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**SAVITRIBAI PHULE PUNE UNIVERSITY**

**M. Sc. II (Microbiology)  
Revised Syllabus  
For  
Credit and Semester System  
Post Graduate Course in Microbiology  
w. e. f. 2014-15**

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**Semester III**

<b>Semester III</b>		
<b>Paper Title</b>	<b>Credit Code</b>	<b>Credit title</b>
<b>MB – 701: Immunology</b>	3.01 TC	Cell surface molecules and receptors
	3.02 TC	Regulation of Immune response
	3.03 TC	Experimental Immunology
	3.04 TN	Tumor Immunology
	3.05 TN	Infection and Immunity
	3.06 TN	Immunological disorders
	3.07 TN	Immune system evolution
<b>MB – 702: Molecular Biology – I</b>	3.08 TC	Tools in molecular biology
	3.09 TC	Fine Control of Prokaryotic and Eukaryotic transcription
	3.10 TC	RNA processing
	3.11 TN	Mobile DNA elements
	3.12 TN	Proteomics
	3.13 TN	Techniques in Molecular biology and diagnostic applications
<b>MB- 703: Industrial wastewater treatment</b>	3.14TC	Wastewater Management Principles
	3.15 TC	Pretreatment & Primary treatment process
	3.16 TC	Secondary and Tertiary Treatment process
	3.17 TN	Current industrial wastewater treatment processes
	3.18 TN	Environment Impact Assessment
	3.19 TN	Advanced wastewater treatment processes
<b>MB-711: Practical course based on Immunology, Pharmaceutical Microbiology and Environmental Microbiology</b>	3.20 PC	Antigen . Antibody Interactions
	3.21 PC	Cell Culture Techniques
	3.22 PC	Detection and isolation of anti-infectives from plant
	3.23 PC	Industrial waste water treatment
	3.24 PC	On-site experimentation
<b>MB-712: Practical course based on Molecular Biology (I and II) and Microbial Technology</b>	3.25 PC	Molecular Biology – I
	3.26 PC	Molecular Biology – II
	3.27 PC	Bioconversion
	3.28 PC	Laboratory scale production
	3.29 PC	Biosorption

**Semester IV**

<b>Semester IV</b>		
<b>Paper Title</b>	<b>Credit Code</b>	<b>Credit title</b>
<b>MB – 801: Pharmaceutical and Medical Microbiology</b>	4.01 TC	Drug Discovery and Development:
	4.02 TC	Development of Anti-infectives
	4.03 TC	Determinants of Microbial Pathogenicity
	4.04 TN	Discovery of anti-infectives
	4.05 TN	Quality Assurance and Validation in Pharmaceutical Industry
	4.06 TN	Biopharmaceuticals –Regulations and Sources
	4.07 TN	Clinical Microbiology
<b>MB 802: Molecular Biology II</b>	4.08 TC	Genomics
	4.09 TC	Gene technology
	4.10 TC	Applications of recombinant DNA technology – Production of Secondary Metabolites
	4.11 TN	Genetically modified animals and plants
	4.12 TN	Gene annotation
	4.13 TN	Genome project
<b>MB 803: Microbial Technology</b>	4.14TC	Bioreactor design and operation
	4.15 TC	Process Variables and Monitoring
	4.16 TC	Microbial Processes and Intellectual property rights
	4.17 TN	Microbial Growth characteristics and product formation
	4.18 TN	Use of fungi in industry
	4.19 TN	Bio-molecule production by animal cell culture technology
	4.20 TN	Principles of Validation Process / Method Validation
<b>MB 811: Dissertation I</b>	<b>(5 credits)</b>	
<b>MB 812: Dissertation II</b>	<b>(5 credits)</b>	

## SEMESTER – III

### MB – 701: Immunology

Credit No	Credit Title and Contents	References
<b>3.01 TC</b>	<p><b>Cell surface molecules and receptors</b></p> <p>a. Structure and function of G-protein coupled receptors, Toll-like receptors, Cytokine receptors, T Cell receptor, B Cell Receptor, adhesion molecules in immune activation</p> <p>b. Tyrosine kinase linked receptors, TCR-CD3 complex, Signal transduction pathways: IL-2 pathway (JAK/STAT and Ras/MAP Kinase Pathways)</p>	<ol style="list-style-type: none"> <li>1. Akihiko Yoshimura, Tetsuji Naka and Masato Kubo, (2007), <i>SOCS proteins, cytokine signaling and immune regulation</i>, Nature Reviews, Immunology, <b>7</b>:454-465</li> <li>2. Austyn J. M. and Wood K. J. (1993) <i>Principles of Molecular and Cellular Immunology</i>, Oxford University Press,</li> <li>3. Barret James D. (1983) <i>Text Book of Immunology</i> 4<sup>th</sup> edition, C. V. Mosby &amp; Co. London.</li> <li>4. Boyd William C. (1966) <i>Fundamentals of Immunology</i>, Interscience Publishers, NY.</li> <li>5. Christopher K. Garcia and Erin J. Adams, (2005), How the T Cell Receptor Sees Antigen—A Structural View, <i>Cell</i>, Vol. 122: 333–336, Elsevier Inc.</li> <li>6. David A. Hafler, (2007), <i>Cytokines and interventional immunology</i>, Nature Reviews, Immunology, <b>7</b>: 423</li> <li>7. Gangal Sudha and Sontakke Shubhangi (2013), <i>Textbook of Basic and Clinical Immunology</i> Paperback, University Press, India</li> <li>8. Kindt, Osborne, Goldsby, (2006), <i>Kuby Immunology</i>, 6<sup>th</sup> Ed., W. H. Freeman &amp; Co.</li> </ol>
<b>3.02 TC</b>	<p><b>Regulation of Immune response</b></p> <p>a. Negative regulation - Immunological tolerance, Mechanisms of tolerance induction (related experimentation using transgenic animals), T cell mediated suppression of immune response</p> <p>b. Regulation of immune responses by: antigen, antigen-antibody complexes, Network theory and its experimental evidence</p>	<ol style="list-style-type: none"> <li>1. Abbas A. K. and Litchman A. H. (2004), <i>Basic Immunology, Functions and Disorders of Immune System</i>, 2<sup>nd</sup> Ed., Elsevier Inc.</li> <li>2. Akihiko Yoshimura, Tetsuji Naka and Masato Kubo, (2007), <i>SOCS proteins, Cytokine signaling and Immune regulation</i>, Nature Reviews, Immunology, <b>7</b>:454-465</li> <li>3. Bhushan Patwardhan, Sham Diwanay and Manish Gautam. (2006). Botanical Immunomodulators and Chemoprotectants in Cancer Therapy. In <i>Drug discovery and development Volume I</i>:</li> </ol>

	<ul style="list-style-type: none"> <li>c. Cytokine mediated cross regulation of T<sub>H</sub> subsets (T<sub>H1</sub>-T<sub>H2</sub>)</li> <li>d. Regulation of complement system – Classical and alternative pathway</li> <li>e. Immunomodulation: BRMs for therapy</li> </ul>	<p><i>Drug Discovery</i>. Ed. Chorghade Mukund S., (2006), Wiley-Interscience, John Wiley and Sons Inc. USA. 405-424.</p> <ul style="list-style-type: none"> <li>4. Kindt, Osborne, Goldsby, (2006), <i>Kuby Immunology</i>, 6<sup>th</sup> Ed., W. H. Freeman &amp; Co.</li> <li>5. Michael C Carroll, (2004), <i>The complement system in regulation of adaptive immunity</i>, Nature Immunology <b>10</b>:981-986</li> <li>6. Michael C Carroll, (2004), <i>The complement system in regulation of adaptive immunity</i>, Nature Immunology, 5(10):981-986</li> <li>7. Roitt I. M. (1988) <i>Essentials of Immunology</i>, ELBS, London.</li> <li>8. Roitt M. (1984) <i>Essentials of Immunology</i>, P. G. Publishers Pvt. Ltd., New Delhi.</li> </ul>
<p><b>3.03 TC</b></p>	<p><b>Experimental Immunology</b></p> <ul style="list-style-type: none"> <li>a. Animal Cell Culture techniques: Definition of terms – primary cell culture and cell lines, established cells lines, suspension and anchorage dependent cell cultures, transformation of cells in culture, culture media, factors affecting cells in culture, cell line nomenclature.</li> <li>b. <i>In vitro</i> systems –Quantification of cytokines (ELISPOT assay), functional assays for phagocytes and cytokines (cytotoxicity and growth assays)</li> <li>c. <i>In vivo</i> systems – Experimental animals in immunology research (Inbred animal strains, Knock-out mice, transgenic animals), Animal models for autoimmunity and AIDS</li> </ul>	<ul style="list-style-type: none"> <li>1. Freshney R. Ian, (2005), <i>Culture of Animal Cells: A Manual of Basic Technique</i>, 5<sup>th</sup> Ed., John Wiley &amp; Sons, Inc.</li> <li>2. Gangal Sudha and Sontakke Shubhangi, 2013, Textbook of Basic and Clinical Immunology Paperback, University Press, India</li> <li>3. House Robert V., (1998), <i>Therapeutic Manipulation of Cytokines</i>, Biotechnology and Safety Assessment, 2<sup>nd</sup> Ed., Taylor &amp; Francis, 81-105</li> <li>4. Kindt, Osborne, Goldsby, (2006), <i>Kuby Immunology</i>, 6<sup>th</sup> Ed., W. H. Freeman &amp; Co.</li> <li>5. Masters John R. W., (2000), <i>Animal Cell Culture – A Practical Approach</i>, 3<sup>rd</sup> Ed., Oxford University Press.</li> <li>6. Mather Jennie P. and Penelope E. Roberts, (1998), <i>Introduction to Cell and Tissue Culture Theory and Technique</i>, Plenum Press, New York</li> <li>7. Roitt Evan, Brostoff J. Male D. (1993) <i>Immunology</i> 6<sup>th</sup> Ed., Mosby &amp; Co. London.</li> <li>8. Talwar G. P. (1983) <i>Handbook of Immunology</i>, Vikas Publishing Pvt. Ltd. New Delhi.</li> <li>9. William E., Md. Paul, (2003), <i>Fundamental Immunology</i>, 5th Ed, Lippincott Williams &amp; Wilkins Publishers</li> </ul>

<b>3.04 TN</b>	<p><b>Tumor Immunology</b></p> <p>a. Cellular transformations during neoplastic growth, Classification of tumors based on histological, physiological, biochemical and immunological properties, Tumors of lymphoid system (lymphoma, myeloma, Hodgkin’s disease)</p> <p>b. Escape mechanisms of tumor from host defense, Host immune response to tumor – Effector mechanisms, Immuno- surveillance theory</p> <p>c. Diagnosis of tumors – biochemical and immunological tumor markers</p> <p>d. Approaches in cancer immunotherapy: Immune adjuvant and tumor vaccine therapy,</p>	<ol style="list-style-type: none"> <li>1. Ann M. Leen, Cliona M. Rooney and Aaron E. Foster, (2007), Improving T Cell Therapy for Cancer, <i>Ann. Rev. Immunol.</i> 25:243–65</li> <li>2. Bhushan Patwardhan, Sham Diwanay and Manish Gautam. (2006). Botanical Immunomodulators and Chemoprotectants in Cancer Therapy. In <i>Drug discovery and development Volume I: Drug Discovery</i>. Ed. Chorghade Mukund S., (2006), Wiley-Interscience, John Wiley and Sons Inc. USA. 405-424.</li> <li>3. Chatterji C. C. (1992) <i>Human Physiology</i> Vol. 1 &amp;2, Medical Allied Agency, Calcutta.</li> <li>4. Guyton A. C. and Hall J. E. (1996) <i>Text Book of Medical Physiology</i>, Goel Book Agency, Bangalore.</li> <li>5. Malati T. (2007), <i>Tumor Markers: An Overview</i>, Indian Journal of Clinical Biochemistry, 22(2):17-31</li> <li>6. Rev., <b>435</b>   2:605-611 Bendelac Albert, Paul B. Savage, and Luc Teyton, (2007), <i>The Biology of NKT Cells</i> <i>Ann. Rev. Immunol.</i> <b>25</b>:297–336</li> <li>7. Sham Diwanay, Manish Gautam and Bhushan Patwardhan. (2004). <i>Cytoprotection and Immunomodulation in Cancer Therapy</i>. <i>Current Medicinal Chemistry – Anti-Cancer Agents</i>, 4: 479-490</li> <li>8. Stuhler G. and Walden P. (2002), <i>Cancer Immune Therapy – Current and Future Strategies</i>, Wiley-VCH</li> </ol>
<b>3.05 TN</b>	<p><b>Infection and Immunity</b></p> <p>Host immune response to pathogens, pathophysiology and Immunotherapeutic approaches to:</p> <p>a. Bacterial infections (<i>M. tuberculosis</i> and <i>Salmonella</i>)</p> <p>b. Viral (HIV-AIDS and Herpes simplex)</p> <p>c. Parasitic (<i>Plasmodium</i> and <i>Leishmania</i>)</p>	<ol style="list-style-type: none"> <li>1. Abbas A. K. and Litchman A. H. (2004), <i>Basic Immunology, Functions and Disorders of Immune System</i>, 2<sup>nd</sup> Ed., Elsevier Inc.</li> <li>2. Gabriel Virella, (2001), <i>Medical Immunology</i>, 5<sup>th</sup> Ed., Marcel Dekker, Inc.</li> <li>3. Hughes Eric A. and Jorge E. Galan, (2002), <i>Immune Response to Salmonella: Location, Location, Location?</i>, <i>Immunity</i>, <b>16</b>: 325–328</li> <li>4. Pathak S. S. and Palan V. (1997) <i>Immunology - Essential and Fundamental</i>, Pareen Publications Bombay.</li> </ol>

		<p>5. Rabson A., Ivan M. Roitt and Peter J. Devles, (2005), <i>Really Essential Medical Immunology</i>, 2<sup>nd</sup> Ed., Blackwell Publishing Ltd.</p> <p>6. Roitt Evan, Brostoff J. Male D. (1993) <i>Immunology</i> 6<sup>th</sup> Ed., Mosby &amp; Co. London.</p>
<b>3.06 TN</b>	<p><b>Immunological disorders</b> Pathophysiology, diagnosis, prognosis and therapeutic approaches to:</p> <p>a. Immunodeficiency disorders – humoral deficiencies, T-cell deficiencies, and combined deficiencies, complement deficiencies</p> <p>b. Autoimmune disorders (Immunopathological mechanisms and theories of autoimmunity) - Rheumatoid arthritis, Systemic Lupus Erythomatosus (SLE), Neurologic disease- Myasthenia gravis</p>	<p>1. Abbas A. K. and Litchman A. H. (2004), <i>Basic Immunology, Functions and Disorders of Immune System</i>, 2<sup>nd</sup> Ed., Elsevier Inc.</p> <p>2. Baron D. N. <i>Short Text book on Chemical Pathology</i>, ELBS, London.</p> <p>3. Garrison Fathman1 C., Luis Soares, Steven M. Chan1 &amp; Paul J. Utz1, (2005), <i>An array of possibilities for the study of autoimmunity</i>, Nature</p> <p>4. Rabson A., Ivan M. Roitt and Peter J. Devles, (2005), <i>Really Essential Medical Immunology</i>, 2<sup>nd</sup> Ed., Blackwell Publishing Ltd.</p> <p>5. Stites D. P., Stobo J. D., Fudenberg H. H. and Wells J. V., (1982), <i>Basic and Clinical Immunology</i>, 4<sup>th</sup> Ed., Lange Medical Publications, Maruzen Asia Pvt. Ltd., Singapore</p>
<b>3.07 TN</b>	<p><b>Immune system evolution</b></p> <p>a. Strategies of survival of species of living forms</p> <p>b. Status of immune system in invertebrates and vertebrates with reference to diversity, complexity and efficiency of cells and molecules, anatomical organization,</p> <p>c. Functional and structural evolution of immunoglobulin</p>	<p>1. Biotechnology by open learning series (BIOTOL), (1993), <i>Defense Mechanisms</i>, Butterworth and Heinemann Ltd., Oxford</p> <p>2. Max D. Cooper and Matthew N. Alder (2006), <i>The Evolution of Adaptive Immune Systems</i>, Cell, 124: 815–822, Elsevier Inc.</p> <p>3. Pancer Zeev and Max D. Cooper, (2006), <i>The Evolution of Adaptive Immunity</i>, Ann. Rev. Immunol. 24:497–518</p> <p>4. Stites D. P., Stobo J. D., Fudenberg H. H. and Wells J. V., (1982), <i>Basic and Clinical Immunology</i>, 4<sup>th</sup> Ed., Lange Medical Publications, Maruzen Asia Pvt. Ltd., Singapore</p> <p>5. William E., Md. Paul, (2003), <i>Fundamental Immunology</i>, 5th Ed, Lippincott Williams &amp; Wilkins Publishers</p> <p>6. Zeev Pancer and Max D. Cooper, (2006), <i>The Evolution of Adaptive Immunity</i>, Ann. Rev. Immunol., <b>24</b>: 497–518</p>

**MB – 702: Molecular Biology I**

Credit No	Credit Title and Contents	References
3.08 TC	<p><b>Tools in molecular biology</b></p> <ul style="list-style-type: none"> <li>• Activity gel assay, ChIP,, Designing probe, Detection of DNA binding, DMS foot printing, DNA helicase assay, Epitope tagging, Sequence tagged sites, Filter binding assay,</li> <li>• Protein foot printing, Knockout mice, phage display, Expressed sequence tags, Yeast two and three hybrid assay,</li> <li>• RFLP, finding the replicon, DNA finger printing, Measuring transcription rates, Finding RNA sequences that interact with each other.</li> </ul>	<ol style="list-style-type: none"> <li>1. Benjamin Lewin. (2008) <i>Genes IX</i>, Jones and Bartlett Publishers Inc.</li> <li>2. Functions and Mechanics of RNA editing, J. M. Goot, <i>Ann. Rew. Gent.</i>, 2000, <b>30</b>, 419-53.</li> <li>3. <a href="http://onlinelibrary.wiley.com/doi/10.1576/toag.12.1.037.27556/pdf">http://onlinelibrary.wiley.com/doi/10.1576/toag.12.1.037.27556/pdf</a></li> <li>4. <a href="http://www.annualreviews.org/doi/abs/10.1146/annurev-biochem-052610-091920">http://www.annualreviews.org/doi/abs/10.1146/annurev-biochem-052610-091920</a></li> <li>5. <a href="http://www.nature.com/nrg/journal/v13/n7/full/nrg3230.html">http://www.nature.com/nrg/journal/v13/n7/full/nrg3230.html</a></li> <li>6. <a href="http://www.nature.com/nrg/journal/v14/n8/full/nrg3535.html">http://www.nature.com/nrg/journal/v14/n8/full/nrg3535.html</a></li> <li>7. <a href="http://www.nature.com/scitable/topicpage/the-role-of-methylation-in-gene-expression-1070">http://www.nature.com/scitable/topicpage/the-role-of-methylation-in-gene-expression-1070</a></li> <li>8. <a href="http://www.ncbi.nlm.nih.gov/pubmed/20920744">http://www.ncbi.nlm.nih.gov/pubmed/20920744</a></li> <li>9. James D. Watson, Tania Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Loswick (2004) <i>Molecular Biology of the Gene</i>, 5th Edition, Pearson Education, Inc. and Dorling Kindersley Publishing, Inc.</li> <li>10. Mechanism of subcellular mRNA localization, 2002, <i>CSH</i>, <b>108</b>, 533-44.</li> <li>11. Micro RNAs in cell proliferation, Cell death and tumorogenesis, <i>B. J. of Cancer</i>, 2006, 94.</li> <li>12. <i>Molecular Biology of the Cell</i>, Bruce Albert et. al., 6<sup>th</sup> Ed., Garland Sciences.</li> <li>13. <i>Molecular Biology</i>, Loddish et. al., 7<sup>th</sup> Edn., W. H. Freeman, 2012</li> <li>14. NC RNAs regulations of disease, Taft et. al., <i>J. of Path</i>, 2010, <b>220</b>, 126-39</li> <li>15. Recent progress in structure, Biology and tRNA processing and</li> </ol>



		<p>modification. Mol. Cell., <b>19(2)</b>, 2005, 157-66</p> <p>16. Weaver R., (2007) <i>Molecular Biology</i>, 4th Edition, McGraw Hill Science.</p>
<b>3.09 TC</b>	<p><b>Fine Control of Prokaryotic and Eukaryotic transcription</b></p> <ul style="list-style-type: none"> <li>• Lactose operon: repressor-operator interactions, mechanism of repression, Positive control of lac operon-Mechanism of CAP action,</li> <li>• The Arabinose operon: Ara operon repression loop, evidence for repression loop, auto regulation of araC</li> <li>• The trp operon:- control of trp operon by attenuation, defeating attenuation, Riboswitches,</li> <li>• Sigma factor Switching:- Phage infection- T4,T7 infection in <i>E. coli</i>, SPO1 infection in <i>B. subtilis</i>.</li> </ul>	<ol style="list-style-type: none"> <li>1. Functions and Mechanics of RNA editing, J. M. Goot, Ann. Rev. Gent., 2000, <b>30</b>, 419-53.</li> <li>2. <a href="http://highered.mcgraw-hill.com/sites/0072943696/student_view0/chapter3/animation__dna_replication__quiz_1_.html">http://highered.mcgraw-hill.com/sites/0072943696/student_view0/chapter3/animation__dna_replication__quiz_1_.html</a></li> <li>3. <a href="http://www.johnkyrk.com/DNAreplication.html">http://www.johnkyrk.com/DNAreplication.html</a></li> <li>4. James D. Watson, Tania Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Loswick (2004) <i>Molecular Biology of the Gene</i>, 5th Edition, Pearson Education, Inc. and Dorling Kindersley Publishing, Inc.</li> <li>5. Lewin's Genes XI, (2014) Jones and Bartlett Publishers Inc.</li> <li>6. Mechanism of subcellular mRNA localization, 2002, CSH, <b>108</b>, 533-44.</li> <li>7. Micro RNAs in cell proliferation, Cell death and tumorigenesis, B. J. of Cancer, 2006, 94.</li> <li>8. Molecular Biology of the Cell, Bruce Albert et. al. , 6<sup>th</sup> Edn., Garland Sciences.</li> <li>9. Molecular Biology, Lodish et. al., 7<sup>th</sup> Edn., W. H. Freeman, 2012</li> <li>10. NC RNAs regulations of disease, Taft et. al., J. of Path, 2010, <b>220</b>, 126-39</li> <li>11. Recent progress in structure, Biology and tRNA processing and modification. Mol. Cell., <b>19(2)</b>, 2005, 157-66</li> <li>12. Weaver R., (2007) <i>Molecular Biology</i>, 4th Edition, McGraw Hill Science.</li> </ol>
<b>3.10 TC</b>	<p><b>RNA processing</b></p> <ul style="list-style-type: none"> <li>• mRNA processing: splicing, capping, polyadenylation., coordination of mRNA processing</li> </ul>	<ol style="list-style-type: none"> <li>1. Concepts of Genetics, W.S. Klug and M.R. Cummings, (2005) Pearson education</li> <li>2. Functions and Mechanics of RNA editing, J. M. Goot, Ann. Rev. Gent, 2000, <b>30</b>, 419-53.</li> </ol>

	<ul style="list-style-type: none"> <li>• rRNA processing: tRNA processing, Non coding RNAs and their production and role. RNA interference; SiRNA, micro-RNA role in gene silencing,</li> </ul>	<ol style="list-style-type: none"> <li>3. James D. Watson, Tania Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Loswick (2004) <i>Molecular Biology of the Gene</i>, 5th Edition, Pearson Education, Inc. and Dorling Kindersley Publishing, Inc.</li> <li>4. Lewin’s Genes XI, (2014) Jones and Bartelett Publishers Inc.</li> <li>5. Mechanism of subcellular mRNA localization, 2002, CSH, <b>108</b>, 533-44.</li> <li>6. Micro RNAs in cell proliferation, Cell death and tumorogenesis, B. J. of Cancer, 2006, 94.</li> <li>7. Molecular Biology of the Cell, Bruce Albert et. al. , 6<sup>th</sup> Edn., Garland Sciences.</li> <li>8. Molecular Biology, Loddish et. al., 7<sup>th</sup> Ed., W. H. Freeman, 2012</li> <li>9. NC RNAs regulations of disease, Taft et. al., J. of Path, 2010, <b>220</b>, 126-39</li> <li>10. Recent progress in structure, Biology and tRNA processing and modification. Mol. Cell., <b>19(2)</b>, 2005, 157-66</li> <li>11. Weaver R., (2007) <i>Molecular Biology</i>, 4th Edition, McGrew Hill Science.</li> </ol>
<p><b>3.11 TN</b></p>	<p><b>Mobile DNA elements</b></p> <ul style="list-style-type: none"> <li>• Transposable elements in bacteria, IS elements, composite transposons, Integrons.</li> <li>• Replicative, nonreplicative transposons, and Mu transposition</li> <li>• Controlling elements in Tn A, Tn 5 and Tn 10 transposition</li> <li>• Transposons in maize and Drosophila</li> <li>• Retroviruses and retrotransposon, Ty elements in yeasts</li> <li>• SINES, LINES and Alu elements.</li> <li>• Significance of transposons and Integrons.</li> </ul>	<ol style="list-style-type: none"> <li>1. Functions and Mechanics of RNA editing, J. M. Goot, Ann. Rew. Gent., 2000, <b>30</b>, 419-53.</li> <li>2. James D. Watson, Tania Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Loswick (2004) <i>Molecular Biology of the Gene</i>, 5th Edition, Pearson Education, Inc. and Dorling Kindersley Publishing, Inc.</li> <li>3. Lewin’s Genes XI, (2014) Jones and Bartelett Publishers Inc.</li> <li>4. Mechanism of subcellular mRNA localization, 2002, CSH, <b>108</b>, 533-44.</li> <li>5. Micro RNAs in cell proliferation, Cell death and tumorogenesis, B. J. of Cancer, 2006, 94.</li> <li>6. Molecular Biology of the Cell, Bruce Albert et. al., 6<sup>th</sup> Ed., Garland</li> </ol>

		<p>Sciences.</p> <ol style="list-style-type: none"> <li>7. Molecular Biology, Loddish et. al., 7<sup>th</sup> Edn., W. H. Freeman, 2012</li> <li>8. NC RNAs regulations of disease, Taft et. al., J. of Path, 2010, <b>220</b>, 126-39</li> <li>9. Recent progress in structure, Biology and tRNA processing and modification. Mol. Cell., <b>19(2)</b>, 2005, 157-66</li> <li>10. Weaver R., (2007) <i>Molecular Biology</i>, 4th Edition, McGrew Hill Science.</li> </ol>
<p><b>3.12 TN</b></p>	<p><b>Proteomics</b></p> <ul style="list-style-type: none"> <li>• Expression, Analysis and Characterization of Protein.</li> <li>• Analysis of protein structure</li> <li>• Protein interaction.</li> <li>• Metabolomics and global biochemical networks</li> </ul>	<ol style="list-style-type: none"> <li>1. Functions and Mechanics of RNA editing, J. M. Goot, Ann. Rew. Gent, 2000, <b>30</b>, 419-53.</li> <li>2. James D. Watson, Tania Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Loswick (2004) <i>Molecular Biology of the Gene</i>, 5th Edition, Pearson Education, Inc. and Dorling Kindersley Publishing, Inc.</li> <li>3. Lewin's Genes XI, (2014) Jones and Bartelett Publishers Inc.</li> <li>4. Mechanism of subcellular mRNA localization, 2002, CSH, <b>108</b>, 533-44.</li> <li>5. Micro RNAs in cell proliferation, Cell death and tumorogenesis, B. J. of Cancer, 2006, 94.</li> <li>6. Molecular Biology of the Cell, Bruce Albert et. al. , 6<sup>th</sup> Ed., Garland Sciences.</li> <li>7. Molecular Biology, Loddish et. al., 7<sup>th</sup> Ed., W. H. Freeman, 2012</li> <li>8. NC RNAs regulations of disease, Taft et. al., J. of Path, 2010, <b>220</b>, 126-39</li> <li>9. Recent progress in structure, Biology and tRNA processing and modification. Mol. Cell., <b>19(2)</b>, 2005, 157-66</li> <li>10. S.B Primrose and R M Twyman 2006 7<sup>th</sup> edition. Blackwell publishing</li> <li>11. Weaver R., (2007) <i>Molecular Biology</i>, 4th Edition, McGrew Hill Science.</li> </ol>

<p><b>3.13 TN</b></p>	<p><b>Techniques in Molecular biology and diagnostic applications</b></p> <ul style="list-style-type: none"> <li>• PCR and its modifications, nested PCR, Hot start PCR, RT –PCR and Real time PCR ( Q –PCR)</li> <li>• DNA microarray</li> <li>• Applications of PCR and microarray.</li> <li>• Molecular diagnostic tools in detection of cancer.</li> </ul>	<ol style="list-style-type: none"> <li>1. Functions and Mechanics of RNA editing, J. M. Goot, Ann. Rev. Gent, 2000, <b>30</b>, 419-53.</li> <li>2. James D. Watson, Tania Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Loswick (2004) <i>Molecular Biology of the Gene</i>, 5th Edition, Pearson Education, Inc. and Dorling Kindersley Publishing, Inc.</li> <li>3. Lewin’s Genes XI, (2014) Jones and Bartelett Publishers Inc.</li> <li>4. Mechanism of subcellular mRNA localization, 2002, CSH, <b>108</b>, 533-44.</li> <li>5. Micro RNAs in cell proliferation, Cell death and tumorigenesis, B. J. of Cancer, 2006, 94.</li> <li>6. Molecular Biology of the Cell, Bruce Albert et. al. , 6<sup>th</sup> Edn., Garland Sciences.</li> <li>7. Molecular Biology, Loddish et. al., 7<sup>th</sup> Edn., W. H. Freeman, 2012</li> <li>8. NC RNAs regulations of disease, Taft et. al., J. of Path, 2010, <b>220</b>, 126-39</li> <li>9. Recent progress in structure, Biology and tRNA processing and modification. Mol. Cell., <b>19(2)</b>, 2005, 157-66</li> <li>10. S.B Primrose and R M Twyman 2006 7<sup>th</sup> edition. Blackwell publishing</li> <li>11. Weaver R., (2007) <i>Molecular Biology</i>, 4th Edition, McGrew Hill Science.</li> </ol>
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**MB- 703: Industrial wastewater treatment**

Credit No.	Credit Title and Contents	References
3.14TC	<p><b>Principles of Wastewater Treatment</b></p> <ul style="list-style-type: none"> <li>• The need for Wastewater Treatment</li> <li>• Measuring Pollution Load of wastewaters</li> <li>• Methods for estimating parameters used for determining treatment efficacy</li> <li>• Layout of typical wastewater treatment plants</li> </ul>	<ol style="list-style-type: none"> <li>1. Biotechnology for Water and Wastewater Treatment. Dr. Satya Prakash. Navyug Publishers &amp; Distributors, New Delhi. 2009.</li> <li>2. Industrial Water Pollution Control. 3<sup>rd</sup> Edition. W. Wesley Eckenfelder Jr. McGraw Hill. 2000. Standard Methods for the Examination of Water &amp; Wastewater. 21<sup>st</sup> Edition. 2005. APHA.AWWA.WEF</li> </ol>
3.15 TC	<p><b>Pretreatment &amp; Primary treatment process (Unit Processes)</b></p> <ul style="list-style-type: none"> <li>• Flow equalization</li> <li>• Screening</li> <li>• Flocculation</li> <li>• Flotation</li> <li>• Granular medium filtration</li> </ul>	<ol style="list-style-type: none"> <li>1. Tchobanoglous G. and F. L. Burton. (1991). <i>Wastewater Engineering, Treatment, Disposal and Reuse</i>. 3rd Ed., Metcalf and Eddy (Eds). Tata Mac Graw Hill Publishing Co. Ltd. New Delhi</li> </ol>
3.16 TC	<p><b>Secondary and Tertiary Treatment process (Unit Processes)</b></p> <ul style="list-style-type: none"> <li>• Biological Processes (Aerobic)</li> <li>• Biological Processes (Anaerobic)</li> <li>• Biological processes (Combined)</li> <li>• Sedimentation and clarification</li> <li>• Disinfection</li> <li>• Adsorption</li> <li>• Sludge treatment and disposal</li> </ul>	<ol style="list-style-type: none"> <li>1. <i>Disposal and Reuse</i>. 3rd Ed., Metcalf and Eddy (Eds). Tata Mac Graw Hill Publishing Co. Ltd. New Delhi</li> <li>2. Tchobanoglous G. and F. L. Burton. (1991). <i>Wastewater Engineering, Treatment,</i></li> <li>3. <i>Wastewater Treatment and Technology</i>. Christopher Forster. Thomas Telford Publishing, London, UK. 2003.</li> </ol>
3.17 TN	<p><b>Current industrial wastewater treatment processes</b></p> <ul style="list-style-type: none"> <li>• Dairies</li> <li>• Food processing</li> <li>• Dyeing industry / Dye-house effluents</li> </ul>	<ol style="list-style-type: none"> <li>1. <i>Industrial Wastewater Treatment</i>. A. D. Patwardhan. © Prentice – Hall of India Pvt. Ltd., New Delhi. 2008. ISBN 978-81-203-3350-5.</li> </ol>

	<ul style="list-style-type: none"> <li>Paper manufacture</li> </ul>	
<b>3.18 TN</b>	<b>Environment Impact Assessment</b> <ul style="list-style-type: none"> <li>Introduction: What is EIA and its need.</li> <li>Types of Impacts and their attributes. Determining the most significant impacts</li> <li>Phase I studies: Initial inquiries</li> <li>Phase II studies: Full EIA study</li> <li>Arriving at the findings (identify, predict and judge)</li> </ul>	<ol style="list-style-type: none"> <li>Introduction to Environmental Impact Assessment. 4<sup>th</sup> Edition. John Glasson, Riki Therivel, Andrew Chadwick. Routledge (2012).</li> <li>Environmental Impact Assessment. A. K. Shrivastava. APH Publishing, Jan-2003.</li> <li>Environmental Impact Assessment R R Barthwal New Age International, Jan-2002.</li> </ol>
<b>3.19 TN</b>	<b>Advanced, Combined and Innovative wastewater treatment processes</b> <ul style="list-style-type: none"> <li>Submerged Aerobic Fixed Film reactors (SAFF)</li> <li>Membrane bioreactors (MBRs)</li> <li>Rotating Biological Contactors (RBCs)</li> <li>Mixed Bed Bioreactors (MBBRs)</li> </ul>	<ol style="list-style-type: none"> <li>Biological Wastewater Treatment. Vol. 5. Activated Sludge and Aerobic Biofilm Reactors. Marcos von Sperling. IWA Publishing. London, New York. © 2007 IWA Publishing</li> </ol>

**MB-711: Practical course based on Immunology, Pharmaceutical Microbiology and Environmental Microbiology**

<b>Credit No.</b>	<b>Credit Title and Contents</b>	<b>References</b>
<b>3.20 PC</b>	<b>Antigen . Antibody Interactions</b> <ol style="list-style-type: none"> <li>Precipitation reactions of antigen-antibody: Immuno-electrophoresis – Single radial immune-diffusion and rocket immune-electrophoresis</li> <li>Agglutination techniques: Titer determination of iso-antibodies to human blood group antigens</li> </ol>	<ol style="list-style-type: none"> <li>Talwar G. P. (1983) <i>Handbook of Immunology</i>, Vikas Publishing Pvt. Ltd. New Delhi.</li> </ol>
<b>3.21 PC</b>	<b>Cell Culture Techniques</b> <ol style="list-style-type: none"> <li>Density gradient based separation of peripheral lymphocytes, Lymphocyte culture and detecting</li> </ol>	<ol style="list-style-type: none"> <li>Freshney R. Ian, (2005), <i>Culture of Animal Cells: A Manual of Basic Technique</i>, 5<sup>th</sup> Ed., John Wiley &amp; Sons, Inc.</li> <li>Masters John R. W., (2000), <i>Animal Cell Culture – A Practical</i></li> </ol>

	<p>proliferation on mitogenic stimulus</p> <p>2. Chick embryo fibroblast cell culture</p>	<p><i>Approach</i>, 3<sup>rd</sup> Ed., Oxford University Press.</p> <p>3. Mather Jennie P. and Penelope E. Roberts, (1998), <i>Introduction to Cell and Tissue Culture Theory and Technique</i>, Plenum Press, New York</p>
<b>3.22 PC</b>	<p><b>Detection and isolation of anti-infectives from plant</b></p> <p>1. Extraction of bioactive principles from plant and activity fractionation</p> <p>2. Estimation of its antimicrobial activity using standard guidelines (CLSI)</p>	<p>1. Lorian. V., (1986), <i>Antibiotics in laboratory medicine</i>, 2nd Ed, Williams &amp; Wilkins Publication</p> <p>2. National Committee for Clinical Laboratory Standards (now Clinical and Laboratory Standards Institute, CLSI). <i>Methods for dilution antimicrobial susceptibility testing for bacteria that grows aerobically. Approved Standards M7-A4</i>. Villanova, PA: NCCLS, 1997.</p> <p>3. National Committee for Clinical Laboratory Standards (now Clinical and Laboratory Standards Institute, CLSI). <i>Performance standards for antimicrobial susceptibility testing; 12th information supplement (M100-S1)</i>. Villanova, PA; NCCLS: 2002</p>
<b>3.23 PC</b>	<p><b>Industrial waste water treatment</b></p> <p>1. Estimation of pollution load of a natural sample (e.g. river water / industrial waste water)</p> <p>2. Setting up a laboratory experiment to assess degradability of synthetic waste water.</p>	<p>1. Assessment. A. K. Shrivastava. APH Publishing, Jan-2003.</p> <p>2. Environmental Impact</p> <p>3. Environmental Impact Assessment, R. R. Barthwal, New Age International, Jan-2002.</p> <p>4. Introduction to Environmental Impact Assessment. 4<sup>th</sup> Edition. John Glasson, Riki Therivel, Andrew Chadwick. Routledge (2012). 416 pages</p> <p>5. Standard Methods for the Examination of Water &amp; Wastewater. 21<sup>st</sup> Edition. 2005. APHA.AWWA.WEF</p>
<b>3.24 PC</b>	<p><b>On-site experimentation</b></p> <p>1. Visit to institute / Industry for demonstration of ELISPOT / CFT / FACS / animal inoculation and bleeding / immuno-electrophoresis / Western blot / cell culture</p>	

	<p>etc. and preparation of visit report.</p> <p>2. EIA of industrial Waste Water Treatment Plant and preparation of facts report. Relevant sampling and simulation analysis.</p>	
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**MB-712: Practical course based on Molecular Biology (I and II) and Microbial Technology**

Credit No.	Credit Title and Contents	References
3.25 PC	<p><b>Molecular Biology - I</b></p> <p>1. Plasmid DNA isolation and Characterization</p> <p>2. Transformation</p>	J. Sambrook and D. W. Russel (2001), Molecular Cloning: A Laboratory Manual, Volume 1, 2, 3, Cold Spring Harbour Laboratory Press, Cold Spring Harbour, New York
3.26 PC	<p><b>Molecular Biology - II</b></p> <p>1. Molecular Characterization of bacterial isolates</p> <p>2. Gene annotation</p>	J. Sambrook and D. W. Russel (2001), Molecular Cloning: A Laboratory Manual, Volume 1, 2, 3, Cold Spring Harbour Laboratory Press, Cold Spring Harbour, New York
3.27 PC	<p><b>Bioconversion</b></p> <p>Bioconversions using immobilized systems (cells / enzyme)</p> <p>Parameter testing:</p> <p>a. Effect of gel concentration</p> <p>b. Effect of cell / enzyme concentration</p>	
3.28 PC	<p><b>Laboratory scale production</b></p> <p>Laboratory scale production and media optimization for exopolysaccharide / bioemulsifier production.</p>	
3.29 PC	<p><b>Biosorption</b></p> <p>Biosorption of dyes or metals using dead biomass.</p>	



## SEMESTER – IV

### MB – 801: Pharmaceutical and Medical Microbiology

Credit No	Credit Title and Contents	References
4.01 TC	<p><b>Drug Discovery and Development:</b> Contributions and postulates of Paul Ehrlich Significance of terms - Lead compound, Lead optimization, Candidate selection</p> <p>A. Drug Discovery:</p> <ol style="list-style-type: none"> <li>i. Conventional Process Bio-prospecting (Medicinal Chemistry) – Extraction and purification principles, Purification and characterization of bioactive molecules from natural sources</li> <li>ii. Rational Drug Design – Principle (Structure activity relationship -SAR) and Tools (applications of High Through Put Screening, Combinatorial synthesis, Pharmaco-genomics)</li> </ol> <p>B. Drug Development</p> <ol style="list-style-type: none"> <li>i. Preclinical development: Toxicity testing – acute, sub-acute and chronic toxicity</li> <li>ii. Clinical development: Clinical trials – (Aims, Objectives, Conduct): I, II, III and IV</li> </ol>	<ol style="list-style-type: none"> <li>1. Agarwal S. S. and Paridhavi M., (2007), <i>Herbal Drug Technology</i>, Universities Press (India) Pvt. Ltd</li> <li>2. Altreuter D., and D S. Clark, (1999), <i>Combinatorial Biocatalysis: Taking the Lead From Nature</i>, Curr. Opin. Biotechnol. <b>10</b>, 130.</li> <li>3. Bentley's Textbook of Pharmaceutics, Ed. E. A. Rawlins, 8th Ed. (2002), Bailliere Tindall, London</li> <li>4. Burn J. H. (1957) <i>Principles of Therapeutics</i>, Blackwell Scientific Pub. O. Ltd. Oxford.</li> <li>5. Chatwal G. P. (2003) <i>Bio-pharmaceutics and Pharmacokinetics</i>, Himalaya Publishing House, Mumbai.</li> <li>6. Paul W. Erhardt, (2006), <i>Medicinal Chemistry in the New Millennium: A Glance into the Future</i>, Ed. Chorghade Mukund S. in Drug discovery and development Volume I: Drug Discovery, Wiley-Interscience, John Wiley and Sons Inc. USA, 17-102.</li> <li>7. Committee for the Purpose of Control and Supervision on Experiments on Animals (CPCSEA), <a href="http://www.cpcsea.com">www.cpcsea.com</a></li> <li>8. Dewick Paul M., (2002), <i>Medicinal natural products: A biosynthetic approach</i>, 2<sup>nd</sup> Ed., John Wiley and Sons</li> <li>9. Graly John O. and Pieter H. Joubert, (1997), <i>Handbook of Phase I / II clinical drug trials</i>, CRC Press</li> <li>10. Iyengar M. A. (1974) <i>Pharmacology of Powdered Crude Drugs</i>, Manipal</li> </ol>

		<ol style="list-style-type: none"> <li>11. Micheles P. S., Y. L. Khmel'nitsley, J. S. Dordick and D. S. Clark, (1998), <i>Combinatorial Biocatalysis, A Natural Approach to Drug Discovery</i>, Trends in Biotechnol. <b>16</b>, 197.</li> <li>12. Satoskar R. S. &amp; S. D. Bhandarkar (1991) <i>Pharmacology and Pharmacotherapeutics</i>, 12th Ed., Vol. 1 &amp; 2, Popular Prakashan, Mumbai.</li> <li>13. Vyas S. P and Dixit V. R. (2002), <i>Pharmaceutical Biotechnology</i>, CBS Publishers and Distributors, New Delhi</li> </ol>
<p><b>4.02 TC</b></p>	<p><b>Development of Anti-infectives:</b> Therapeutic ratio, MIC and MBC Susceptibility Testing:</p> <ol style="list-style-type: none"> <li>A. Use of liquid and solid media</li> <li>B. Factors affecting susceptibility testing, CLSI guidelines</li> <li>C. Diffusion methods – agar dilution technique, gradient plate techniques, E-test, Kirby Bauer, Stokes method</li> <li>D. Susceptibility testing for:             <ol style="list-style-type: none"> <li>i. Anti-mycobacterial agents</li> <li>ii. Anti-fungal agents</li> <li>iii. Anti-protozoan agents</li> <li>iv. Anti-viral agents</li> </ol> </li> </ol>	<ol style="list-style-type: none"> <li>1. Franklin T. J. and Snow G. A., (1975), <i>Biochemistry of Antimicrobial Action</i>, Chapman and Hall, London, 1-22 and 160-174</li> <li>2. Gale E. F., Cundliffe E., Reynolds P. E., Richmond M. H. and Waring M. J., (1972), <i>The molecular basis of antibiotic action</i>, John Wiley and Sons, London</li> <li>3. Goldstein A., Aronow L., and Kalman S. M. (1969) <i>Principles of Drug Action, The Basis of Pharmacology</i>, Harper international edition New York.</li> <li>4. Lorian V., (1986), <i>Antibiotics in laboratory medicine</i>, 2nd Ed, Williams &amp; Wilkins Publication</li> <li>5. National Committee for Clinical Laboratory Standards (now Clinical and Laboratory Standards Institute, CLSI). <i>Methods for dilution antimicrobial susceptibility testing for bacteria that grows aerobically. Approved Standards M7-A4</i>. Villanova, PA: NCCLS, 1997.</li> <li>6. National Committee for Clinical Laboratory Standards (now Clinical and Laboratory Standards Institute, CLSI). <i>Performance standards for antimicrobial susceptibility testing; 12th information supplement (M100-S1)</i>. Villanova, PA; NCCLS: 2002</li> </ol>

<b>4.03 TC</b>	<p><b>Determinants of Microbial Pathogenicity:</b></p> <ol style="list-style-type: none"> <li>a. Adhesion and Colonization</li> <li>b. Invasion</li> <li>c. Evasion</li> <li>d. Toxigenesis (mode of action and <i>in vitro</i> and <i>in vivo</i> assay systems for diphtheria, cholera, tetanus toxins and endotoxins of Gram negative bacteria)</li> <li>e. Bacterial resistance to host defenses: phagocytosis, nonspecific and specific humoral factors</li> <li>f. Molecular basis of bacterial pathogenicity – cytoskeletal modulation of host cell, virulence genes and pathogenicity islands</li> </ol>	<ol style="list-style-type: none"> <li>1. Babych E. M., Ryzhkova T. A., Kalinichenko S. V. and Sklyar N. I., (2008), <i>General Characteristic of the methods for detection of diphtheria toxin</i>, Annals of Mechnikov Institute, 19-21 (<a href="http://www.imiamn.org/journal.htm">www.imiamn.org/journal.htm</a>)</li> <li>2. Bhavsar Amit P., Julian A. Guttman and B. Brett Finlay, (2007), <i>Manipulation of host-cell pathways by bacterial pathogens</i>, Nature Rev <b>449/18</b>:827-834</li> <li>3. Brubaker R. R., (1985), <i>Mechanisms of Bacterial Virulence</i>, Ann. Rev. Microbiol. 39:21-50</li> <li>4. Carpenter Philip L., (1975), <i>Saunders International Edition - Immunology and Serology</i>, W. B. Saunders and Co., London</li> <li>5. David N. Fredricks and David A. Relman, (1996), <i>Sequence-Based Identification of Microbial Pathogens: a Reconsideration of Koch's Postulates</i>, Clinical Microbiology Reviews, 18–33</li> <li>6. Eduardo A. Groisman and Howard Ochman, (1994), <i>How to become a pathogen</i>, Trends in Microbiology, <b>2(8)</b>:289-294</li> <li>7. Hughes Eric A. and Jorge E. Galan, (2002), <i>Immune Response to Salmonella: Location, Location, Location?</i>, Immunity, <b>16</b>: 325–328</li> <li>8. Mark J. Pallen<sup>1</sup> &amp; Brendan W. Wren, (2007), <i>Bacterial pathogenomics</i>, Nature Rev. <b>449   18</b>: 835-842</li> <li>9. Schlessinger David, Editor, <i>Biochemical Genetics of Pathogenicity</i>, in Microbiology – 1979, American Society for Microbiology, Washington D. C., 79 - 230</li> <li>10. Schlessinger David, Editor, <i>Mechanism of Microbial Virulence</i>, in Microbiology – 1979, American Society for Microbiology, Washington D. C., 79-230</li> <li>11. Unsworth K. E. and David W. Holden, (2000), <i>Identification and analysis of bacterial virulence genes in vivo</i>, Phil. Trans. R. Soc. London B. <b>355</b>, 613-622</li> </ol>
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		<p>12. Unsworth Kate E. and Holden David W., (2000), <i>Identification and analysis of bacterial virulence genes in vivo</i>, Phil. Trans. R. Soc. London B., 355:613-622</p> <p>13. Woods D. E., (2002), <i>The use of animal infection models to study the pathogenesis of melioidosis and glanders</i>, Trends Microbiol, 10(11):483-5</p>
<p><b>4.04 TN</b></p>	<p><b>Discovery of anti-infectives:</b></p> <p>a. Drug targets in bacteria with examples of established drugs: Cell wall biosynthesis, Cell membrane function, Proteins synthesis and Nucleic acid synthesis and metabolism</p> <p>b. Methods to quantify growth / inhibition and metabolic changes in microbial population on exposure to anti-infectives, for evaluation of anti-infective activity and developing insight in its' mode of action:</p> <p>i. Direct counts (Counting chambers, calibrated smears, proportionate counts),</p> <p>ii. Turbidometry and nephelometry,</p> <p>iii. Electrical Resistance, Electrical impedance,</p> <p>iv. Microcalorimetry,</p> <p>v. Flow cytometry and</p> <p>vi. Radiometric methods</p> <p>vii. Radiolabelling techniques</p> <p>c. Laboratory methods to assess activity of antimicrobial combinations (antagonism, Synergism, and additive effect)</p>	<p>1. Franklin T. J. and Snow G. A., (1975), <i>Biochemistry of Antimicrobial Action</i>, Chapman and Hall, London, 1-22 and 160-174</p> <p>2. Kavanagh Frederick, (1963), <i>Analytical Microbiology Volume I and II</i>, Academic Press, London</p> <p>3. Lorian V., (1986), <i>Antibiotics in laboratory medicine</i>, 2nd Ed, Williams &amp; Wilkins Publication</p> <p>4. Sylvie E. Blondelle, Enrique Pe´Rez-Paya, And Richard A. Houghten, (1996), <i>Synthetic Combinatorial Libraries: Novel Discovery Strategy for Identification of Antimicrobial Agents</i>, Antimicrobial Agents and Chemotherapy, 1067–1071</p> <p>5. Vyas S. P and Dixit V. R. (2002), <i>Pharmaceutical Biotechnology</i>, CBS Publishers and Distributors, New Delhi</p>

<p><b>4.05 TN</b></p>	<p><b>Quality Assurance and Validation in Pharmaceutical Industry</b></p> <ol style="list-style-type: none"> <li>a. Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP) in pharmaceutical industry.</li> <li>b. Quality assurance and quality management in pharmaceuticals ISO, WHO and US certification. Safety in microbiology laboratory.</li> <li>c. Safety profile of drugs:             <ol style="list-style-type: none"> <li>i. Pyrogenicity testing,</li> <li>ii. Mutagenicity and Carcinogenicity testing,</li> <li>iii. Teratogenicity testing,</li> <li>iv. Adverse Drug Reactions,</li> <li>v. <i>In vivo</i> and <i>in vitro</i> drug interactions</li> </ol> </li> </ol>	<ol style="list-style-type: none"> <li>1. Kokate C. K., Purohit A. P., Gokhale A. B. (2000) <i>Pharmacology</i>, 4th Ed., Nirali Prakashan.</li> <li>2. Mannfred A. Holliger, (2008), <i>Introduction to pharmacology</i>, 3rd Ed., CRC Press <b>38</b></li> <li>3. Maron Dorothy M. and Bruce N. Ames, (1983), <i>Revised methods for the Salmonella mutagenicity test</i>, Mutation Research, <b>113:173-215</b></li> <li>4. MAron Dorothy M. and Bruce N. Ames, (1983), <i>Revised methods for the Salmonella mutagenicity test</i>, Mutation Research, 113:173-215</li> <li>5. Osol Arther (1975) <i>Remington's Pharmaceutical Sciences</i>, 15th Ed., Mack Pub. Co., Pennsylvania.</li> <li>6. Sylvie E. Blondelle, Enrique Pe´Rez-Paya, And Richard A. Houghten, (1996), <i>Synthetic Combinatorial Libraries: Novel Discovery Strategy for Identification of Antimicrobial Agents</i>, Antimicrobial Agents and Chemotherapy, 1067–1071</li> <li>7. Vyas S. P and Dixit V. R. (2002), <i>Pharmaceutical Biotechnology</i>, CBS Publishers and Distributors, New Delhi</li> </ol>
<p><b>4.06 TN</b></p>	<p><b>Biopharmaceuticals –Regulations and Sources</b></p> <p>Regulatory authorities and its role: FDA and Pharmacopeia (IP, UK, US)</p> <p>Drug formulations - Carriers and delivery systems, targeted drug delivery, sustained release</p> <p>Pharmacokinetic – ADME / Bioavailability studies</p> <p><b>Sources of biopharmaceuticals -</b></p> <ul style="list-style-type: none"> <li>• <i>E. coli</i> as a source of recombinant, therapeutic proteins</li> </ul>	<ol style="list-style-type: none"> <li>1. Kokate C. K., Purohit A. P., Gokhale A. B. (2000) <i>Pharmacology</i>, 4th Ed., Nirali Prakashan.</li> <li>2. Mannfred A. Holliger, (2008), <i>Introduction to pharmacology</i>, 3rd Ed., CRC Press <b>38</b></li> <li>3. Micheles P. S., Y. L. Khmel'nitsley, J. S. Dordick and D. S. Clark, (1998), <i>Combinatorial Biocatalysis, A Natural Approach to Drug Discovery</i>, Trends in Biotechnol. <b>16</b>, 197.</li> </ol>

	<ul style="list-style-type: none"> <li>• Expression of recombinant proteins in animal cell culture systems</li> <li>• Production systems using yeasts and fungi</li> <li>• Transgenic animals</li> <li>• Transgenic plants</li> </ul>	<ol style="list-style-type: none"> <li>4. Satoskar R. S. &amp; S. D. Bhandarkar (1991) <i>Pharmacology and Pharmacotherapeutics</i>, 12th Ed., Vol. 1 &amp; 2, Popular Prakashan, Mumbai.</li> <li>5. Sylvie E. Blondelle, Enrique Pe´Rez-Paya, And Richard A. Houghten, (1996), <i>Synthetic Combinatorial Libraries: Novel Discovery Strategy for Identification of Antimicrobial Agents</i>, Antimicrobial Agents and Chemotherapy, 1067–1071</li> <li>6. Vyas S. P and Dixit V. R. (2002), <i>Pharmaceutical Biotechnology</i>, CBS Publishers and Distributors, New Delhi</li> <li>7. Walsh Gary, (2003), <i>Biopharmaceuticals Biochemistry And Biotechnology</i>, 2nd Ed., John Wiley &amp; Sons Ltd, England</li> </ol>
<p><b>4.07 TN</b></p>	<p><b>Clinical Microbiology</b> Epidemiological and investigational approaches for emerging infectious diseases:</p> <ol style="list-style-type: none"> <li>a. Viral diseases: SARS (severe acute respiratory syndrome), Avian and Swine influenza</li> <li>b. Diseases by multi-drug resistant bacterial pathogens: Mechanisms of development of drug resistance Vancomycin resistant Enterococci (VRE), Methicillin resistant <i>Staphylococcus aureus</i> (MRSA), Vancomycin resistant <i>Staphylococcus aureus</i> (VRSA) Extended Spectrum Beta Lactamase (ESBL) producers</li> </ol>	<ol style="list-style-type: none"> <li>1. Carpenter Philip L., (1975), <i>Saunders International Edition - Immunology and Serology</i>, W. B. Saunders and Co., London</li> <li>2. David N. Fredricks and David A. Relman, (1996), <i>Sequence-Based Identification of Microbial Pathogens: a Reconsideration of Koch’s Postulates</i>, Clinical Microbiology Reviews, 18–33</li> <li>3. Eduardo A. Groisman and Howard Ochman, (1994), <i>How to become a pathogen</i>, Trends in Microbiology, <b>2(8)</b>:289-294</li> <li>4. Franklin T. J. and Snow G. A., (1975), <i>Biochemistry of Antimicrobial Action</i>, Chapman and Hall, London, 1-22 and 160-174</li> <li>5. Mark J. Pallen<sup>1</sup> &amp; Brendan W. Wren, (2007), <i>Bacterial pathogenomics</i>, Nature Rev. <b>449 18</b>: 835-842</li> <li>6. Schlessinger David, Editor, <i>Biochemical Genetics of Pathogenicity</i>, in Microbiology – 1979, American Society for Microbiology, Washington D. C., 79 - 230</li> <li>7. Schlessinger David, Editor, <i>Mechanism of Microbial Virulence</i>, in Microbiology – 1979, American Society for Microbiology, Washington D. C., 79-230</li> </ol>

	<p>c. Microorganisms as weapons in biological warfare: Examples and significance of microorganisms as weapons - anti-personnel, anti-agricultural and entomological warfare. Offensive and defensive strategies, Tactical advantages.</p>	<p>8. Unsworth K. E. and David W. Holden, (2000), <i>Identification and analysis of bacterial virulence genes in vivo</i>, Phil. Trans. R. Soc. London B. <b>355</b>, 613-622</p> <p>9. Woods D. E., (2002), <i>The use of animal infection models to study the pathogenesis of melioidosis and glanders</i>, Trends Microbiol, 10(11):483-5</p>
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### MB 802 - Molecular Biology II

Credit No	Credit title and content	References
4.08 TC	<p><b>Genomics</b></p> <ul style="list-style-type: none"> <li>• Gene sequencing, conserved genes, finding base sequences which form genes, many proteins from one gene, alternative gene expression: DNA imprinting and Epigenetics.</li> <li>• Genomic variation-SNPs, SNPS and diseases, SNPS and medical therapies. Role of genomic variation in nagging. Costs of prolonged life. Recognition of trades offs associated with genomic variation. Eucaryotic and bacterial SNPS and pharmacogenomics</li> </ul>	<ol style="list-style-type: none"> <li>1. Benjamin Lewin. (2008) <i>Genes IX</i>, Jones and Bartelett Publishers Inc.</li> <li>2. Discovering genomics, Proteomics and Bioinformatics, Malom Campbell and L. J. Heyer 2<sup>nd</sup> Edn., Pearson Publication, 2009.</li> <li>3. James D. Watson, Tania Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Loswick (2004) <i>Molecular Biology of the Gene</i>, 5th Edition, Pearson Education, Inc. and Dorling Kindersley Publishing, Inc.</li> <li>4. Walker J.M., Rapley R. (eds.) <i>Molecular Biology and Biotechnology</i>, 4<sup>th</sup> Ed., 2009, Royal Society Press, U.K.</li> <li>5. Principles and applications of recombinant DNA, B. R. Glick, J.J. Pasterneck, 3<sup>rd</sup> Edn., ASM press.</li> <li>6. S.B Primrose and R M Twyman 2006 7<sup>th</sup> edition. Blackwell publishing</li> <li>7. Weaver R., (2007) <i>Molecular Biology</i>, 4th Edition, McGrew Hill Science.</li> </ol>
4.09 TC	<p><b>Gene technology</b></p> <ul style="list-style-type: none"> <li>• Gene cloning strategies: preparation of gene, genome libraries, cDNA libraries, PCR cloning and</li> </ul>	<ol style="list-style-type: none"> <li>1. B. R. Glick, J.J. Pasterneck, Principles and applications of recombinant DNA, 3<sup>rd</sup> Ed., ASM press.</li> </ol>

	<p>alternatives. Library screening</p> <ul style="list-style-type: none"> <li>• Site directed mutagenesis and protein engineering,</li> <li>• Cloning and manipulating large fragments of DNA ; YAC BAC HAC</li> <li>• Gene transfer to host cells.</li> <li>• Expression vectors</li> <li>• Genetically modified animals and plant , applications of these transgenic plants and animals</li> </ul>	<ol style="list-style-type: none"> <li>2. James D. Watson, Tania Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Loswick (2004) <i>Molecular Biology of the Gene</i>, 5th Edition, Pearson Education, Inc. and Dorling Kindersley Publishing, Inc.</li> <li>3. Lewin’s Genes XI, (2014) Jones and Bartelett Publishers Inc.</li> <li>4. Malom Campbell and L. J. Heyer, <i>Discovering genomics, Proteomics and Bioinformatics</i>, 2<sup>nd</sup> Ed., Pearson Publication, 2009.</li> <li>5. S.B Primrose and R M Twyman 2006 7<sup>th</sup> edition. Blackwell publishing</li> <li>6. Walker J.M., Rapley R. (eds.) <i>Molecular Biology and Biotechnology</i>, 4<sup>th</sup> Ed., 2009, Royal Society Press, U.K.</li> </ol>
<b>4.10 TC</b>	<p><b>Applications of recombinant DNA technology – Production of Secondary Metabolites</b></p> <p>Synthesis of commercial products: Amino acids, ascorbic acid, novel antibiotics, peptide antibodies, biopolymers: gum, rubber, polyhydroxyalkanoates. Unconventional microbial systems for production of high quality protein drugs.</p>	<ol style="list-style-type: none"> <li>1. <i>Discovering genomics, Proteomics and Bioinformatics</i>, Malom Campbell and L. J. Heyer 2<sup>nd</sup> Ed., Pearson Publication, 2009.</li> <li>2. <i>Molecular Biology and Biotechnology</i>, 4<sup>th</sup> Ed., 2009, Royal Society Press, U.K.</li> <li>3. <i>Principles and applications of recombinant DNA</i>, B. R. Glick, J.J. Pasterneck, 3<sup>rd</sup> Ed., ASM press.</li> <li>4. S.B Primrose and R M Twyman 2006 7<sup>th</sup> edition. Blackwell publishing</li> </ol>
<b>4.11 TN</b>	<p><b>Genetically modified plants and animals</b></p> <ul style="list-style-type: none"> <li>• Genetically modified organisms- social and ethical issues</li> <li>• Applications in medicine – prevention, early detection and cure of diseases</li> <li>• Gene augmentation, gene therapy</li> <li>• Applications in agriculture – examples of transgenic plants advantages and disadvantages</li> <li>• Producing useful molecules examples</li> </ul>	<ol style="list-style-type: none"> <li>1. B. R. Glick, J.J. Pasterneck, <i>Principles and applications of recombinant DNA</i>, 3<sup>rd</sup> Ed., ASM press.</li> <li>2. Malom Campbell and L. J. Heyer, <i>Discovering genomics, Proteomics and Bioinformatics</i>, 2<sup>nd</sup> Edn., Pearson Publication, 2009.</li> <li>3. Walker J.M., Rapley R. (eds.) <i>Molecular Biology and Biotechnology</i>, 4<sup>th</sup> Ed., 2009, Royal Society Press, U.K.</li> <li>4. S. B Primrose and R M Twyman 2006 7<sup>th</sup> edition. Blackwell publishing</li> </ol>
<b>4.12 TN</b>	<p><b>Bioremediation and biomass utilization</b></p> <ul style="list-style-type: none"> <li>• Degradation of xenobiotics, engineered degradative</li> </ul>	<ol style="list-style-type: none"> <li>1. B. R. Glick, J.J. Pasterneck, <i>Principles and applications of recombinant DNA</i>, 3<sup>rd</sup> Ed., ASM press.</li> </ol>



	<p>pathways.</p> <ul style="list-style-type: none"> <li>Utilization of starch and cellulose for fructose, alcohol and silage production</li> </ul>	<ol style="list-style-type: none"> <li>Malom Campbell and L. J. Heyer, Discovering genomics, Proteomics and Bioinformatics, 2<sup>nd</sup> Edn., Pearson Publication, 2009.</li> <li>Walker J.M., Rapley R. (eds.) Molecular Biology and Biotechnology, 4<sup>th</sup> Ed., 2009, Royal Society Press, U.K.</li> <li>S. B Primrose and R M Twyman 2006 7<sup>th</sup> edition. Blackwell publishing</li> </ol>
<b>4.13 TN</b>	<p><b>Genome projects</b></p> <ul style="list-style-type: none"> <li>Concept and meaning of genome projects and their applications.</li> <li>Introduction to Genome projects of <i>E. coli</i> yeast, Plasmodium, Fruit fly, Mouse, Drosophila, and Rice and comparative genomics</li> <li>Gene annotation</li> <li>Human Genome project and its applications</li> </ul>	<ol style="list-style-type: none"> <li>B. R. Glick, J.J. Pasternack, Principles and applications of recombinant DNA, 3<sup>rd</sup> Ed., ASM press.</li> <li>Malom Campbell and L. J. Heyer, Discovering genomics, Proteomics and Bioinformatics, 2<sup>nd</sup> Edn., Pearson Publication, 2009.</li> <li>Walker J.M., Rapley R. (eds.) Molecular Biology and Biotechnology, 4<sup>th</sup> Ed., 2009, Royal Society Press, U.K.</li> <li>S.B Primrose and R M Twyman 2006 7<sup>th</sup> edition. Blackwell publishing</li> </ol>

**MB 803 - Microbial Technology**

Credit No.	Credit Title and Contents	References
<b>4.14TC</b>	<p><b>Bioreactor design and operation</b></p> <ol style="list-style-type: none"> <li>Designing of bioreactors - Design aspects CSTRs: The dimensional ratios of the outer shell, and the operational aspects such as working volume, baffles and impellers.</li> <li>The configuration (placement) of impellers in a vessel and the different types of impellers (types of turbines and propellers, and their combinations)</li> <li>Immobilized cell reactors and air-lift reactors – Design and operation.</li> </ol>	<ol style="list-style-type: none"> <li>Bioreactor Design and Product Yield (1992), BIOTOL series, Butterworths Heinemann.</li> <li>Doran Pauline (1995) Bioprocess Engineering Principles, Academic Press.</li> <li>Lydersen B., N. a. D' Elia and K. M. Nelson (Eds.) (1993) Bioprocess Engineering: Systems, Equipment and Facilities, John Wiley and Sons Inc.</li> <li>Ratledge C and Kristiansen B eds. (2001) Basic Biotechnology 2nd Ed. Cambridge Univ. Press. Cambridge</li> </ol>

	d. Batch, Fed-batch and Continuous operation: Applications, advantages and limitations of each type.	
<b>4.15 TC</b>	<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>iii. Fermentation broth rheology and power requirements for agitation – Concept of Newtonian and non-Newtonian fluids, effect of broth rheology on heat, nutrient and oxygen transfer, Reynold’s number, Power number, Aeration number: working out examples using different softwares</p> <p><b>b. Monitoring of process variables:</b> Use of various types of sensors and biosensors for monitoring environmental parameters (pressure, pH, temperature, DO and DCO<sub>2</sub>), Basic principles of operation, types of biosensors</p>	<ol style="list-style-type: none"> <li>1. Lydersen B., N. a. D’ Elia and K. M. Nelson (Eds.) (1993), Bioprocess Engineering: Systems, Equipment and Facilities, John Wiley and Sons Inc.</li> <li>2. Operational Modes of Bioreactors, (1992) BIOTOL series, Butterworths Heinemann.</li> <li>3. Shuichi and Aiba. Biochemical Engineering. Academic Press. 1982</li> <li>4. Stanbury and Whittaker. Fermentation technology</li> </ol>
<b>4.16 TC</b>	<p><b>Microbial Processes and Intellectual property rights</b></p> <p><b>a. Microbial Processes:</b> Upstream, Fermentation and Downstream Processing for the following:</p> <p>iv. Antibiotics (Rifamycin)</p> <p>ii. Microbial enzymes (Chitinase).</p> <p>iii. Exopolysaccharides (Pullulan)</p> <p>iv. Use of immobilized cells / enzymes to produce protease</p>	<ol style="list-style-type: none"> <li>1. Klegerman, M.E and Groves M.J. (1992) Pharmaceutical Biotechnology: Fundamentals and Essentials. Interpharm Press Ltd. Buffalo Grove IL</li> <li>2. Peppler H. J. and D. Perlman (1970) Microbial Technology Volume 1 and 2, Academic Press New York.</li> <li>3. Ponkhshe S. (1988) Management of Intellectual Property, Bhate and Ponkhshe Prakasham, Pune</li> <li>4. Reed G. Ed. Prescott and Dunn’s Industrial Microbiology. 4th Ed., CBS Pub. New Delhi.</li> </ol>

	<p><b>b. Intellectual Property Rights (IPR):</b></p> <ul style="list-style-type: none"> <li>i. Basic concepts of IPR</li> <li>ii. Introduction to forms of IPR – Patents and Designs</li> </ul>	<ul style="list-style-type: none"> <li>5. Van Damme E. J. (1984) Biotechnology of Industrial Antibiotics, Marcel Dekker Inc. New York.</li> <li>6. Wiseman A.(1985) Topics in Enzyme and Fermentation - Biotechnology, Vol. 1 and 2, John Wiley and Sons, New York</li> </ul>
4.17 TN	<p><b>Microbial Growth characteristics and product formation</b></p> <ul style="list-style-type: none"> <li>a. Concept of primary (growth associated) and secondary (growth non-associated) metabolites and their control,</li> <li>b. Kinetics of growth and product formation (growth rate, yield coefficient, efficiency etc.)</li> <li>c. Effect of type of growth on fermentation: The type of growth (mycelial pellet form, mycelial filamentous form, free cell, cells producing exopolysaccharides) affects mass transfer of nutrients, oxygen and heat; as also cell proliferation can be affected by shearing of cells. At least one example of each type may be explained to show these effects in any suitable fermentation.</li> </ul>	<ul style="list-style-type: none"> <li>1. Dubasi Govardhana Rao, Rao 2010 Introduction to Biochemical Engineering Tata Mcgraw- Hill Education</li> <li>2. Peter F. Stanbury. Principles Of Fermentation Technology, 2E, Elsevier (A Division of Reed Elsevier India Pvt. Limited), 2009</li> <li>3. Vijai Kumar Gupta, Monika Schmoll, Minna Maki, Maria Tuohy, Marcio Antonio Mazutt editors Applications of Microbial Engineering. CRC Press 2013</li> </ul>
4.18 TN	<p><b>Use of fungi in industry</b></p> <ul style="list-style-type: none"> <li>a. Food industry, biosensors and fuel cells (Architecture of the fungal cell: cell wall, membranes and cytoskeleton)</li> <li>b. Use of fungi in agriculture and environmental applications: <ul style="list-style-type: none"> <li>i. Biofertilizers, Bioremediation and Biological control.</li> <li>ii. Food industry, biosensors and fuel cells</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>1. C.S.K. Mishra, Ed., Pascale Champagne Associate editor, Biotechnology applications. I.K. International Pvt. Ltd. 2009</li> <li>2. Dilip K. Arora editor, Fungal Biotechnology in agricultural, food and environmental applications (Mycology), 2005. Marcel Dekker, Inc. New York. Basel</li> <li>3. Sudhir U. Meshram, Gangadhar B Shinde, Applied biotechnology. I.K. International Pvt. Ltd. 2009</li> </ul>
4.19 TN	<p><b>Animal cell culture technology to produce:</b></p> <ul style="list-style-type: none"> <li>a. Recombinant forms of natural proteins (insulin, erythropoietin),</li> <li>b. Recombinant vaccines (protein: HIV, hepatitis B and DNA: HIV, malaria),</li> </ul>	<ul style="list-style-type: none"> <li>1. Moo-Young M. ed. (1985) Comprehensive Biotechnology Vol: III &amp; IV, Pergamon Press. N.Y</li> <li>2. Ratledge C and Kristiansen B eds. (2001) Basic Biotechnology 2nd Ed. Cambridge Univ. Press. Cambridge</li> <li>3. U. Satyanarayana, Biotechnology, Books and Allied (p) limited.</li> </ul>

	<p>c. Recombinant enzymes(lipase, restriction endonuclease),</p> <p>d. Monoclonal antibodies</p> <p>e. Nucleic acid-based products (introduction to gene therapy)</p>	2005
<b>4.20 TN</b>	<p><b>Principles of Validation Process / Method Validation:</b></p> <p>a. The concept of ISO Certification.</p> <p>b. Preparation of SOPs</p> <p>c. Validation protocols for methods in:</p> <p style="padding-left: 20px;">i. Quality Control</p> <p style="padding-left: 20px;">ii. Process validation</p> <p><i>The above should be discussed within WHO Norms.</i></p> <p><i>Exercises on preparation of SOPs, operation and validation for analytical methods</i></p>	<p>1. Supplementary Training Modules on Good Manufacturing Practice. Validation-WHO Technical Report Series, No.937, 2006, Annex 4.</p> <p>2. The FDA’s draft process validation Guidance-A perspective from industry. By Naula Calnan, Alice Redmond and Stan O’ Neill. Process Validation Guidance</p>

## Dissertation

### MB 811 and 812

1. A dissertation can be carried out by a single student or by group of students where the group should not contain more than three students. The dissertation report will be prepared as per the thesis format. Submission of the dissertation report will be at least three days before the date of examination. One copy of the report will be preserved in the department. If there is more than one student carrying out a single dissertation, a single report can be submitted and these students will be assessed based on single oral presentation. In such case, presentation should be carried out by all the students carrying out the same work; dividing the presentation equally among them.
2. At the time of presentation, the external and internal examiners appointed by the university will be present; the dissertation guide may or may not be present.
3. Presentation should be carried out to an audience comprising of examiners appointed by the university, departmental teaching staff and the postgraduate students of the department. Oral presentation can be carried out using posters, blackboard, transparencies, model or LCD projector. The allotted time for each oral presentation (one project) should be 10 to 12 minutes, followed by question-answer session of 5 to 8 minutes. The audience can participate in this session.

4. The assessment of the dissertation is for total of 200 marks, out of which the university examinations assessment – end-semester - will be for 100 marks and the in-semester assessment will be for 100 marks.
5. The marks (200) should be divided as 100 + 100. The assessment of first 100 marks (in-semester examination for both courses) will be carried out by the guide who has supervised the work of the candidate(s) throughout the semester. The assessment will be carried out on the basis of the points, as per the accompanied format of the mark sheet. Head of the department should communicate this point-wise assessment system to the dissertation supervisor (Guide), well in advance. Guide will give appropriate marks, point-wise and submit it in a sealed envelope to the Head of the respective department, three days prior to examination and project presentation. On the day of examination, Head of the department will hand over these unopened envelopes to the examiners.
6. Assessment of second 100 marks (end-semester examination for both courses) will be carried out (i.e. oral presentation) for individual student at the time of examination jointly by internal and external examiners. The assessment will be carried out on the basis of the points as per the accompanied format of the mark sheet.
7. Students should be made aware of the assessment parameters, on which they will be assessed at the end of the fourth semester.
8. The external and internal examiners by mutual agreement will appropriately settle the marks given by the guide (reconsider, if necessary) and marks of oral presentation, for both the courses (MB 811 and MB 812) and submit the mark lists to the Coordinator of the M. Sc. Examination Panel for that examination.

**SAVITRIBAI PHULE PUNE UNIVERSITY**

**Practical Examination in M. Sc. Microbiology *Month - Year***

**Course MB – 811 and MB – 812**

Name of the center: \_\_\_\_\_

Name of the student: \_\_\_\_\_ Exam No.: \_\_\_\_\_

**Point-wise mark sheet – to be filled in by the Guide  
(Based on the evaluation carried out throughout the period of dissertation work)**

Points for Evaluation	Max. Marks	Evaluation
Intellectual potential – Understanding of the research problem by the student	10	
Research aptitude –		
a) Depth of literature survey for the proposed work.	10	
b) Inputs of student in development of plans and protocols for the experimentation	20	
c) Ability to analyze data and formulate a solution	10	
d) Analytical and reasoning abilities of the student for interpretation of data, inputs in discussion	15	
Motivation – punctuality, meeting dead-lines and seriousness	05	
Ability to work with others	05	
Maturity of scientific thoughts	05	
Communication skill – oral and written	20	
<b>Total</b>	<b>100</b>	

***These marks are to be distributed equally (out of 50) for both courses as in-semester evaluation***

Place of work : \_\_\_\_\_

Name of the Guide : \_\_\_\_\_

Signature : \_\_\_\_\_

Date: \_\_\_\_\_

**SAVITRIBAI PHULE PUNE UNIVERSITY**

**Practical Examination In M. Sc. Microbiology Month - Year**

**Course MB – 811 and MB - 812**

Name of the center: \_\_\_\_\_

Name of the student: \_\_\_\_\_ Exam No.: \_\_\_\_\_

**Point-wise mark sheet – to be filled in by the External examiner  
(Based on oral presentation and *viva-voce* of the dissertation as end-semester evaluation)**

<b>Points for Evaluation</b>	<b>Max. Marks</b>	<b>Evaluation</b>
Proficiency of presentation skills – use of audio-visual aids, preparation of graphs, charts, models, etc., use of scientific language	20	
Research potential of the work, results and interpretation, outcome of the study and possible future plans, publication potential of the work	15	
The dissertation report preparation (scientific writing) and its contents	10	
Abilities of satisfactory responses to the queries from the audience	05	
<b>Total</b>	<b>50</b>	

Name of the External Examiner :

Signature :

Date:

**SAVITRIBAI PHULE PUNE UNIVERSITY**

**Practical Examination in M. Sc. Microbiology Month - Year**

**Course MB – 811 and MB - 812**

Name of the center: \_\_\_\_\_

Name of the student: \_\_\_\_\_ Exam No.: \_\_\_\_\_

**Point-wise mark sheet – to be filled in by the Internal Examiner  
(Based on oral presentation and *viva-voce* of the dissertation as end-semester evaluation)**

<b>Points for Evaluation</b>	<b>Max. Marks</b>	<b>Evaluation</b>
Proficiency of presentation skills – use of audio-visual aids, preparation of graphs, charts, models, etc., use of scientific language	20	
Quality of the work, results and interpretation, outcome of the study and possible future plans, publication potential of the work	10	
Submission of progress reports, the dissertation report preparation (scientific writing) and its contents	15	
Abilities of satisfactory responses to the queries from the audience	05	
<b>Total</b>	<b>50</b>	

Name of the Internal Examiner :

Signature :

Date: