

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

**(Affiliated to Savitribai Phule Pune University, Pune)**



**Choice Based Credit System (CBCS)**

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

**Syllabus of**

**M.Sc. Part-II (Microbiology)**

**Implemented from**

**Academic Year 2022 - 23**

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

**Board of Studies in Microbiology**

| Sr. No. | Name                    | Designation              |
|---------|-------------------------|--------------------------|
| 1.      | Mr. Kukreja Girish P.   | Chairman                 |
| 2.      | Ms. Giramkar Dipali D.  | Member                   |
| 3.      | Dr. Dixit Prashant P.   | Academic Council Nominee |
| 4.      | Dr. Naphade Bhushan S.  | Academic Council Nominee |
| 5.      | Mr.Choure Rajendra G.   | Vice Chancellor Nominee  |
| 6.      | Mr. Yewatkar Saikiran   | Alumni                   |
| 7.      | Mr. Dube Chandrakant G. | Industry Expert          |
| 8.      | Dr. Patil Ulhas K.      | Member (co-opt)          |
| 9.      | Mr.Shaikh Sajid H.      | Member (co-opt)          |
| 10.     | Dr. Gahile Yogesh R.    | Member (co-opt)          |
| 11.     | Mr.Wani Ashish S.       | Member (co-opt)          |

### 3. Programme Structure and Course Titles: (All academic years)

| Sr. No. | Class | Semester | Course Code    | Course Title  | Credits |
|---------|-------|----------|----------------|---|---------|
| 01      | M.Sc. | I        | MSC-MR111T     | Cell Organization and Biochemistry  | 04      |
| 02      | M.Sc. | I        | MSC-MR112T     | Quantitative Biology  | 04      |
| 03      | M.Sc. | I        | MSC-MR113T     | Microbial Systematics   | 02      |
| 04      | M.Sc. | I        | MSC-MR114P     | Practical course based on Biochemical Techniques  | 02      |
| 05      | M.Sc. | I        | MSC-MR115P     | Practical course based on Biostatistics and Bioinformatics                              | 02      |
| 06      | M.Sc. | I        | MSC-MR116P     | Practical course based on Developmental Biology and Microbial Diversity                 | 02      |
| 07      | M.Sc. | I        | MSC-MR117T(A)  | Fungal Systematics and Extremophiles  | 02      |
| 08      | M.Sc. | I        | MSC-MR117 T(B) | Experimental Design and Quantitative approaches for Biologist                           | 02      |
| 09      | M.Sc. | I        | MSC-MR118 P(A) | Practical course based on Fungal Systematics and Extremophiles                          | 02      |
| 10      | M.Sc. | I        | MSC-MR118 P(B) | Practical course based on Experimental Design and Quantitative approaches for Biologist | 02      |
| 11      | M.Sc. | I        | MSC-MR119 T    | Evolution and Ecology   | 02      |

|    |       |     |                |   |    |
|----|-------|-----|----------------|---|----|
| 12 | M.Sc. | II  | MSC-MR211T     | Instrumentation and Molecular Biophysics                                      | 04 |
| 13 | M.Sc. | II  | MSC-MR212T     | Molecular Biology I   | 04 |
| 14 | M.Sc. | II  | MSC-MR213T     | Nitrogen Metabolism, Respiration and Photosynthesis                           | 02 |
| 15 | M.Sc. | II  | MSC-MR214P     | Practical course based on Instrumentation Techniques                          | 02 |
| 16 | M.Sc. | II  | MSC-MR215P     | Practical course based on Molecular Biology                                   | 02 |
| 17 | M.Sc. | II  | MSC-MR216P     | Practical course based on Nitrogen Metabolism, Respiration and Photosynthesis | 02 |
| 18 | M.Sc. | II  | MSC-MR217T(A)  | The Chemistry and Metabolism of Lipids and Carbohydrates                      | 02 |
| 19 | M.Sc. | II  | MSC-MR217 T(B) | Enzymology and Bioenergetics  | 02 |
| 20 | M.Sc. | II  | MSC-MR218 P(A) | Practical course based on Lipid and Carbohydrate Biochemistry                 | 02 |
| 21 | M.Sc. | II  | MSC-MR218 P(B) | Practical course based on Enzymology  | 02 |
| 22 | M.Sc. | II  | MSC-MR219T     | Basic Virology  | 02 |
| 23 | M.Sc. | III | MSC-MR311T     | Immunology  | 04 |
| 24 | M.Sc. | III | MSC-MR312T     | Molecular Biology II  | 04 |
| 25 | M.Sc. | III | MSC-MR313T     | Waste Water Treatment   | 02 |

|    |       |     |                |   |    |
|----|-------|-----|----------------|---|----|
| 26 | M.Sc. | III | MSC-MR314P     | Practical course based on based on Immunology                     | 02 |
| 27 | M.Sc. | III | MSC-MR315P     | Practical course based on Molecular Biology                       | 02 |
| 28 | M.Sc. | III | MSC-MR316P     | Practical course based on Waste Water Treatment                   | 02 |
| 29 | M.Sc. | III | MSC-MR317T(A)  | Cell Culture Technique  | 02 |
| 30 | M.Sc. | III | MSC-MR 317T(B) | Microbiology in Sustainable Development                           | 02 |
| 31 | M.Sc. | III | MSC-MR318P(A)  | Practical course based on Cell Culture Techniques                 | 02 |
| 32 | M.Sc. | III | MSC-MR318P(B)  | Practical course based on Microbiology in Sustainable Development | 02 |
| 33 | M.Sc. | III | MSC-MR319T     | Clinical Microbiology   | 02 |
| 34 | M.Sc. | IV  | MSC-MR411T     | Drug Discovery and Development                                    | 04 |
| 35 | M.Sc. | IV  | MSC-MR412T     | Microbial Technology  | 04 |
| 36 | M.Sc. | IV  | MSC-MR413T     | Advanced Virology   | 02 |
| 37 | M.Sc. | IV  | MSC-MR414P     | Practical course based on Drug Discovery and Development          | 02 |
| 38 | M.Sc. | IV  | MSC-MR415P     | Practical course based on Microbial Technology                    | 02 |
| 39 | M.Sc. | IV  | MSC-MR416P     | Practical course based on Virology                                | 02 |

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|    |       |    |               |   |    |
|----|-------|----|---------------|---|----|
| 40 | M.Sc. | IV | MSC-MR417T(A) | Bioethics, Biosafety, Quality Control and Quality Assurance                           | 02 |
| 41 | M.Sc. | IV | MSC-MR417T(B) | Scientific Writing  | 02 |
| 42 | M.Sc. | IV | MSC-MR418P(A) | Practical course based on Bioethics, Biosafety, Quality Control and Quality Assurance | 02 |
| 43 | M.Sc. | IV | MSC-MR418P(B) | Practical course based on Scientific Writing  | 02 |
| 44 | M.Sc. | IV | MSC-MR419P    | Dissertation  | 02 |

**Ahmednagar Jilha Maratha Vidya Prasarak Samaj's  
New Arts, Commerce and Science College, Ahmednagar (Autonomous)  
Syllabus of M.Sc.-Part II (Microbiology)  
under  
Faculty of Science and Technology**

|                                |  |
|--------------------------------|--|
| <b>Semester –III</b>           | <b>Paper –I</b>                        |
| <b>Course Code: MSC-MR311T</b> | <b>Title of the Course: Immunology</b> |
| <b>Credits: 04</b>             | <b>Total Lectures : 60 Hrs.</b>        |

### Course Outcomes (COs):

- a. Students will be introduced to various cell surface receptors.
- b. Students will understand regulation of immune response.
- c. Students will be introduced to mechanisms of tumor formation, tumor-immune system interaction and its diagnosis.

### Detailed Syllabus:

| <b>Unit No.</b> | <b>Topics</b>   | <b>No. of hours</b> |
|-----------------|---|---------------------|
| <b>Unit 1</b>   | <p><b>Cell surface molecules and receptors</b></p> <p>A. Definition, general Structure and mechanism (dimerization and rotation), components of signal transduction (extracellular signaling molecule, receptor proteins, intracellular signaling proteins and target proteins)</p> <p>B. Adhesion molecules in immune activation, structure and function of B Cell Receptor, TCR-CD3 complex, Toll-like receptors, G-protein coupled receptors</p> <p>C. Signal transduction pathways: IL-2 pathway (JAK/STAT, Ras/MAPKinase Pathways, TCR-CD3 activation pathway)</p> | 15                  |
| <b>Unit 2</b>   | <p><b>Regulation of Immune response</b></p> <p>A. Negative regulation - Immunological tolerance, Mechanisms</p>   |                     |

|               |  |    |
|---------------|--|----|
|               | <p>of tolerance induction, T cell mediated suppression of immune response.</p> <p>B. Regulation of immune responses by antigen, Network theory and its experimental evidence</p> <p>C. Cytokine mediated cross regulation of TH subsets (TH1-TH2)<br/>Regulation of complement system – Classical and alternative pathway</p> <p>D. Biological Response Modifiers for cancer therapy and autoimmune disorders</p>  | 15 |
| <b>Unit 3</b> | <p><b>Experimental Immunology</b></p> <p>A. <i>In vitro</i> systems –ELISPOT assay, functional assays for phagocytes and cytokines (cytotoxicity and growth assays)</p> <p>B. <i>In vivo</i> systems – Experimental animals in immunology research (Inbred animal strains, Knockout mice, transgenic animals), Animal models for autoimmunity and AIDS</p>   | 15 |
| <b>Unit 4</b> | <p><b>Tumor Immunology</b></p> <p>A. Cellular transformations during neoplastic growth, Tumors of lymphoid system (lymphoma, myeloma, Hodgkin's disease).</p> <p>B. Escape mechanisms of tumor from host defence, Host immune response to tumor – Effector mechanisms, Immuno-surveillance.</p> <p>C. Theory Diagnosis of tumors – biochemical and immunological tumor markers</p> <p>D. Approaches in cancer immunotherapy: Immune adjuvant and tumor vaccine therapy</p> | 15 |

### Suggested Readings:

1. Abbas A. K. and Lichtman A. H. (2004) Basic Immunology. Functions and



- Disorders of Immune System. Second edition. Elsevier Inc.
2. Austyn J. M. and Wood K. J. (1993) Principles of Molecular and Cellular Immunology. First edition Oxford University Press, New York.
  3. Bendelac A., Savage P. B. and Teyton L. (2007) The Biology of NKT Cells. *Annu. Rev. Immunol.* 25:297–336.
  4. Boyd W. C. (1966) Fundamentals of Immunology, Interscience Publishers, New York.
  5. Carroll M. C. (2004) The complement system in regulation of adaptive immunity. *Nature Immunology.* 5(10): 981-986.
  6. Chatterjee C. C. (1992) Human Physiology Tenth edition Vol. 1 and 2. Medical Allied Agency, Calcutta.
  7. Guyton A. C. and Hall J. E. (1996) Text Book of Medical Physiology. Goel Book Agency, Bangalore.
  8. Hafler D. A. (2007) Cytokines and interventional immunology, *Nature Reviews, Immunology.* 7(6): 423-423.
  9. Kindt T. J., Osborne B. A. and Goldsby R. A. (2006) Kuby Immunology, Sixth edition,
  10. Leen A. M., Rooney C. M. and Foster A. E. (2007) Improving T Cell Therapy for Cancer. *Annu Rev. Immunol.* 25 (1):243–65.
  11. Malati T. (2007) Tumor Markers: An Overview, *Indian Journal of Clinical Biochemistry.* 22(2):17-31.
  12. Mather J. P. and Roberts P. E. (1998). Introduction to Cell and Tissue Culture Theory and Technique. Plenum Publishing Corporation, New York.
  13. Roitt I. M. (1984) Essentials of Immunology. P. G. Publishers Pvt. Ltd., New Delhi.
  14. Roitt I. M. 1988. Essentials of Immunology. ELBS, London.
  15. Roitt I., Brostoff J. and Male D. (1993) Immunology .Sixth edition .Mosby & Co. London.
  16. Talwar G. P. (1983). Handbook of Immunology. Vikas Publishing Pvt. Ltd. New Delhi.

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|--------------------------------|--|
| <b>Semester –III</b>           | <b>Paper –II</b>                                 |
| <b>Course Code: MSC-MR312T</b> | <b>Title of the Course: Molecular Biology II</b> |
| <b>Credits: 04</b>             | <b>Total Lectures : 60 Hrs</b>                   |

### Course Outcomes (COs):

- Students will understand concept of genomics and genetically modified plant and animal.
- Students will understand various transposable DNA elements and their mechanism of transposition.
- Students will be able to understand the concept & technique applied in proteomics.

### Detailed Syllabus:

| <b>Unit No.</b> | <b>Topics</b>  | <b>No. of hours</b> |
|-----------------|--|---------------------|
| <b>Unit 1</b>   | <b>Genomics</b><br>A. Gene sequencing, conserved genes, finding base sequences which form genes<br>B. Many proteins from one gene, alternative gene expression: DNA imprinting and Epigenetics.<br>C. Genomic variation-SNPs, SNPS and diseases, SNPS detection and medical therapies. Prokaryotic SNPs<br>D. Role of genomic variation in aging, Trades offs associated with genomic variation. | 15                  |
| <b>Unit 2</b>   | <b>Genetically modified plants and animals</b><br>A. Genetically modified organisms- social and ethical issues<br>B. Gene therapy<br>C. Applications in medicine – prevention, early   | 15                  |

|               |   |    |
|---------------|---|----|
|               | <p>detection and cure of diseases</p> <p>D. Applications of transgenic plants and animal</p> <p>E. Advantages and disadvantages of transgenic plants and animals</p>  |    |
| <b>Unit 3</b> | <p><b>Mobile DNA elements</b></p> <p>A. Transposable elements in bacteria,</p> <p>B. IS elements, composite transposons, Integrons. Replicative, nonreplicative transposons, and Mu transposition</p> <p>C. Controlling elements in Tn A, Tn 5 and Tn 10 transposition</p> <p>D. Transposons in maize and Drosophila</p> <p>E. Retroviruses and retrotransposon, Ty elements in yeasts</p> <p>F. SINES, LINES and Alu elements.</p> | 15 |
| <b>Unit 4</b> | <p><b>4. Proteomics</b></p> <p>A. Basic concept of proteomics</p> <p>B. Expression, Analysis and Characterization of Protein.</p> <p>C. Analysis of protein structure</p> <p>D. Protein interaction.</p> <p>E. Basic concept of Metabolomics with examples and global biochemical networks</p>  | 15 |

### Suggested Readings:

1. Brown TA. (2002) Genomes. 2nd edition. Oxford: Wiley-Liss; Chapter 7, Understanding a Genome Sequence.
2. Stojanovic N., Florea L., Riemer C., Gumucio D., Slightom J., Goodman M., Miller W., and Hardison R. (1999) Comparison of five methods for finding conserved sequences in multiple alignments of gene regulatory regions, Nucleic

- Acids Research, 27 (19) 1,3899–3910.
3. Primrose S. B. and Twyman R. M. (2006) Principles of Gene Manipulation and Genomics, 7<sup>th</sup> Edition. S. B. Primrose & R. M. Twyman. Blackwell Publishing: U.S. 626 pp.
  4. Watson J. D., Baker T. A., Gann A., Bell S. P., Levine M. and Losick R. 7<sup>th</sup> Edition. Molecular Biology of the Gene. Pearson-USA
  5. Alwi Z. B. (2005) The Use of SNPs in Pharmacogenomics Studies. *Malays J Med Sci.* 12(2):4- 12.
  6. Butler J. M. (2012) Single Nucleotide Polymorphisms and Applications In: Advanced Topics in Forensic DNA Typing: Methodology. Academic Press: United States.347-369
  7. Lemaître J. F., Berger V., Bonenfant C., Douhard M., Gamelon M., Plard F. and Gaillard J.M. (2015) Early-late life trade-offs and the evolution of ageing in the wild. *Proc Biol Sci.* 7; 282(1806): 20150209.
  8. Morris B. J., Willcox B. J and Donlon T.A. (2019) Genetic and epigenetic regulation of human aging and longevity. *Biochim Biophys Acta Mol Basis Dis.* 1; 1865(7):1718-1744.
  9. Yashin A. I., Ukraintseva S. V., Akushevich I. V., Arbeev K. G., Kulminski A. and Akushevich L. (2009)
  10. Trade-off between cancer and aging: what role do other diseases play? Evidence from experimental and human population studies. *Mech Ageing Dev.* 130(1-2):98-104.
  11. Gene Therapy Tools and Potential Applications- Francisco Martin Molina (2013) Janeza Trdine 9, 51000 Rijeka, Croatia
  12. Glick B. R. and Pasternak J. J. (1998) Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington D C, ASM Press.
  13. Weaver R. (2007) Molecular Biology. 4<sup>th</sup> Edition. Mc-Grew Hill Publication
  14. Maghari B. M. and Ardekani A.M. (2011) Genetically modified foods and social concerns. *Avicenna J Med Biotechnol.* 3(3):109-17.
  15. Lewin B. (2011) Genes X. Jones and Bartlett Publication.
  16. Watson J. D., Baker T. A., Gann A., Bell S. P., Levine M. and Losick R. 7<sup>th</sup> Edition.

Molecular Biology of the Gene. Pearson-USA

17. Bhushan Patwaradhan and Rathnam Chagutire (2005) An overview of the basics of proteomics. In: Innovative approaches in drug discovery, Academic Press: United States.
18. Nölting B. (2006) Methods in Modern Biophysics. Second Edition, Springer: Germany.
19. Tang J. (2011) Microbial metabolomics. *Curr Genomics*. 12(6):391-403.
20. Wilson K. And Walker J. (2005) Principles and Techniques of Biochemistry and Molecular Biology, 6<sup>th</sup> Edn., Cambridge University Press, New York.
21. Chen F, Ma R, Chen XL. (2019) Advances of Metabolomics in Fungal Pathogen-Plant Interactions. *Metabolites*.15;9(8):169

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|--------------------------------|---|
| <b>Semester –III</b>           | <b>Paper –III</b>                                 |
| <b>Course Code: MSC-MR313T</b> | <b>Title of the Course: Waste Water Treatment</b> |
| <b>Credits: 02</b>             | <b>Total Lectures : 30 Hrs.</b>                   |

### Course Outcomes (COs):

- Students will understand the layout of a wastewater treatment process and will be able to measure Pollution Load of wastewaters.
- Students will understand the different stages of wastewater treatment –Pre-treatment & Primary treatment, Secondary and Tertiary Treatment.
- Students will learn about Advanced, Combined and Innovative wastewater treatment processes

### Detailed Syllabus:

| Unit No.      | Topics  | No. of hours |
|---------------|---|--------------|
| <b>Unit 1</b> | <b>Principles of Wastewater Treatment</b><br>A. The need for Wastewater Treatment<br>B. Measuring Pollution Load of wastewaters<br>C. Methods for estimating parameters used for determining treatment efficacy<br>D. Layout of typical wastewater treatment plants | 07           |
| <b>Unit 2</b> | <b>Pretreatment &amp; Primary treatment process (Unit Processes)</b><br>A. Flow equalization<br>B. Screening<br>C. Flocculation<br>D. Flotation<br>E. Primary sedimentation   | 08           |
| <b>Unit 3</b> | <b>Secondary and Tertiary Treatment process (Unit Processes)</b>  |              |

|               |  |    |
|---------------|--|----|
|               | A. Biological Processes (Aerobic)<br>B. Biological Processes (Anaerobic)<br>C. Biological processes (Combined)<br>D. Disinfection<br>E. Sludge treatment and disposal  | 08 |
| <b>Unit 4</b> | <b>Advanced, Combined and Innovative wastewater treatment processes</b><br>A. Submerged Aerobic Fixed Film reactors (SAFF)<br>B. Membrane bioreactors (MBRs)<br>C. Rotating Biological Contactors (RBCs)<br>D. Mixed Bed Bioreactors (MBBRs) | 07 |

### Suggested Readings:

1. Abdallah M. N., Abdelhalim W. S. and Abdelhalim H. S. (2016) Industrial wastewater treatment of food industry using best techniques. *International Journal of Engineering Science Invention*, 5(8):15-28.
2. Ali, Z. and Rahman, M. (2008)
2. Ashtekar S., Bhandari V.M., Shirsath S.R., Sai Chandra P.L.V.N. and Jolhe P.D. (2013) Dye wastewater treatment: removal of reactive dyes using inorganic and organic coagulants. *Journal of Industrial Pollution Control*, 30(1):33-42
3. Baird, Rodger., and Laura Bridgewater. *Standard Methods for the Examination of Water and Wastewater*. 23rd edition. Washington, D.C.: American Public Health Association, 2017.
4. Bajpai P. 2001. Microbial degradation of pollutants in pulp mill effluents. *Advances in Applied Microbiology*.48:79-134.
5. Bajpai P. and Bajpai P.K. 1994. Mini review: Biological colour removal of pulp and paper mill wastewaters. *Journal of Biotechnology*. 33: 211-220.
6. *Biological Wastewater Treatment*. Vol. 5. Activated Sludge and Aerobic Biofilm Reactors. Marcos von Sperling. IWA Publishing, London, New York. © 2007 IWA Publishing

7. Biotechnology for Water and Wastewater Treatment. Dr. Satya Prakash. Navyug Publishers & Distributors, New Delhi. 2009.
8. Industrial Water Pollution Control. 3rd Edition. W. Wesley Eckenfelder Jr. McGraw Hill. 2000. Standard Methods for the Examination of Water & Wastewater. 21st Edition. 2005.
9. Physico-chemical characteristics of pulp and paper mill effluent. Research in Environment and Life Sciences.1 (2):59-60.
10. Tchobanoglous G. and F. L. Burton. (1991). Wastewater Engineering, Treatment, Disposal and Reuse. 3rd Ed., Metcalf. Eddy (Eds). Tata Mac Graw Hill Publishing Co. Ltd. New Delhi
11. Wastewater Treatment and Technology. Christopher Forster. Thomas Telford Publishing, London, UK. 2003.



| Semester –III           | Paper –IV   |
|-------------------------|---|
| Course Code: MSC-MR314P | Title of the Course: Practical course based on Immunology |
| Credits: 02             | Total Lectures : 60 Hrs.                                  |

### Course Outcomes (COs):

- Student will be able perform immunoelectrophoresis and immunodiffusion.
- Student will be able to determine antibody titer.
- Animal handling and animal inoculation will be demonstrated to students.

### Detailed Syllabus:

| Title of the Experiment   |
|---|
| <ul style="list-style-type: none"> <li>Quantitative estimation of antigen/antibody by Single radial diffusion</li> </ul>  |
| <ul style="list-style-type: none"> <li>Rocket Immuno- electrophoresis</li> </ul>  |
| <ul style="list-style-type: none"> <li>Agglutination techniques: Determination of iso-antibodies titre to human blood group antigens</li> </ul>   |
| <ul style="list-style-type: none"> <li>Demonstration of Western Blotting</li> </ul>   |
| <ul style="list-style-type: none"> <li>Visit to institute/industry for demonstration of ELISPOT/CFT/FACS/animal inoculation</li> <li>Demonstration of routine Hematological tests by using automated analyzers</li> </ul> |
| <ul style="list-style-type: none"> <li>Widal test</li> </ul>  |
| <ul style="list-style-type: none"> <li>Detection of antigen or antibody using Immunoelectrophoresis</li> </ul>  |
| <ul style="list-style-type: none"> <li>Double immuno diffusion technique</li> </ul>   |
| <ul style="list-style-type: none"> <li>Quantification of antigen/antibody using ELISA</li> </ul>  |
| <ul style="list-style-type: none"> <li>Hands on Venipuncture procedures: site selection, sterilization and sample collection and storage.</li> </ul>  |

| Semester –III           | Paper –V   |
|-------------------------|--|
| Course Code: MSC-MR315P | Title of the Course: Practical course based on Molecular Biology |
| Credits: 02             | Total Lectures : 60 Hrs.   |

### Course Outcomes (COs):

- Students can use methods for separation and analysis of nucleic acid like RNA.
- Students will acquire practical knowledge of transformation in bacteria and be able to calculate transformation frequency.
- Students will be able to know the database used in genomics and proteomics and principles of southern blotting.

### Detailed Syllabus:

| Title of the Experiment  |
|--|
| <ul style="list-style-type: none"> <li>Study of nucleic acid sequence database and sequence retrieval-NCBI GenBank, DDBJ, EMBL</li> </ul>  |
| <ul style="list-style-type: none"> <li>Isolation, purification and estimation of RNA</li> </ul>  |
| Ligation of DNA <ul style="list-style-type: none"> <li>Perform ligation of digest using Ligase.</li> <li>Analyze the ligated sample by agarose gel electrophoresis</li> </ul>  |
| GFP Cloning: Bacterium <i>E. coli</i> using a gene for green fluorescent protein <ul style="list-style-type: none"> <li>Vector and Insert Ligation,</li> <li>Preparation of competent cells</li> <li>Transformation of <i>E. coli</i> with standard plasmids,</li> <li>Calculation of transformation efficiency</li> </ul> |

Study of the process of bacterial conjugation and transfer of the gene of interest

- Understand the naturally occurring bacterial conjugation events
  - Transfer antibiotic resistance from one bacterium to another.
- 
- Analysis of DNA sequence by blotting and hybridization -Demonstration
- 
- Demonstration of use of PCR / RT PCR in Diagnosis of infectious diseases.
- 
- Study of Protein sequence database sequence retrieval-PDB

|                                |   |
|--------------------------------|---|
| <b>Semester –III</b>           | <b>Paper –VI</b>  |
| <b>Course Code: MSC-MR316P</b> | <b>Title of the Course: Practical course based on Waste Water Treatment</b> |
| <b>Credits: 02</b>             | <b>Total Lectures : 60 Hrs.</b>   |

### Course Outcomes (COs):

- Students will be able to perform TS, TSS, TDS, total alkalinity, BOD and COD of waste water sample.
- Students will be able to determine pollution load of waste water sample.
- Students will be able to set up laboratory experiment to assess degradability of synthetic waste water.

### Detailed Syllabus:

| <b>Title of the Experiment</b>   |
|--|
| • Determination of TS, TSS, TDS of wastewater sample.  |
| • Determination of total alkalinity of wastewater sample.                                      |
| • Determination of Total Carbon / Nitrogen / Chloride in given water sample                    |
| • Determination of BOD and COD of wastewater sample.   |
| • Estimation of pollution load of a natural sample (e.g. river water / industrial waste water) |
| • Setting up a laboratory experiment to assess degradability of synthetic waste water          |
| • Visit to waste water / effluent treatment plant  |
| • Bacteriological monitoring of waste water  |
| • Total Bacterial population by SPC  |
| • Fecal coliform (MFT, MPN )   |
| • Isolation and characterization of human pathogen from sewage water                           |

|                                   |   |
|-----------------------------------|---|
| <b>Semester –III</b>              | <b>Paper –VII</b>                                   |
| <b>Course Code: MSC-MR317T(A)</b> | <b>Title of the Course: Cell Culture Techniques</b> |
| <b>Credits: 02</b>                | <b>Total Lectures : 30 Hrs.</b>                     |

### Course Outcomes (COs):

- Students will be introduced to primary cell culture, cell lines established cell lines.
- Students will be explained different culture media, factors affecting cells in culture.
- Students will understand concepts of lymphoid cell culture.

### Detailed Syllabus:

| <b>Unit No.</b> | <b>Topic</b>   | <b>No. of hours</b> |
|-----------------|--|---------------------|
| <b>Unit 1</b>   | <b>Animal Cell Culture Techniques:</b><br>A. Definition of terms: Primary cell cultures and cell lines, established cell lines, suspension and anchorage dependent cell cultures.<br>B. Transformation of cells in culture, culture media, factors affecting cells in culture. | 15                  |
| <b>Unit 2</b>   | <b>Commonly used cell culture systems and cell lines in immunological studies:</b><br>A. Cell culture systems and their applications: primary lymphoid cell culture, cloned lymphoid cell lines, hybrid lymphoid cell lines, Immunomodulation                                  | 15                  |

**Suggested Readings:**

1. Freshney R. I. (2005) Culture of Animal Cells: A Manual of Basic Technique. 5th Ed. John Wiley and Sons, Inc.
2. Masters J. R. W. (2000). Animal Cell Culture – A Practical Approach. 3rd Ed. Oxford University Press.
3. Mather J. P. and Penelope E. R. (1998) Introduction to Cell and Tissue Culture Theory and Technique. Plenum Press, New York
4. Kindt T. J., Goldsby R. A., Osborne B. A. and Kuby J. (2007) Kuby Immunology. 6th Ed. W. H. Freeman and Co.
5. Patwardhan B., Diwanay S. and Gautam M. (2006) Botanical immunomodulators and chemoprotectants in cancer therapy. In Drug Discovery and Development Volume I: Drug Discovery. Ed. Chorghade Mukund S. Wiley-Interscience, John Wiley and Sons Inc. USA. 405-424.

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| <b>Semester –III</b>              | <b>Paper –VII</b>   |
| <b>Course Code: MSC-MR317T(B)</b> | <b>Title of the Course: Microbiology in Sustainable Development</b> |
| <b>Credits: 02</b>                | <b>Total Lectures : 30 Hrs.</b>                                     |

### Course Outcomes (COs):

- Students will understand the current scenarios and the threats to the environment.
- Students will know the role of microbes in environment.
- Students will explore the role of microbes in sustainable development.

### Detailed Syllabus:

| <b>Unit No.</b> | <b>Topics</b>   | <b>No. of hours</b> |
|-----------------|---|---------------------|
| <b>Unit 1</b>   | <p><b>Threats to Environment</b></p> <p>A. Global and regional threats to the environment environmental pollution (air, water and soil) and its impact on environment (biotic &amp; abiotic), transport, diffusion and monitoring of pollutants.</p> <p>B. Future scenarios of the global environment, causes and consequence of climate change (greenhouse effect and global warming, ozone hole, sea level rise) carbon footprints, carbon sequestration (biological) and carbon credit in biodiversity conservation.</p> <p>C. Environment monitoring- applications of remote sensing and GIS in environmental monitoring.</p> <p>D. Environmental impact assessment: Introduction, Objectives, Classification, Guidelines, case study. International and Indian eco-standards ISO 14000 series overview</p> | 15                  |

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| <p><b>Unit 2</b></p> | <p><b>Environmental Microbiology in Achievement of Sustainable Development Goals</b></p> <p>A. Microbes in the environment ( Land, Water, Air, Space )</p> <p>B. Sample collection and Processing (overview of Microscopic techniques, cultural, Physiological , Immunological and Nucleic acid based methods of analysis )</p> <p>C. Biochemical cycling of nutrients (C, H, O, N, P, S, Fe) with emphasis of role of microbes .</p> <p>D. Microbes in Biodegradation , Biomineralization, Bioremediation and Transformations with reference to metal pollutants, organic pollutants, xenobiotics</p> <p>E. Role of Microbes in sustainable agricultural practices – PGPR, Mycorrhiza and other useful Plant Microbe interactions</p> | <p>15</p> |
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### Suggested Readings:

1. Environmental Microbiology. By Raina M Maier, , Ian L Pepper, and , Charles P Gerba. San Diego (California): Academic Press ISBN: 0–12–497570–4. 2000.
2. Glick B. R., Pasternak J. J., Cheryl L. and Patten C. L. (1998) Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington D C, ASM Press.
3. Gupta G. V. (2016) New and Future Developments in Microbial Biotechnology and Bioengineering. *Aspergillus* System Properties and Applications. Elsevier Book Publication.
4. Jaiswal S., Singh D. K. and Shukla P. (2019) Gene Editing and Systems Biology Tools for Pesticide Bioremediation: A Review. *Front Microbiol.* 10:87.
5. Karpouzias D. G. and Singh B. K. (2006) Microbial degradation of organophosphorus



- xenobiotics: metabolic pathways and molecular basis. *Adv Microb Physiol.* 51:119-185.
6. Lal P.B., Wells F.M., Lyu Y., Ghosh I.N., Landick R. and Kiley P.J. (2019) A marker less method for genome engineering in *Zymomonas mobilis* ZM4. *Front. Microbiol.* 10: 2216.
  7. *Microbial Ecology: Fundamentals and Applications* Pearson; 4th edition (2008 ) ISBN-978-81-317-1384-6
  8. *Microbial Ecology* by Larry L. Barton Diana E. Northup Wiley-Blackwell; 1st edition.
  9. Ramos J. L., González-Pérez M. M. and Caballero A., van Dillewijn P. (2015) Bioremediation of polynitrated aromatic compounds: plants and microbes put up a fight. *Curr Opin Biotechnol.* 16(3): 275-281.

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| <b>Semester –III</b>               | <b>Paper –VIII</b>  |
| <b>Course Code: MSC-MR318 P(A)</b> | <b>Title of the Course: Practical course based on Cell Culture Techniques</b> |
| <b>Credits: 02</b>                 | <b>Total Lectures : 60 Hrs.</b>   |

### Course Outcomes (COs):

- Students will learn basics of density gradient centrifugation.
- Students will be able to make lymphocyte culture using blood.
- Students will be able to create primary cell culture from chick embryo.

### Detailed Syllabus:

| <b>Title of the Experiment</b>  |
|---|
| <ul style="list-style-type: none"> <li>Instruments used in animal tissue culture, preparation of media and sera.</li> </ul> |
| <ul style="list-style-type: none"> <li>Cell count and viability</li> </ul>  |
| <ul style="list-style-type: none"> <li>Density gradient based separation of peripheral lymphocytes</li> </ul>               |
| <ul style="list-style-type: none"> <li>Preparation of Lymphocyte culture</li> </ul>   |
| <ul style="list-style-type: none"> <li>Preparation of primary cell culture from chick embryo</li> </ul>                     |
| <ul style="list-style-type: none"> <li>Culture of virus using fertilized egg</li> </ul>                                     |
| <ul style="list-style-type: none"> <li>Visit to Animal tissue culture laboratory</li> </ul>                                 |

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| <b>Semester –III</b>              | <b>Paper – VIII</b>  |
| <b>Course Code: MSC-MR318P(B)</b> | <b>Title of the Course : Practical course based on Microbiology in Sustainable Development</b> |
| <b>Credits: 02</b>                | <b>Total Lectures : 60 Hrs.</b>  |

### Course Outcomes (COs):

- Students will learn to isolate p-nitrophenol, pesticide degrading bacteria.
- Students will learn to decolorize dye with help of biomass
- students will learn to isolate biodiesel producing microalgae

### Detailed Syllabus:

| <b>Title of the Experiment</b>  |
|---|
| <ul style="list-style-type: none"> <li>Low density plastic/bioplastic or para nitrophenol degradation using bacterial isolates</li> </ul> |
| <ul style="list-style-type: none"> <li>Detection, isolation and characterization of PHB granules in bacteria</li> </ul>                   |
| <ul style="list-style-type: none"> <li>Isolation of Biodiesel production using micro-algae</li> </ul>                                     |
| <ul style="list-style-type: none"> <li>Isolation and characterization of bio-emulsifier producing organism</li> </ul>                     |
| <ul style="list-style-type: none"> <li>Isolation of pesticide degrading bacteria</li> </ul>   |
| <ul style="list-style-type: none"> <li>Biosorption of Dyes using microbial biomass (living/dead)</li> </ul>                               |
| <ul style="list-style-type: none"> <li>Isolation and characterization of sulfate reducing bacteria</li> </ul>                             |

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| <b>Semester –III</b>           | <b>Paper –IX</b>                                  |
| <b>Course Code: MSC-MR319T</b> | <b>Title of the Course: Clinical Microbiology</b> |
| <b>Credits: 02</b>             | <b>Total Lectures : 30 Hrs.</b>                   |

### Course Outcomes (COs):

- Students will learn about the determinants of microbial pathogenicity.
- Students will learn different Disease Prediction Epidemiological Models.
- Students will acquire knowledge about epidemiological and investigational approaches for emerging infectious diseases.

### Detailed Syllabus:

| <b>Unit No.</b> | <b>Topics</b>   | <b>No. of hours</b> |
|-----------------|---|---------------------|
| <b>Unit 1</b>   | <p><b>1. Microbial Pathogenicity</b></p> <p>A. Determinants of pathogenicity-Adhesion, Invasion, Evasion, Toxigenesis ( mode of action –In vivo and In vitro assay systems for diphtheria, cholera, tetanus toxoid and endotoxins of Gram negative bacteria)</p> <p>B. Bacterial resistance to host defenses -Phagocytosis, specific and nonspecific humoral factors)</p> <p>C. Molecular basis of bacterial pathogenicity –Cytoskeletal modulation of host cell. Virulence genes and pathogenicity islands.</p> <p><b>2. Disease Prediction Epidemiological Models:</b></p> <p>A. Introduction to epidemiological modeling for infectious disease dynamics</p> <p>B. Types of Models: SIR model, SEIR model, SIS model</p> | 15                  |

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| <b>Unit 2</b> | <p><b>Epidemiological and investigational approaches for emerging infectious diseases:</b></p> <p>A. Viral diseases: SARS (severe acute respiratory syndrome), Avian and Swine influenza</p> <p>B. Diseases by multi-drug resistant bacterial pathogens:<br/>Mechanisms of development of drug resistance<br/>Vancomycin resistant Enterococci (VRE),<br/>Methicillin resistant Staphylococcus aureus (MRSA),<br/>Vancomycin resistant Staphylococcus aureus (VRSA)<br/>Extended Spectrum Beta Lactamase (ESBL) producers</p> <p>C. Microorganisms as weapons in biological warfare:<br/>Examples and significance of microorganisms as weapons - anti-personnel, anti-agricultural and entomological warfare. Offensive and defensive strategies, Tactical advantages</p> | 15 |
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### Suggested Readings:

1. Gal-Mor B. and Finlay B. B. (2006) Pathogenicity islands: a molecular toolbox for bacterial virulence. Cellular Microbiology. 8 (11): 1707-1719.
2. Iglewski B. H. (1990) Molecular Basis of Bacterial Pathogenesis, first edition, Academic Press: United States.
3. Kudva I. T., Cornick N. A., Plummer P. J., Zhang Q., T. L., Bannantine J.P. and Bellaire B. H. (2016) Virulence Mechanisms of Bacterial Pathogens. Fifth Edition, ASM: Washington.
4. Peterson J. W. (1996) Bacterial Pathogenesis In: Medical Microbiology, 4th Edition. Editor by Samuel Baron, Galveston, Texas.
5. Rosenberg E. (2005) The diversity of bacterial pathogenicity mechanisms. Genome Biol.6(5):320.
6. Schmidt H. and Hensel M. (2004) Pathogenicity islands in bacterial pathogenesis.

- Clin Microbiol Rev. 17(1):14-56.
7. Hethcote H. W. (1989) The basic epidemiology models: models, expressions for  $r_0$ , parameter estimation, and applications mathematical understanding of infectious disease dynamics. © World Scientific Publishing Co. Pte. Ltd. 1-61.
  8. Li L., Yang Z., Dang Z., *et al.* (2020), Propagation analysis and prediction of the COVID-19. Infect Dis Model, 5: 282-292.
  9. Siettos C.I. and Russo L. (2013) Mathematical modeling of infectious disease dynamics. Virulence. 4(4):295-306.
  10. Wearing H.J., Rohani P. and Keeling M.J. (2005) Appropriate models for the management of infectious diseases. PLoS Med 2(7): e174
  11. Carpenter Philip L., (1975), Saunders International Edition - Immunology and Serology, W. B. Saunders and Co., London.
  12. David N. Fredricks and David A. Relman, (1996), Sequence-Based Identification of Microbial Pathogens: a Reconsideration of Koch's Postulates, Clinical Microbiology Reviews, 18–33.
  13. Eduardo A. Groisman and Howard Ochman, (1994), How to become a pathogen, Trends in Microbiology, 2 (8):289-294.
  14. Franklin T. J. and Snow G. A., (1975), Biochemistry of Antimicrobial Action, Chapman and Hall, London, 1-22 and 160- 174.

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| <b>Semester –IV</b>            | <b>Paper –I</b>  |
| <b>Course Code: MSC-MR411T</b> | <b>Title of the Course: Drug Discovery and Development</b> |
| <b>Credits: 04</b>             | <b>Total Lectures : 60 Hrs.</b>                            |

### Course Outcomes (COs):

- Students will understand the basics of drug discovery process.
- Various phases of drug development like lead optimization, safety profile will be introduced to students.
- Students will learn pharmacokinetic aspects of drug and susceptibility tests in detail

### Detailed Syllabus:

| <b>Unit No.</b> | <b>Topic</b>   | <b>No.of hours</b> |
|-----------------|--|--------------------|
| <b>Unit 1</b>   | <b>Drug Discovery</b><br>A. Historical perspectives, significance of medicinal chemistry<br>B. Bioprospecting, Principles of Extraction, Rational Drug design, receptor / target concept in drug designing (Hits and lead compounds), Introduction to pharmacogenomics, Combinatorial chemistry, High Throughput Screening<br>C. Classification of drugs based on therapeutic classes, target, mechanism of action, chemistry, etc | 15                 |
| <b>Unit 2</b>   | <b>Drug development</b><br>A. Lead optimization: lead likeness, drug likeness<br>B. Safety profile of drugs: pyrogenicity testing, mutagenicity carcinogenicity testing, teratogenicity testing.   | 15                 |

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|               | <p>C. Clinical development: Clinical trials (aims, objectives and conduct). Clinical trials I, II, III and IV- Objectives, Conduct of trials, Outcome of trials</p> <p>D. Introduction to FDA, IP, USP, and BP</p>   |    |
| <b>Unit 3</b> | <p><b>Pharmacokinetics</b></p> <p>A. Passage of molecules through biological barriers. Membrane transport (paracellular, transcellular).</p> <p>B. Drug absorption:</p> <p>C. Drug dosages, from gastric emptying to gastric permeability to drug, first pass effect, bioavailability.</p> <p>D. Drug distribution:</p> <p>E. Drug-plasma/ serum binding, blood brain barrier, accumulations in tissues.</p> <p>F. Drug elimination Drug excretion, Drug biotransformation, Biotransformation reactions, Functionalization, Conjugation reaction, Reactions leading to toxic metabolites</p> | 10 |
| <b>Unit 4</b> | <p><b>Drug study and susceptibility tests</b></p> <p><b>1. Drug:</b> Drug formulation, Drug interactions, drug delivery system, routes of administration of drug, Factors modifying drug dose and response</p> <p><b>2. Susceptibility testing</b></p> <p>A. Introduction to Clinical Laboratory Standards Institute (CLSI)</p> <p>B. CLSI guidelines for susceptibility tests, Factors affecting susceptibility testing,</p> <p>C. Agar dilution technique, gradient plate techniques, E-test, Kirby Bauer, Stokes method</p>   | 20 |



**Suggested Readings:**

1. Agarwal S. S. and Paridhavi M. (2007) Herbal drug technology. Universities Press (India) Pvt. Ltd.
2. Altreuter D. and Clark D. S. (1999) Combinatorial Biocatalysis: Taking the Lead From Nature. *Curr. Opin. Biotechnol.* 10: 130-136.
3. Bentley's Textbook of Pharmaceutics, Ed. E. A. Rawlins, 8th Ed. (2002) Bailliere Tindall, London.
4. Burn J. H. (1957) Principles of Therapeutics. Blackwell Scientific Pub. O. Ltd. Oxford.
5. Chatwal G. P. (2003) Bio-pharmaceutics and Pharmacokinetics. Himalaya Publishing House, Mumbai.
6. Committee for the Purpose of Control and Supervision on Experiments on Animals (CPCSEA). [www.cpcsea.com](http://www.cpcsea.com)
7. Dewick P. M. (2002). Medicinal natural products: A biosynthetic approach, 2nd Ed., John Wiley and Sons
8. Erhardt P. W. (2006) Medicinal Chemistry in the New Millennium: A Glance into the Future, Ed. Chorghade M. S. in Drug discovery and Development Volume I: Drug Discovery. Wiley-Interscience, John Wiley and Sons Inc. USA. 17-102.
9. Gale E. F., Cundliffe E., Reynolds P. E., Richmond M. H. and Waring M. J. (1972) The molecular basis of antibiotic action. John Wiley and Sons. London
10. Goldstein A., Aronow L., and Kalman S. M. (1969) Principles of Drug Action. The Basis of Pharmacology. Harper international edition New York.
11. Graly J. O. and Joubert P.H. (1997) Handbook of Phase I /II clinical drug trials, CRC Press
12. Gund R.S., Yeole P.G., Yadav A.V., Gokhle S.B. A Text Book of Pharmaceutics, Nirali prakashan.
13. Iyengar M. A. (1993) Pharmacology of Powdered Crude Drugs. Iyengar

14. Lorian V. (1986) Antibiotics in laboratory medicine. 2nd Ed. Williams & Wilkins Publication
15. National Committee for Clinical Laboratory Standards (now Clinical and Laboratory Standards Institute, CLSI). NCCLS: 1997. Methods for dilution antimicrobial susceptibility testing for bacteria that grows aerobically. Approved Standards M7-A4. Villanova, PA:
16. National Committee for Clinical Laboratory Standards (now Clinical and Laboratory Standards Institute, CLSI). NCCLS: 2002. Performance standards for antimicrobial susceptibility testing; 12th information supplement (M100-S1). Villanova, PA;
17. Seth S.D, Seth Vimlesh, Text book of Pharmacology. Elsevier, 3<sup>rd</sup> edition.

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| <b>Semester –IV</b>            | <b>Paper –II</b>                                 |
| <b>Course Code: MSC-MR412T</b> | <b>Title of the Course: Microbial Technology</b> |
| <b>Credits: 04</b>             | <b>Total Lectures : 60 Hrs.</b>                  |

### Course Outcomes (COs):

- Students will understand the design and operation of CSTR, Air lift and immobilized cell bioreactors, operational modes of fermentation and kinetics of growth and product formation
- Students will learn about the different process variables and the large scale production of different fermentation products
- Students will learn the validation process.

### Detailed Syllabus:

| <b>Unit No.</b> | <b>Topics</b>   | <b>No. of hours</b> |
|-----------------|---|---------------------|
| <b>Unit 1</b>   | <p><b>Bioreactor design and operation</b></p> <p>A. Practical Considerations For Bioreactor Construction</p> <p>B. Designing of bioreactors:</p> <ol style="list-style-type: none"> <li>Design aspects of CSTRs: The dimensional ratios of the outer shell, and the operational aspects such as working volume, baffles, Different types of impellers and spargers</li> </ol> <p>C. Immobilized cell reactors and air-lift reactors– Design and operation.</p> <p>D. Batch, Fed-batch and Continuous operation: Applications, advantages and limitations of each type.</p> <p>E. Kinetics of growth and product formation of batch fermentation (growth rate, yield coefficient, efficiency etc.)</p> | 15                  |

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| <p><b>Unit 2</b></p> | <p><b>Process Variables and Monitoring</b></p> <p><b>A. Process Variables:</b></p> <p>i. Aeration: Theory of oxygen transfer in bubble aeration, Oxygen transfer kinetics (Oxygen Uptake Rate –OUR; Oxygen Transfer Rate OTR; Ccrit), determination of KLa.</p> <p>ii. Agitation: Functions of agitation, Flow patterns with different types of impellers.</p> <p>a) Fermentation broth rheology and power requirements for agitation – Concept of Newtonian and non-Newtonian fluids</p> <p>b) Factors affecting broth rheology</p> <p>c) Power requirement for mixing, Reynold’s number, Power number, Flow regimes in fermentation tank (Laminar, turbulent and transition), Aeration number: working out examples using different software.</p> <p><b>B. Monitoring of process variables:</b></p> <p>i. Use of various types of sensors and biosensors for monitoring environmental parameters (pressure, pH, temperature, DO and DCO<sub>2</sub>)</p> <p>Basic principles of operation, types of biosensors</p> | <p>15</p> |
| <p><b>Unit 3</b></p> | <p><b>Microbial Fermentation Processes:</b></p> <p>A. Upstream, Fermentation and Downstream Processing for the following:</p> <p>a) Antibiotics (Rifamycin)</p> <p>b) Microbial enzymes (Chitinase).</p> <p>c) Exopolysaccharides (Pullulan)</p> <p>d) Recombinant product( Hepatitis B vaccine)</p> <p>e) Food products ( soy sauce)</p> <p>B. Use of fungi in agriculture and environmental applications</p>   | <p>15</p> |

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| <b>Unit 4</b> | <p><b>Validation Process:</b></p> <p>A. Quality Control (QC) and Quality assurance(QA) : Roles and responsibilities of QC and QA departments, Common Quality control tests</p> <p>B. Validation protocols for methods in:</p> <p>a) Quality Control</p> <p>b) Process validation</p> <p>c) Preparation of SOPs</p> <p>d) The concept of ISO Certification.</p> <p><i>The above should be discussed within WHO Norms. Exercises on preparation of SOPs, operation and validation for analytical methods</i></p> | 15 |
|---------------|--|----|

### Suggested Readings:

1. Bioreactor Design and Product Yield (1992), BIOTOL series, Butterworths Heinemann.
2. Doran P. M. (1995) Bioprocess Engineering Principles. Imprint-Academic Press. Copyright-Elsevier.
3. Lydersen B. K., D'Elia N. A. and Nelson K. M. (Eds.) (1993) Bioprocess Engineering: Systems, Equipment and Facilities. JohnWiley and Sons Inc.
4. Maiti B. R. (2018) Principles of Bioreactor Design. Publisher: Viva books
5. McDuffie N. G.(1991) Bioreactor Design Fundamentals 1st Edition, Elsevier: eBook ISBN: 9781483221083
6. Ratledge C. and Kristiansen B. eds. (2001) Basic Biotechnology. 2nd Ed. Cambridge Univ. Press. Cambridge
7. Singh L., Mahapatra D. and Yousuf A. (2019). Bioreactors: Sustainable Design and Industrial Applications in mitigation of GHG emissions. Elsevier. ISBN- 0128212640, 9780128212646
8. Aiba S., Humphrey A. E. and Millis N. F. (1982). Biochemical Engineering. Second Edition. Academic Press.

9. Larroche C., Sanroman M., Du G. and Pandey A. (Editors). (2016) Current Developments in Biotechnology and Bioengineering: Bioprocesses, Bioreactors and Controls. Publisher-Elsevier, ISBN 0444636749, E- Book- 9780444636744
10. Operational Modes of Bioreactors (1992) BIOTOL series, Butter worths – Heinemann.
11. Stanbury P., Whitaker A. and Hall S. (2016) Principles of Fermentation Technology. 3rd Edition Imprint: Butterworth-Heinemann
12. Arora D. K. (2005) Fungal Biotechnology in Agricultural, Food and Environmental Applications (Mycology), Marcel Dekker, Inc. New York. Basel
13. Klegerman M. E. and Groves M. J. (1992) Pharmaceutical Biotechnology: Fundamentals and Essentials. Interpharm Press Ltd. Buffalo Grove, Illinois
14. Meshram S. U. and Shinde G. B. (2009) Applied Biotechnology. I.K. International Pvt. Ltd.
15. Peppler H. J. and Perlman D. (1970) Microbial Technology Volume 1 and 2, Academic Press, New York.
16. Reed G. Ed. Prescott and Dunn's Industrial Microbiology. 4th Ed., CBS Pub. New Delhi.
17. Calnan N., Redmond A. and O'Neill S. (2009). The FDA's draft process validation Guidance A perspective from industry. Process Validation Guidance. Pharmaceutical Engineering. GMP Publishing. 7(4): 1-17
18. Supplementary Training Modules on Good Manufacturing Practice. Validation WHO Technical Report Series, No.937, 2006, Annex 4

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| <b>Semester –IV</b>            | <b>Paper –III</b>                             |
| <b>Course Code: MSC-MR413T</b> | <b>Title of the Course: Advanced Virology</b> |
| <b>Credits: 02</b>             | <b>Total Lectures : 30 Hrs.</b>               |

### Course Outcomes (COs):

- Students will learn about the Viral Therapeutics including vaccines ,Antivirals,
- Students will learn diagnostic and detection methods for viruses
- Students will learn about the Antiretroviral and Modern approaches of virus control

### Detailed Syllabus:

| <b>Unit No.</b> | <b>Topics</b>   | <b>No. of hours</b> |
|-----------------|---|---------------------|
| <b>Unit 1</b>   | <p><b>Viral Therapeutics</b></p> <p>A. Viral Vaccines</p> <p>Conventional vaccines: Killed and attenuated</p> <p>Modern vaccines: Concepts and examples (DNA vaccines, Recombinant DNA/protein vaccines, Subunits vaccines, Peptide vaccines, Anti-idiotypic vaccines, Edible vaccines, Vaccine formulations and delivery: Adjuvants, immunomodulators, cytokines)</p> <p>B. Antivirals</p> <p>Designing and screening, Mechanism of action (e.g. Nucleoside analogues, Nucleotide analogues, Antisense, Topical immune modulator, neuraminidase inhibitors, Ion channel function inhibitors of M2 proteins, Pyrimidines)</p> <p>Antiretrovirals, Mechanism of action, Mechanism of resistance, Modern approaches of virus control, Small</p> | 15                  |

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|               | interfering RNA (siRNA), Ribozymes  |    |
| <b>Unit 2</b> | <b>Diagnostic and detection methods for viruses:</b><br>A. Sampling techniques and Processing of samples<br>B. Direct methods of detection – Light microscopy (inclusion<br>C. bodies), Electron microscopy and Fluorescence<br>microscopy<br>D. Immunodiagnosis, Hemagglutination and<br>Hemagglutination inhibition tests, Complement fixation,<br>Neutralization, Western blot, Radioactive Immuno<br>Precipitation Assay (RIPA), Flow Cytometry and<br>Immunohistochemistry<br>E. Nucleic acid based diagnosis: Nucleic acid hybridization,<br>Polymerase Chain Reaction (PCR), Microarray and<br>Nucleotide sequencing, LINE probe assay<br>F. Infectivity assay for animal and bacterial viruses - Plaque<br>method, Pock counting, End point methods, LD50, ID50,<br>EID50, TCID50<br>G. Infectivity assays of plant viruses | 15 |

### Suggested Readings:

1. Clercq E. (2004) Antivirals and antiviral strategies, Nature Reviews, 2, 704 – 720.
2. Clerq E. (2011) A 40- year journey in search of selective antiviral chemotherapy, Annual Review of Pharmacology and Toxicology, 51, 1 - 24.
3. Colmon M. P. ( 2009) New New antivirals and drug resistance, Annual Review of Biochemistry, 78, 95 – 118.
4. Flint S. J., V. R. Racaniello, L. W. Enquist, V. R. Rancaniello, A. M. Skalka, (2003), Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses, American Society Microbiology.



5. Idrees S. and Ashfaq U. A. (2013) RNAi: Antiviral therapy against dengue virus, Asian Pacific Journal of Tropical Biomedicine, 3(3), 232 – 236.
6. Jarczak D., Korf M., Beger C., Manns M. P. and Kruger M. (2005) Hairpin ribozymes in combination with siRNAs against highly conserved hepatitis C virus sequence inhibit RNA replication and protein translation from hepatitis C virus subgenomic replicons, FEBS Journal, 272, 5910 – 5922.
7. Knipe David M., Peter M. Howley, Diane E. Griffin, Robert A. Lamb, Malcolm A. Martin, Bernard Roizman, Stephen E. Straus, (2007), Field's Virology, 5th Ed. Lippincott Williams & Wilkins.
8. Tying S. K. (2005), Antiviral Agents, Vaccines, and Immunotherapies, Marcel Dekker/CRC Press.
9. Agrios G (2005) Plant Pathology, 5th Ed., Elsevier Academic Press. Hull R (2002) Matthew's Plant Virology, 4<sup>th</sup> Ed., Academic Press.
10. Gibbs Adrian & Bryan Harrison ( ) Plant Virology –The Principles. Edward Arnold Press.
11. Hull R (2009) Comparative Plant Virology, 2nd Ed., Elsevier Academic Press.
12. Khan J. A. and J. Dijkstra (2002) Plant Viruses as Molecular Pathogens, Food Products Press. unotherapies, Marcel Dekker/CRC Press.
13. Mahy B. WJ. And Kangro H.O., (1996), Virology Methods Manual, Academic Press.
14. Shors T. (2011), Understanding Viruses, 2nd Ed., Jones & Bartlett Publishers LLC, Canada.
15. Stephenson J. R. and Warnes A., (1998), Diagnostic Virology Protocols: Methods in Molecular Medicine, Humana Press.
16. Wiedbrauk D. L. and Farkas D.H., (1995) Molecular Methods For Virus Detectin, Academic Press.

| Semester-IV             | Paper -IV   |
|-------------------------|---|
| Course Code: MSC-MR414P | Title of the Course: Practical course based on Drug Discovery and Development |
| Credits: 02             | Total Lectures : 60 Hrs.  |

### Course Outcomes (COs):

- Students will learn to perform Bioassay of antibiotics, E test.
- Students will be able to isolate antibiotic producing fungi, extraction of bioactive principles from plant, antimicrobial activity.
- Students will be able to carry out sterility test according to IP

### Detailed Syllabus:

| Title of the Experiment  |
|--|
| <ul style="list-style-type: none"> <li>Bioassay of antibiotic or growth factor</li> </ul>  |
| <ul style="list-style-type: none"> <li>Isolation and identification of antifungal-antibiotic producing bacteria</li> </ul>   |
| <ul style="list-style-type: none"> <li>Determination of an antibiotic MIC using E test</li> </ul>  |
| <ul style="list-style-type: none"> <li>Detection and isolation of anti-infective from plant               <ol style="list-style-type: none"> <li>Extraction of bioactive principles from plant and activity fractionation</li> <li>Estimation of its antimicrobial activity using standard guidelines (CLSI)</li> </ol> </li> </ul>  |
| <ul style="list-style-type: none"> <li>Sterility testing of following pharmaceutical preparations as per IP:<br/>Antipyretic / Antibiotic tablets/ Liquid preparation (Saline/ Water for injection)</li> </ul>   |
| <p>Common Microbiological Tests used in different Industries</p> <ul style="list-style-type: none"> <li>Growth Promotion test</li> <li>Bioburden test (Membrane filtration Techniques)</li> <li>Bacterial Endotoxin Test</li> <li>Pathogen testing (Pharmacopeial microorganism) – <i>E.coli</i>, <i>S. aureus</i>, <i>Pseudomonas aeruginosa</i>, <i>Salmonella</i>.</li> </ul> |

| Semester –IV            | Paper –V  |
|-------------------------|---|
| Course Code: MSC-MR415P | Title of the Course: Practical course based on Microbial Technology |
| Credits: 02             | Total Lectures : 60 Hrs.  |

### Course Outcomes (COs):

- Students will be able to perform bioconversion using immobilized cell system and check effect of cell and gel concentration on bioconversion.
- Students will be able to carry out lab scale production of antibiotic/enzymes /exopolysaccharide by submerged and medium optimization.
- Students will be able to carry out lab scale production ,purification and detection of organic acid/enzyme by solid state fermentation process.

### Detailed Syllabus:

| Title of the Experiment  |
|--|
| <ul style="list-style-type: none"> <li>Bioconversions using immobilized systems (cells / enzyme)</li> </ul>  |
| Parameter testing: <ul style="list-style-type: none"> <li>Effect of gel concentration</li> <li>Effect of cell / enzyme concentration</li> </ul>                  |
| <ul style="list-style-type: none"> <li>Laboratory scale production and media optimization for: Microbial exopolysaccharide production</li> </ul>                 |
| <ul style="list-style-type: none"> <li>Optimization of medium for laboratory scale production of enzyme/antibiotics by submerged fermentation process</li> </ul> |
| <ul style="list-style-type: none"> <li>Laboratory scale production ,purification and detection of organic acid/enzyme by solid state fermentation</li> </ul>     |
| <ul style="list-style-type: none"> <li>Visit to fermentation industry</li> </ul>   |

|                                |  |
|--------------------------------|--|
| <b>Semester –IV</b>            | <b>Paper –VI</b>   |
| <b>Course Code: MSC-MR416P</b> | <b>Title of the Course: Practical course based on Virology</b> |
| <b>Credits: 02</b>             | <b>Total Lectures : 60 Hrs.</b>                                |

### Course Outcomes (COs):

- Students will be able to perform the methods for virus cultivation and detection.
- Students will be able to perform detection and quantification of bacteriophages and understand one step growth curve.
- Students will be able to perform the infectivity assay of plant viruses and prepare herbaria of plants infected with plant virus.

### Detailed Syllabus:

| <b>Title of the Experiment</b>  |
|---|
| <ul style="list-style-type: none"> <li>Egg inoculation technique for virus cultivation by various routes - embryo, yolk sac, allantoic fluid, amniotic cavity, chorioallantoic membrane.</li> </ul>   |
| <ul style="list-style-type: none"> <li>Animal virus titration by Hemagglutination technique</li> </ul>  |
| <ul style="list-style-type: none"> <li>Confocal Microscopy demonstration / Analysis of confocal images</li> </ul>   |
| <ul style="list-style-type: none"> <li>Qualitative and quantitative detection of bacteriophage</li> <li>One step growth curve of bacteriophage               <ol style="list-style-type: none"> <li>Preparation of plantlets from seeds of indicator plant,</li> <li>leaf infection and infectivity assay for plant mosaic viruses</li> </ol> </li> </ul> |
| <ul style="list-style-type: none"> <li>Study of plant virus diseases: Collecting data and samples (preparation of herbaria)</li> </ul>  |
| <ul style="list-style-type: none"> <li>Chloroplast agglutination test</li> </ul>  |

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|-----------------------------------|---|
| <b>Semester –IV</b>               | <b>Paper - VII</b>  |
| <b>Course Code: MSC-MR417T(A)</b> | <b>Title of the Course: Bioethics, Biosafety, Quality Control and Quality Assurance</b> |
| <b>Credits: 02</b>                | <b>Total Lectures : 30 Hrs.</b>   |

### Course Outcomes (COs):

- Students will understand importance of biosafety practices and guidelines.
- Students will understand concept of bioethics.
- Students will gain knowledge about quality control and quality assurance.

### Detailed Syllabus:

| <b>Unit No.</b> | <b>Topics</b>   | <b>No. of hours</b> |
|-----------------|---|---------------------|
| <b>Unit 1</b>   | <p><b>Bioethics and Biosafety</b></p> <p>A. Bioethics</p> <ol style="list-style-type: none"> <li>Concept of ethics and bioethics with respect to microbiological research</li> <li>Principles of bioethics.</li> <li>Ethical conflicts in microbiological and biotechnological research</li> <li>Biological Diversity Act: onservation of biological diversity, sustainable use of its components and fair and equitable sharing of the benefits arising out of utilization of genetic resources</li> </ol> <p>B. Biosafety</p> <ol style="list-style-type: none"> <li>Regulatory bodies (Role and functions)</li> <li>Advisory Committee: Recombinant DNA Advisory Committee (RDAC)</li> </ol> <p>C. Regulatory / Approval Committees:</p> | 15                  |

|               |   |    |
|---------------|---|----|
|               | <ul style="list-style-type: none"> <li>a) Genetic Engineering Appraisal Committee (GEAC)</li> <li>b) Review Committee on Genetic Manipulation (RCGM)</li> <li>c) SIRO (DSIR)</li> <li>d) Institutional Biosafety Committee (IBSC):</li> </ul> <p>D. Importance of Biosafety Institutional Biosafety Committees (IBSCs), Laboratory associated infections and hazards Bio safety regulation: handling of recombinant DNA products and process in industry and in institutions</p> <p>E. Monitoring Committees: State Biotechnology Coordination Committee (SBCC)</p>   |    |
| <b>Unit 2</b> | <p><b>Quality Control and Quality Assurance</b></p> <ul style="list-style-type: none"> <li>A. Quality Control: <ul style="list-style-type: none"> <li>Assessment of suitability of components and products</li> <li>Evaluation of the performance of the manufacturing process</li> </ul> </li> <li>B. Quality Assurance <ul style="list-style-type: none"> <li>reviewing and approval of procedures, reviewing records and performing audits</li> </ul> </li> <li>C. Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP)</li> <li>D. Regulatory bodies (Role and functions): <ul style="list-style-type: none"> <li>a) The Central Drugs Standard Control Organization (CDSCO)</li> <li>b) National Accreditation Board for Testing and Calibration Laboratories (NABL)</li> <li>c) Food Safety and Standards Authority of India (FSSAI): Food and water Laboratories</li> <li>d) International Standard ISO/IEC 17025:2017(E).</li> <li>e) Bureau of Indian Standards -IS 14648 (2011):</li> </ul> </li> </ul> | 15 |

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|--|---|--|
|  | <p>Methods of Test for Microbiological Examination of Industrial Product (examples Cosmetics And Cosmetic Raw Materials)</p> <p>f) The Central Pollution Control Board (CPCB)- Prevention and control of water and air pollution and improvement of the quality of air.</p> |  |
|--|---|--|

### Suggested Readings:

1. Biotechnology: A comprehensive treatise (Vol. 12). Legal economic and ethical dimensions VCH. (2nded) ISBN- 10 3527304320. 2. Encyclopedia of Bioethics 5 vol set, (2003) ISBN- 10: 0028657748.
2. Draft Manual on method of microbiological testing (2016) microbiology of foods. Food safety and Food Standards.
3. Eleftheriadou M. and Tsimillis K. C. (Eds), Eurachem guide: Accreditation for Microbiological Laboratories, Second edition (2013), ISBN: 978-91-87017-92-6.
4. <http://www.electropedia.org/>
5. <https://archive.fssai.gov.in/home/food-testing/food-testing- manual.html>.
6. <https://cdsco.gov.in/opencms/opencms/en/About-us/Functions/>
7. <https://cdsco.gov.in/opencms/opencms/en/Home/>
8. <https://cpcb.nic.in/functions/>
9. <https://www.iso.org/obp>
10. International Standard ISO/IEC 17025:2017(E). General requirements for the competence of testing and calibration Laboratories. Third edition. 2017-11
11. IS 14648 (2011): Methods of Test for Microbiological Examination of Cosmetics And Cosmetic Raw Materials. Available at:
12. Manual for Good Food Laboratory Practices (GFLPs). 2018. Food Safety and Standards Authority of India (FSSAI), Ministry Of Health and Family Welfare Government Of India, New Delhi
13. Manual of Methods for Analysis of Water 2016. Food Safety and Standards Authority of

- India (FSSAI), Ministry Of Health and Family Welfare Government of India, New Delhi
14. Ministry of Law And Justice (Legislative Department) New Delhi, the 5th February 2003/Magha 16, 1924 (Saka) published for general information: The Biological Diversity Act, 2002 No. 18 of 2003 [5th February, 2003].
15. National Accreditation Board for Testing and Calibration.
16. Notification from Department of Biotechnology, Ministry of Science and Technology, India. (2020) Revised simplified procedures/guidelines on Import, Export and Exchange of GE organisms and product thereof for R& D purpose. File no. BT/BS/17/635/2015-PID. dated-17/01/2020 <https://ibkp.dbtindia.gov.in/>
17. Thomas, J.A., Fuch, R.L. (2002). Biotechnology and safety Assessment (3rd Ed) Academic press.



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|-----------------------------------|--|
| <b>Semester –IV</b>               | <b>Paper –VII</b>                              |
| <b>Course Code: MSC-MR417T(B)</b> | <b>Title of the Course: Scientific Writing</b> |
| <b>Credits: 02</b>                | <b>Total Lectures : 30 Hrs.</b>                |

### Course Outcomes (COs):

- Students will learn presentation skills, power point presentation, poster preparation.
- Students will gain the knowledge about formats of scientific reports, copy rights, plagiarism.
- Students will able design research experiment.

### Detailed Syllabus:

| <b>Unit No.</b> | <b>Topics</b>  | <b>Allotted hours</b> |
|-----------------|--|-----------------------|
| <b>Unit 1</b>   | <p><b>Introduction of Research Methodology:</b></p> <p>A. Meaning of research, objectives of research, types of research, significance of research.</p> <p>B. Research Design: Meaning, need and features of good research design, types of research designs, -, Descriptive Research Design - concept, types and uses. Experimental Design - Concept of Independent &amp; Dependent variables. Biased and unbiased research design Qualitative and Quantitative Research: Qualitative - Quantitative Research - Concept of measurement.</p> <p>C. Problem Identification &amp; Formulation: definition and formulating the research problem, Necessity of defining the problem, Importance of literature review in defining a problem. Literature survey: primary and secondary; web sources; critical literature review.</p> | 15                    |

|               |   |    |
|---------------|---|----|
| <b>Unit 2</b> | <p><b>Scientific Communication</b></p> <p>A. Concept of effective communication: Presentation skills, formal scientific presentation skills; Preparing power point presentation, Presenting the work, Scientific poster preparation &amp; presentation; Participating in group discussions.</p> <p>B. Technical writing skills: Types, Formats of scientific reports, scientific writing skills, Significance of communicating science, ethical issues, Copy rights and plagiarism, Components of a research paper, publishing scientific papers - peer review process and problems.</p> <p>C. Use of search engines for scientific data mining, Use of reference management tools, statistical data analysis using software.</p> | 15 |
|---------------|---|----|

### Suggested Readings:

1. Anthony M. Graziano A. M. And Raulin M. L., 2009. Research Methods: A Process Of Inquiry Allyn And Bacon.
2. Coley S. M., and Scheinberg C.A., 1990, "Proposal Writing", Sage Publications
3. Fink A., 2009. Conduction Research Literature Reviews: From the Internet to Paper. Sage Publications.
4. Garg, B. L.Karadia R. Agrawal, F. and Agrawal U. K., 2002. An Introduction to Research Methodology, RBSA Publishers.
5. How to Write and publish a Research Paper- Seventh Edition-Robert Day And Barbara Gastle.
6. Kothati C. R.,1990. Research Methodology: Methods And Techniques New Age International 418p.
7. Leedy, P. D. and Ormrod J. E., 2004 Practical Research: Planning and Design, Prentice Hall.

8. Practical Research Methodology-Catherine Dawson.
9. Research Methodology and Scientific Writings- C George Thomas.
10. Research Methodology: A Step By Step Guide for beginners- Ranjeet Kumar.
11. Research Methodology: An Introduction-Stuart Melville and Wayne.
12. Research Methodology: Principle, Methods and Practices-Joshua O.Miluwi and Hina Rashid.
13. Research Methodology-C R Kothari.
14. Research Methods for Science Michael P Marder.
15. Sinha S. C. and Dhiman A. K., 2002. Research Methodology Ess Ess Publications 2 Columes.
16. Trochim W. M. K., 2005. Research Methods: The Concise Knowledge Base Atomic Dog Publishing. 270P.
17. Wadehra B. L., 2000. Law Relating to Patents, Trade Marks, Copyright Design and Geographical Indications, Universal Law Publishing.

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|-----------------------------------|---|
| <b>Semester –IV</b>               | <b>Paper -VIII</b>  |
| <b>Course Code: MSC-MR418P(A)</b> | <b>Title of the Course: Practical course based on Bioethics, Biosafety, Quality Control and Quality Assurance</b> |
| <b>Credits: 02</b>                | <b>Total Lectures : 60 Hrs.</b>   |

### Course Outcomes (COs):

- Students will be able to calibrate different instruments.
- Students will be able to perform microbial analysis according to FSSAI
- Students will understand the methods of plate count for different bacteria according to FSSAI

### Detailed Syllabus:

| <b>Title of the Experiment</b>   |
|--|
| <p><b>NABL norms for Calibration of:</b></p> <ul style="list-style-type: none"> <li>Autoclave- Calibration of pressure gauge and temperature by thermal mapping, sterility testing, SOP preparation.</li> <li>Laminar Air Flow- checking the functioning of UV light by colony count method and sterility checking by blood agar media plate method, SOP preparation.</li> </ul> |
| <p><b>Food Safety and Standards Authority of India (FSSAI)</b></p> <p><b>Regulations Test Methods for Drinking Water</b></p> <ul style="list-style-type: none"> <li>Detection of sulphite-reducing anaerobes (Clostridia)</li> <li>Detection of viruses</li> </ul>   |
| <p><b>Food Safety and Standards Authority of India (FSSAI) Regulations Test Methods for Water/butter/cheese/milk product for Processed Food Industry:</b></p> <p>(perform any two)</p> <ul style="list-style-type: none"> <li>Proteolytic Plate Count</li> </ul>   |

- Lipolytic Plate Count
- Thermophilic Bacterial Count (for Dairy Industry-Processing)
- Slime Forming Bacteria (for Dairy industry-Hot water)

**Food Safety and Standards Authority of India (FSSAI) Regulations for Microbiological Testing of food:**

- Detection and Confirmation of *Listeria monocytogenes* in Foods
- Fermentation Test (Incubation test for Cans, Tetrapacks, Standby pouches).

|                                   |  |
|-----------------------------------|--|
| <b>Semester –IV</b>               | <b>Paper -VIII</b>   |
| <b>Course Code: MSC-MR418P(B)</b> | <b>Title of the Course: Practical course based on Scientific Writing</b> |
| <b>Credits: 02</b>                | <b>Total Lectures : 60 Hrs.</b>  |

### Course Outcomes (COs):

- Student will be able to write literature review, plant experiment, represent data.
- Students will learn formats of progress reports and synopsis.
- Students will learn dissertation techniques.

### Detailed Syllabus:

| <b>Title of the Experiment</b>   |
|--|
| <p><b>Scientific communication</b></p> <ul style="list-style-type: none"> <li>Literature review (and choosing a suitable topic)</li> <li>Experiment planning</li> <li>Experimentation, with the use of contemporary methods and standard protocols</li> <li>Representation of and calculations for data obtained</li> <li>Interpretation of data with the use of statistical tools (if required)</li> <li>Writing progress reports / synopsis / abstract of the work done (as applicable).</li> <li>Writing a pedagogical (academic) article on a scientific theme (Review).</li> <li>Writing a Masters' thesis/Writing a review article</li> <li>Oral presentation: Critically commenting on a manuscript (Research Paper / Article).</li> <li>Presenting the thesis in an 'Open Defense'</li> <li>Preparation of display material (such as scientific posters)</li> <li>Preparation of Visual Aids: Photomicrography, taking photographs of experimental results and using them in the reports Scanning pictures</li> <li>Making Power Point slide shows</li> <li>Paper Presentation: Presentation of research article published in peer reviewed journal</li> </ul> |

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| Semester –IV            | Paper -IX                         |
|-------------------------|-----------------------------------|
| Course Code: MSC-MR419P | Title of the Course: Dissertation |
| Credits: 02             | Total Lectures : 60 Hrs.          |

1. A dissertation can be carried out by a single student or by group of students where the group should not contain more than two students.
2. The dissertation report will be prepared as per the thesis format.
3. Submission of the dissertation report will be at least ten days before the date of examination.
4. One copy of the report will be preserved in the department, in college.
5. If there are more than one student carrying out a single dissertation, a single report can be submitted to the department and these students will be assessed based on single oral presentation.
6. In such case, presentation should be carried out by all the students carrying out the same work; dividing the presentation equally among them.
7. The allotted time for each oral presentation (one project) should be 10 to 12 minutes, followed by question and answer session of 5 to 8 minutes. The audience can participate in this session.
8. Students should be made aware of the assessment parameters, on which they will be assessed throughout the semester and at the end of the fourth semester.
9. The students may be assessed on the basis of Intellectual potential, research aptitude, motivation, ability to work with others, communication skills, proficiency of presentation skills, research potential of the work, dissertation report preparation, responses to the queries from the audience.