end of the course the learner will be able to

1. Isolate and characterize fungal pigments
2. Perform Mycotoxin isolation and characterization
3. Estimate fungal enzymes using chemical assay

## Curriculum:

PSMB407 – Practicals of PSMB406		
Title	Learning Points	No of Lectures
Practicals of PSMB406 (Mycology and Protozoology Practicals)	<b>PRACTICALS</b> 1. Qualitative and quantitative estimation of fungal Laccase enzyme 2. Isolation and characterization of fungal pigments. 3. Mycotoxin isolation and characterization. 4. Laboratory diagnosis of protozoan diseases. 5. Isolation and identification of environmental protozoa <b>SELF STUDY</b> 1. Assignment on Emerging protozoa/fungal diseases.	60 (2)

## Learning Resources recommended:

1. Medical Mycology Laboratory procedures by Chakrabarti A. and Shivaprakash M. R.
2. Mycology Manual by M. S. Ali Shtayeh, R. M. Jamous and R. Yaghmour
3. The handbook of water and waste water Microbiology by Duncan Mara and Nigel Horan, 2003
4. Textbook of Medical Parasitology: Protozoology and Helminthology, 4<sup>th</sup> edition by S. C. Parija

## Teaching Plan

Sr. No.	Practical Title	Teaching Methods	No. of Lectures
I	Mycology and Protozoology Practicals	Practical & Demonstration	60

## Evaluation Pattern –

Practical Course	External		Internal			Total
	Major technique	Minor Technique	Journal	Viva	Spots / Quiz/ Lab	
PSMB407	20 Marks	10 Marks	05 Marks	05 Marks	10 Marks	50 Marks

<b>Name of the Course</b>	Research Project
<b>Course Code</b>	PSMB408
<b>Class</b>	M.Sc. II
<b>Semester</b>	IV
<b>No of Credits</b>	06
<b>Nature</b>	Research Project
<b>Type</b>	Major: Mandatory
<b>Highlight revision specific to employability/ entrepreneurship/ skill development</b>	Engaging in a research project can develop a wide range of skills that are highly valuable in terms of employability, entrepreneurship, and skill development. Research projects often involve presenting findings through written reports, presentations, and discussions. Developing clear and concise communication skills is essential for effectively conveying ideas to different audiences, whether it's for a job interview, or collaborating with others. Planning, organizing, and executing a research project requires strong project management skills. Learning how to manage time, resources, and tasks efficiently can be beneficial for career advancement and entrepreneurial ventures. Research projects often involve encountering obstacles and challenges that require innovative solutions. Developing problem-solving abilities through research can help individuals adapt to various situations in their careers. Research projects encourage creativity in exploring new ideas, hypotheses, and approaches. Cultivating a mindset of innovation through research can lead to the development of novel solutions, products, or services, which are essential for entrepreneurship and staying ahead in dynamic industries.

Inclusion of project work in the course curriculum of the M.Sc. programme is one of the ambitious aspects in the programme structure. The main objective of inclusion of project work is to inculcate the element of research work challenging the potential of learner as regards to his/her eager to enquire and ability to interpret particular aspect of the study in his/her own words. It is expected that the guiding teacher should undertake the counselling sessions and make the awareness among the learners about the methodology of formulation, preparation and evaluation pattern of the project work.

Marks: 90 (Research Project); 30 (Presentation); 30 (Project Viva): Total 150 Credits: 6

## Course Outcomes

1. Identify the research problem and formulate objectives
2. Choose appropriate methodology with proper tools and techniques
3. Analyse and interpret the data collected from the performed experiments.
4. Make decision or find out conclusions on the basis of data analysis
5. Recall and list key research paradigms and methodologies in the subject.
6. Explain the principles of statistical analysis and their application in subject of research.

## Guidelines for preparation of Research Project

1. Research Project can be undertaken on any Major subject.
2. Research Project can be based on primary data or secondary data.
3. The Research Project should be prepared under the guidance of the Project Guide.
4. The Research Project shall contain the chapters as follows:  
Preliminary Pages of Thesis  
Chapter I: Abstract  
Chapter II: Introduction  
Chapter III: Literature Review  
Chapter IV: Materials and Methods  
Chapter V: Results and Discussion  
Chapter VI: Conclusion  
Chapter VII: Future Prospects  
Chapter VIII: References  
Chapter IX: Appendix
5. Project Work will be done by the student individually or in groups.
6. The Research Project (Thesis) shall consist of 80 to 100 Pages.
7. The student should prepare a PowerPoint presentation based on the research project and he or she has to present it during practical and/or internal examination.
8. Two Copies of typed Research Projects should be submitted to the department as per the schedule provided by the college.
9. All P.G. Teachers under the Faculty of Science are eligible to work as Project Guide.
10. The Responsibility of guiding the projects will be shared by all P.G.Teachers in proportion.
11. Project viva shall be conducted by the practical examiners.

For this purpose, the following points may be kept in mind while assessing the project reports:

- a. The panel of experts should try to verify that the candidate has done the project on his own and also identify his/her insight in the research problem concerned. The quality of the work should be evaluated on the basis of novelty, use of research methodology, contribution to the

society and developing critical thinking, analytical thinking and decision-making skills of students.

b. Research Project report will be examined by the External and/or Internal Examiner, for 90 marks.

c. Project work presentation will be assessed by the External and/or Internal examiner, for 30 Marks.

d. Project viva will be assessed by the External and/or Internal examiner, for 30 Marks.

### **Structure to be followed to maintain the uniformity in formulation and presentation of Project Work**

#### **(Model Structure of the Project Work)**

#### **Preliminary Pages of Thesis**

##### **Chapter I: Abstract**

Abstract should be a miniature version of the thesis, and provide a brief summary of each of the main chapters of the thesis. A typical thesis abstract should have information on four aspects—(1) the rationale and main objectives of the study, (2) the materials and methods used, (3) the summary of the results obtained, and finally, (4) the conclusion of the entire thesis.

##### **Chapter II: Introduction**

In this chapter Selection and relevance of the problem, historical background of the problem, brief profile of the study area, definition/s of related aspects, characteristics, different concepts pertaining to the problem etc can be incorporated by the learner.

##### **Chapter III: Literature Review**

This chapter will provide information about studies done on the respective issue. This would specify how the study undertaken is relevant and contribute for value addition in information/ knowledge/ application of study area which ultimately helps the learner to undertake further study on same issue.

##### **Chapter IV: Materials and Methods**

This chapter will include Objectives, Hypothesis, Scope of the study, limitations of the study, significance of the study, Selection of the problem, Sample size, Data collection, Tabulation of data, Techniques and tools to be used, etc. can be incorporated by the learner.



## **Chapter V: Results and Discussion**

In this section, you present your findings with supporting data. The Results, therefore, should communicate the facts, measurements, and observations gathered by the student supported by data in tables, diagrams, graphs, and photographs. Along with results there should be a Discussion section to show the relationships among observed facts. This chapter must show how far the objectives set out or assumptions made at the start of the experiment are proved or disproved. Application of bio statistical tools should be encouraged while interpreting the results.

## **Chapter VI: Conclusions**

In this chapter of project work, findings of work will be covered and suggestion will be enlisted to validate the objectives and hypotheses.

## **Chapter VII: Future Prospects**

This chapter should highlight avenues for future research that could stem from the current project, including unanswered questions, potential follow-up studies, or areas for further exploration.

## **Chapter VIII: References / Bibliography**

The references or bibliography section of a research project should contain a list of all the sources cited within the main text. This section serves to acknowledge the work of other researchers and provide readers with the information they need to locate and consult the cited sources themselves.

## **Chapter IX: Appendix**

The appendix of a research project typically includes supplementary materials that provide additional information or support for the main text.



Chairperson,  
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