

**NORTH MAHARASHTRA UNIVERSITY,  
JALGAON**



**SYLLABUS**

**Master of Science  
in  
Microbiology**

**Part-II  
(Semester – III and IV)**

**w. e. f. June 2016 -2017**

NORTH MAHARASHTRA UNIVERSITY, JALGAON  
**MICROBIOLOGY**

Syllabus for M.Sc. (Part- II) Microbiology

Effective from June 2016 -2017

Subject code	Title of the paper	Duration (Hrs./Wk)	Max. Marks	Exam. Time (Hrs.)
<b>SEMESTER – III</b>				
<b>Theory courses</b>				
MB-301	Applied and Environmental Microbiology	<b>04</b>	<b>100</b>	<b>03</b>
MB-302	Molecular Biology and Bioinformatics	<b>04</b>	<b>100</b>	<b>03</b>
MB-303	Pharmaceutical Microbiology	<b>04</b>	<b>100</b>	<b>03</b>
<b>Laboratory courses</b>				
MB-304	Methods in Biostatistics and Bioinformatics	<b>04+04</b>	<b>100</b>	<b>06</b>
MB-305	Methods in Applied Microbiology	<b>04+04</b>	<b>100</b>	<b>06</b>
<b>SEMESTER – IV</b>				
<b>Theory courses</b>				
MB-401	Fermentation Technology	<b>04</b>	<b>100</b>	<b>03</b>
MB-402	Applied Molecular Biology	<b>04</b>	<b>100</b>	<b>03</b>
MB-403	Agricultural Microbiology	<b>04</b>	<b>100</b>	<b>03</b>
<b>Laboratory courses</b>				
MB-404	Methods in Biotechnology	<b>04+04</b>	<b>100</b>	<b>06</b>
MB-405	Laboratory course (Project Dissertation)	<b>04+04</b>	<b>100</b>	<b>06</b>

**Instructions:**

1. Each theory course has to be completed in 50 lectures of 60 min duration each in one semester.
2. Semester II and IV will have THREE theory courses and TWO Practical courses
3. Practical examination of each laboratory course shall be conducted at the end of each respective semester.
4. Each course will be of 100 marks (40 marks internal assessment and 60 marks-external examinations) in the School of Life Sciences of NMU, Jalgaon.

SEMESTER III

<b>MB-301 Applied and Environmental Microbiology</b>		<b>Lectures</b>
<b>Unit I</b>	<p><b>Food Microbiology</b></p> <ul style="list-style-type: none"> <li>• Methods of sampling and investigation</li> <li>• Preparation of dilutions</li> <li>• Offline and online approach of microbial analysis</li> <li>• Detection and enumeration of indicator bacteria, pathogenic and toxigenic microbes</li> <li>• Mycotoxins</li> <li>• Microbiological examination of specific foods                             <ul style="list-style-type: none"> <li>○ Meat and meat products</li> <li>○ Milk and milk products</li> </ul> </li> <li>• Food intoxications: Causes, pathogenesis and prevention and control</li> </ul>	10
<b>Unit-II</b>	<p><b>Microbiological treatment of waste water</b></p> <ul style="list-style-type: none"> <li>• Principles and need for biological waste water treatment</li> <li>• Conventional treatment process                             <ul style="list-style-type: none"> <li>Primary- Sedimentation or settling</li> <li>Biological treatment process: Aerobic suspended-growth, Aerobic attached-growth (TF, RBC, PBR), Anaerobic suspended growth and Anaerobic attached growth                                     <ul style="list-style-type: none"> <li>- Advanced tertiary process: Solids removal</li> <li>- Biological nitrogen removal</li> <li>- Biological phosphorus removal</li> <li>- Disinfection</li> </ul> </li> </ul> </li> <li>• Waste water treatment for distillery and antibiotic industries</li> <li>• Solid waste management                             <ul style="list-style-type: none"> <li>○ Composting: Principle, chemistry and biology of composting, technology of composting, criteria of compost maturity, applications of compost</li> <li>○ Biomethanation: Feedstocks, BMP, microbiology of biomethanation, biochemistry of methane synthesis.</li> </ul> </li> </ul>	10
<b>Unit- III</b>	<p><b>Biological conversion of Lignocellulosic waste</b></p> <ul style="list-style-type: none"> <li>• Composition, structure of lignocelluloses and issues</li> <li>• Pre-treatment of lignocellulosic material: Physical, Chemical and Biological</li> <li>• Fermentation: Submerged, SSF, SHF, SS<sub>C</sub>F</li> <li>• Applications in lignocellulosic ethanol production</li> </ul>	10
<b>Unit- IV</b>	<p><b>Bioremediation and biodegradation of xenobiotics</b></p> <ul style="list-style-type: none"> <li>• Concept of biodegradability and bioconversion</li> <li>• Principles for measuring biodegradability</li> <li>• Mechanism of biodegradation / bioremediation</li> <li>• Methods for bioremediation: Intrinsic, Biostimulation, and Bioaugmentation</li> <li>• Impediments to microbial degradation of compounds</li> <li>• Biodegradation of xenobiotics</li> </ul>	10

	<ul style="list-style-type: none"> <li>○ Biochemical/ physiological approach</li> <li>○ Molecular techniques</li> <li>○ Toxicological risk assessments</li> </ul>	
<b>Unit- V:</b>	<b>Biomarkers and Bioreporters</b> <ul style="list-style-type: none"> <li>● Concept and approaches to metagenomics analysis, ecological inference</li> <li>● Biomarker gene (antibiotic and heavy metal resistance genes, ice-nucleation, bioluminescence genes, green fluorescent genes)</li> <li>● Bioreporter genes</li> <li>● Biosensor</li> </ul>	10

### References:

- Singh, A. and Ward, O. P. (2004) Biodegradation and Bioremediation, Springer-Verlag,, Berlin (ISBN: 3-540-21101-2)
- Hurst, C.J. (2002) Manual of Environmental Microbiology, ASM Press, Washington D.C. (ISBN: 1-55581-199-x)
- Demain, A. L. and Davies, J. E. (1999) Manual of Industrial Microbiology and Biotechnology, ASM Press, Washington D.C. (ISBN: 1-55581-128-0)
- Martin, A. M. (1998) Bioconversion of waste materials to Industrial Products, Blackie Academic and Professional, London (ISBN: 0-7514-0423-3)
- Harrigan, W. F. and McCance, M.E. (1994) Laboratory Methods in Food and Dairy Microbiology. Academic Press, London
- Mossel, D.A.A., Correy, J.E.L., Struijk, C.B. and Baird, R. M. (1995) Esesentials of the Microbiology of Foods, John-Wiley and Sons Inc., New York.
- Satyanaraya, U. (2005) Biotechnology, Books and Allied (P) Ltd., Kolkata
- Hobbs, B & Roberts, D. (1993) Food Poisoning & Food Hygiene, Edward Arnold, London
- Baker, K.H. and Herson, D. S. (1994) Bioremediation, Mc-Graw Hill Inc., New York.
- Pandey, A. (2004) Concise Encyclopedia of Bioresource Technology, Food Products Press, The Haworth Reference Press, New York (ISBN: 1-56022-980-2)
- Rehm, R. G. and Reed, G. (1984) Biotechnology, Vol.1-8, Verlag-Chemie, Weinheim.
- Forster, C. F. (1985) Biotechnology and waste water treatment, Cambridge Univeristy Press, Cambridge.
- Maier, R. Pepper, I. L. and Gerba, C. P. (2000) Environmental Microbiology, Academic Press, London

<b>MB-302 Molecular Biology and Bioinformatics</b>		<b>Lectures</b>
<b>Unit I:</b>	<b>Basics molecular biology</b> <ul style="list-style-type: none"> <li>● DNA: topological properties (linking, writhing, twisting number), Structure of super helix, Base flipping, Palindrome, Inverted repeats and stem and loop.</li> <li>● Overview of DNA replication</li> <li>● RNA: Structure, types and functions</li> <li>● Denaturation and renaturation kinetics of nucleic acids</li> <li>● Proteins: Domain and motifs Histone proteins,</li> <li>● DNA –Protein interactions - helix-loop-helix, helix-turn-helix, leucine zipper, Zinc finger motifs,</li> </ul>	10
<b>Unit II</b>	<b>Transcription</b>	10

	<ul style="list-style-type: none"> <li>• Types of RNA polymerase (prokaryotic &amp; eukaryotic), Process of transcription</li> <li>• mRNA processing, editing: capping, adenylation, splicing, RNA transport</li> <li>• Transcriptional regulation: transcriptional bursting/pulsing, specificity factors, enhancers, repressors, activators and general transcription factors</li> <li>• Post-transcriptional modifications:, RNA degradation, nuclear transport, mRNA localization, anti-sigma factors, RNAi (siRNA, miRNA and CRISPR mechanism)</li> </ul>	
<b>Unit III:</b>	<b>Translation</b>	10
	<ul style="list-style-type: none"> <li>• Ribosome (structure and composition), Activation of tRNA, tRNA synthetase</li> <li>• Genetic code and its properties</li> <li>• Steps: Initiation: factors and their regulation, Elongation, Termination</li> <li>• Inhibitors</li> <li>• Post translational modification of proteins and protein degradation</li> <li>• Translational regulation: Cytoplasmic polyadenylation, UTR sequence elements, RNA binding proteins, ribosomal regulation, non-sense mediated RNA decay, 5` decapping</li> </ul>	
<b>Unit IV</b>	<b>Protein targeting &amp; degradation</b>	10
	<ul style="list-style-type: none"> <li>• Signal hypothesis</li> <li>• Signal sequences in bacteria</li> <li>• Membrane and Lysosomal protein targeting</li> <li>• HSP and Chaperons</li> <li>• Protein degradation</li> </ul>	
<b>Unit V</b>	<b>Basic Bioinformatics</b>	10
	<ul style="list-style-type: none"> <li>• Biological databases :Nucleic acid databases (GenBank, EMBL, DDBJ)</li> <li>• Protein sequence data base (UniProt, PDB)</li> <li>• Scoring matrices, local. global and multiple sequence alignment</li> <li>• Database search for homologous sequences, BLAST</li> <li>• Phylogenetic analysis: Overview and tree construction methods</li> </ul>	

#### References:

- Lewin B. (2013) Gene XI, Pearson Prentice Hall, Pearson Education, Inc., NT, USA (ISBN: 0-13-123826-4)
- Malacinski GM (2003) Essentials of Molecular Biology, 4<sup>th</sup> edn., Jones & Batiett, London. (ISBN: 0-7637-2133-6)
- Watson JD, Baker JA, Bell SP, Gann A, Lewin M, Losick R (2004) Molecular Biology of the Gene, Benjamin Cummings- CSHL Press, USA
- Stryer, Lubert () Biochemistry 5<sup>th</sup> edn. W. H. Freeman & Co. New York
- Wink M. (2006) An Introduction to Molecular Biotechnology, Wiley-VCH Verlag GmbH & Co., Weinheim, Germany (ISBN: 978-3-527-31412-6/3-527-31412-1)
- Weaver, RF (1999) Molecular Biology, WCB McGraw-Hill Co. Inc., NY (ISBN: 0-697-14750-9)
- Brown, TA (1995) Essential Molecular Biology, Vol. I, A Practical Approach, IRL Press, Oxford, UK
- Nelson DL & Cox MM (2005) Lehninger's Principles of Biochemistry, 4<sup>th</sup> edn.,

- McMillan Worth Publ. Inc. NY
- Russell, PJ (1998) Genetics, 5<sup>th</sup> edn, Benjamin-Cummings Publ. Co. Inc., NY (ISBN: 0-321-0038-2)
  - Oliver, RP and Schweizer, M. (1999) Molecular Fungal Biology, Cambridge University Press, Cambridge, UK (ISBN: 0-521-56784-X)
  - Klug, WS and Cummings, MR (2003) Concepts of Genetics, 7<sup>th</sup> edn., Pearson Education Inc., (ISBN: 81-7808-884-3)
  - Bates, AD and Maxwell, A (2006) DNA Topology, Indian Edn., Oxford University Press, New Delhi (ISBN: 0-19-56831-X)
  - Turner, PC, McLennan, AG, Bates AD and White, MRH (2002) Instant Notes: Molecular Biology, 2<sup>nd</sup> edn., Viva Books Pvt. Ltd., New Delhi (ISBN: 81-7649-215-9)
  - Lesk, AM (2002) Introduction to Bioinformatics, Oxford University Press, UK (ISBN:0-19-925196-7)
  - Korf, I, Yandell, M and Bedell, J () An essential guide to the Basic Local Alignment Search Tool-BLAST O'Reilly Network Publishers, (ISBN: )
  - Baxevanis, A. D. and Ouellette, B. F. F. (2001) Bioinformatics: A practical guide to the analysis of genes and proteins. Second Edition. John Wiley & Sons, New York.
  - Mount, D. W. (2001) Bioinformatics: sequence and genome analysis. Cold Spring Harbor Laboratory Press, New York.
  - Zoe L. and Terence C. (2004) Bioinformatics: Managing Scientific Data, Morgan Kaufmann Publishers, New Delhi.

<b>MB-303      Pharmaceutical Microbiology</b>		<b>Lectures</b>
<b>Unit I</b>	<b>Antibiotics and Synthetic antimicrobial agents</b>	<b>10</b>
	Mechanism of action, microbial resistance, therapeutic, prophylactic usage and adverse reactions <ul style="list-style-type: none"> <li>• Antibiotic and Synthetic antimicrobial agents: <math>\beta</math>-lactam, aminoglycosides, tetracyclines, ansamycins, macrolides</li> <li>• Antifungal antibiotics: Griseofulvin</li> <li>• Antiviral drugs: Amantidines, Nucleoside analogues, Interferons</li> <li>• Peptide antibiotics</li> <li>• Synthetic antibiotics: Sulphonamides, Chloramphenicol, Quinolone</li> </ul>	
<b>Unit II</b>	<b>Microbial aspects of pharmaceutical products</b>	10
	<ul style="list-style-type: none"> <li>• Microbial contamination</li> <li>• Microbial spoilage (Types &amp; factors affecting) &amp; preservation</li> <li>• Sterilization of pharmaceuticals (survivor curve, D, Z, F value) <ul style="list-style-type: none"> <li>○ Methods: Heat, Gaseous, Radiation, Filtration</li> <li>○ Disinfectants</li> </ul> </li> </ul>	
<b>Unit III</b>	<b>Regulatory aspects and quality assurance in pharmaceuticals</b>	<b>10</b>
	<ul style="list-style-type: none"> <li>• GMP in pharmaceuticals</li> <li>• FDA regulation and pharmacopeia</li> <li>• Design of sterile product manufacturing unit</li> <li>• Quality control in pharmaceuticals: In-process &amp; final product control and ICH process</li> <li>• Sterilization control and sterility validation</li> </ul>	
<b>Unit V</b>	<b>Production of Biopharmaceuticals</b>	<b>10</b>
	<ul style="list-style-type: none"> <li>• Asperaginase, and Clinical dextran</li> <li>• Vaccines (DNA/ multivalent subunit/ bacterial)</li> </ul>	

	<ul style="list-style-type: none"> <li>Viral vaccines: Live attenuated, Inactivated, , Live recombinant Virion subunit vaccines, production of viruses for vaccines, Virus-like particles, Synthetic peptide vaccines,</li> <li>Immunosera</li> </ul>	
<b>Unit VI</b>	<b>Drug design</b>	<b>10</b>
	<ul style="list-style-type: none"> <li>Rational drug design <ul style="list-style-type: none"> <li>Lead drug and Pro-drug</li> <li>Structure based and combinatorial approach</li> <li>Peptidomimetic and strategies for drug discovery</li> </ul> </li> <li>Drug delivery : Concept and approaches</li> </ul>	

### References:

- Hugo, WB and Russell, AD (2003/1998) Pharmaceutical Microbiology, 6<sup>th</sup> edn, Blackwel Science, Oxford, UK (ISBN: 0-632-04196-X) Reprinted
- Krogsgaard-Larsen, P., Lilijefors, T. and Madsen, U. (2004) Textbook of Drug Design and Discovery, 3<sup>rd</sup> edn., Taylor and Francis, London (ISBN: 0-415-28288 PB)
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- Seth SD (2004) Textbook of Pharmacology, 2<sup>nd</sup> edn., Elsevier, New Delhi (ISBN: 81-8147-553-4)
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- Chakraborty C and Bhattacharya A (2004) Pharmacogenomics: An approach to New Drug Development. Biotech Books, New Delhi (ISBN: 81-7622-105-8)

<b>MB 304 Methods in Biostatistics and Bioinformatics</b>	
1	Calculate mean, median, mode, range, variance, standard deviation, standard error, confidence interval using MS-Excel/suitable software
2	Plot straight Line (Linear Least squares) using LINEST Function of MS-excel/suitable software
3	Plot - line, scatter graphs, bar graphs, error bars using MS-Excel/suitable software
4	Determine: linear regression, Correlation and their coefficients using MS-Excel/suitable software
5	Compute paired and unpaired, F-test, t-test, using MS-Excel/suitable software
6	Compute ANOVA, $\chi^2$ -test using MS-Excel/suitable software
7	Biological databases – NCBI, Protein Data Bank and ExPasy
8	Primary and tertiary structure analysis of protein/ DNA using BLAST
9	Multiple sequence alignments using Clustal W
10	Phylogenetic tree analysis using MEGA 5.
11	Primer designing using biological software
12	Demonstration of Microplate Reader
13	Demonstration of HPLC for analysis of microbial metabolite

## References:

- Bailey, N.T.J (1959) Statistical methods in Biology, ELBS and The English Universities Press Ltd., UK
- Irfan Ali Khan and Atiya Khanum (2004) Fundamentals of biostatistics, Ukaaz Publication, Hyderabad.
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- Gore A, Paranjpe, S. and Kulkarni M. (2009) Statistics for everyone, SIPF Academy Publishers, Nashik
- Baxevanis, A. D. and Ouellette, B. F. F. (2001) *Bioinformatics: A practical guide to the analysis of genes and proteins*. Second Edition. John Wiley & Sons, New York.
- Ewens Warren J. and Gregory R. Grant. (2004) *Statistical Methods in Bioinformatics, An Introduction*, Springer, New York.
- Lacroix, Z. and Critchlow, T. (Eds.) 2003. *Bioinformatics. Managing Scientific Data*. Morgan Kaufmann Publishers.
- Misener, S. and Krawetz, S. A. (Eds.). 2000. *Methods in Molecular Biology*, Volume 132. Bioinformatics: Methods and Protocols. Humana Press, New Jersey.
- Mount, D. W. (2001) *Bioinformatics: sequence and genome analysis*. Cold Spring Harbor Laboratory Press, New York.

MB 305 Methods in Applied Microbiology	
1	Survivor curve for Ultraviolet light/Heat /ethylene oxide
2	Validation of autoclave
3	Phenol coefficient (Rideal Walker Test/ Chick Martin Test),
4	Sterility testing of in-process materials and finished products
5	Evaluation of carcinogenicity using Ames test
6	Microbial Assay of Vitamin
7	Microbial Limit Test (analysis of water, raw material, finished product, packaging material, Excipients)
8	Environmental monitoring of samples from production areas and personnel.
9	Evaluation of quality of media/reagents for Growth promotion tests.
10	Endotoxin/pyrogen using LAL (water, in-process, final product)
11	Validation of efficiency of laminar air flow
12	Demonstrations : Lyophilization
13	Demonstration of LCMS for analysis of microbial product

## References:

- White, D (2000) The Physiology and Biochemistry of Prokaryotes, Oxford University Press, Oxford
- Mudili, J (2007) Introductory Practical Microbiology, Narosa Publ. House Pvt. Ltd., New Delhi (ISBN: 978-81-7319-744-4)
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- Sawhney, SK and Singh, R. (2001) Introductory Practical Biochemistry, Narosa Publ. House, Chennai



## SEMESTER – IV

<b>MB-401 Fermentation Technology</b>		<b>Lectures</b>
<b>Unit I</b>	<b>Underlying principles, Upstream processing</b> <ul style="list-style-type: none"> <li>• Metabolic pathways and control mechanisms</li> <li>• Fermentation- kinetics of batch and continuous culture</li> <li>• Designing of medium and strain improvement</li> <li>• Microbial growth kinetics and measurement of cell growth</li> <li>• Stoichiometry of microbial growth and product formation</li> </ul>	10
<b>Unit II</b>	<b>Bioreactors ( Design and Application) bioreactor operation</b> <ul style="list-style-type: none"> <li>• Design and construction materials of bioreactor</li> <li>• Parameters involved in fermentation process monitoring</li> <li>• Aeration and agitation for mass transfer</li> <li>• Strategy for medium sterilization, maintenance of aseptic/axenic condition</li> <li>• Control of process parameters and overview of process automation</li> <li>• Scale up and production economics</li> </ul>	10
<b>Unit III</b>	<b>Downstream processing and product recovery</b> <ul style="list-style-type: none"> <li>• Biomass harvesting: centrifugation, filtration</li> <li>• Cell disruption: ultrasonication, thawing, enzymatic way.</li> <li>• Product extraction: Liquid –liquid, supercritical fluid extraction, ultrafiltration, Three phase partitioning</li> <li>• Product purification and characterization: Chromatography-adsorption, size exclusion, affinity, ion exchange, reverse phase, HPLC</li> </ul> <b>Quality practices and audit</b> <ul style="list-style-type: none"> <li>• Quality practices- concept of SOP, GLP and role of FDA</li> <li>• Biosafety aspects of handling infectious organisms</li> <li>• IPR: Patents, copyrights, trademarks, geographical indications</li> <li>• Patenting biological materials, transgenic materials</li> <li>• Patent regulatory bodies at National and International level</li> </ul>	10
<b>Unit IV</b>	<b>Microbial Products I</b> <ul style="list-style-type: none"> <li>• Enzymes: Protease, asparaginase</li> <li>• Organic acids: citric acid, lactic acid</li> <li>• Amino acids: Lysine, aspartic acid</li> <li>• Polysaccharides: Alginate, Hyaluronic acid</li> </ul>	10
<b>Unit V</b>	<b>Microbial Products II</b> <ul style="list-style-type: none"> <li>• Antibiotics: Penicillin, streptomycin</li> <li>• Ethanol: 1st, 2nd and 3rd generation</li> <li>• Vaccines production: DPT, MMR</li> <li>• Recombinant proteins: Insulin, Monoclonal antibodies</li> <li>• Nucleotides: IMP, GMP</li> </ul>	10
<b>References:</b> <ul style="list-style-type: none"> <li>• Mukhopadhyay, S.N. (2004) Process Biotechnology Fundamentals, 2nd edn., Viva Books, Mumbai, (ISBN: 81-7649-496-8)</li> </ul>		

- Shuler M.L. and Kargi F (2008) "Bioprocess Engineering--basic Concepts", 2<sup>nd</sup> Edn. Prentice-Hall
- The Indian Environmental Protection Act (EPA), 1986
- Food Safety and Standards act (Government of India), 2006
- El-Mansi, EMT, Bryce, CFA, Demain, AL and Allman, AR (2007) Fermentation Microbiology and Biotechnology, 2nd edn., CRC Taylor & Francis Group, Boca Raton, Florida (ISBN: 0-8493-5334-3)
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- Goodfrey, T. and Reichelt, JR (1997) Industrial Enzymology, 2nd edn., McMillan Publ. Co., London
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<b>MB-402 Applied Molecular Biology</b>		<b>Lectures</b>
<b>Unit I</b>	<b>Tools of molecular biology (or rDNA technology)</b> <ul style="list-style-type: none"> <li>• <b>Enzymes:</b> Restriction endonucleases and its types, DNA methylases, DNA polymerase, DNA ligases, Kinases, Phosphatases, topoisomerase</li> <li>• <b>Cloning vectors:</b> Choice and its properties, Bacterial vectors: plasmid, Bacteriophage, Cosmids, Phagmids, BACs. Eukaryotic vectors: YACs, Ti, SV40</li> <li>• <b>Cloning hosts:</b> Prokaryotic and eukaryotic hosts: properties</li> </ul>	<b>10</b>
<b>Unit II</b>	<b>Methods in rDNA technology</b> <ul style="list-style-type: none"> <li>• Vector mediated and chromosomal integration</li> <li>• Genomic and cDNA library construction</li> <li>• Gene transfer techniques: Transfection, Electroporation, Microinjection, Biolistic</li> <li>• <b>Screening, analysis and confirmation of rDNA</b> <ul style="list-style-type: none"> <li>○ Genetic methods</li> <li>○ Hybridization techniques – Dot Blot, Colony, Dip stick, Plaque</li> <li>○ Immunochemical methods</li> <li>○ Plus and minus screening, HRT and HART</li> <li>○ Analysis – Restriction mapping, Blotting techniques</li> <li>○ Confirmation by genetic marker and reporter genes</li> </ul> </li> <li>• <b>Applications of genetic engineering</b></li> </ul>	<b>10</b>
<b>Unit III</b>	<b>Microbial Genomics</b> <ul style="list-style-type: none"> <li>• <b>Concept of -</b> Genome density, GC content, CPG Islands, Isochores, codon usage bias, cDNAs and ESTs, Contigs, epigenomics</li> <li>• <b>Structural, Functional, Application and Comparative Genomics:</b></li> </ul>	<b>10</b>

	<ul style="list-style-type: none"> <li>○ Methods for whole genome sequencing, gene annotation</li> <li>○ Gene and SNP identification</li> <li>○ Genome mapping (Conjugation, Recombination and complementation) and map integration</li> <li>● Genome editing using CRISPR-<i>cas</i> system</li> </ul>	
<b>Unit IV</b>	<b>Protein Engineering and Proteomics</b>	<b>10</b>
	<ul style="list-style-type: none"> <li>● <b>Protein identification and Expression Mapping:</b> 2D-gel electrophoresis, Mass Spectrophotometry and isotope labelling</li> <li>● <b>Protein-ligand docking</b></li> <li>● <b>Experimental approach to Protein-Protein interaction mapping:</b> <ul style="list-style-type: none"> <li>○ Yeast and Bacterial 2-hybrid systems</li> <li>○ Protein-ligand interactions</li> <li>○ Protein fragment complement assays</li> </ul> </li> <li>● <b>Protein arrays and chips:</b> Antibody and peptide arrays</li> </ul>	
<b>Unit V</b>	<b>Techniques in Molecular biology</b>	<b>10</b>
	<ul style="list-style-type: none"> <li>● DNA Sequencing : Sanger, Maxam Gilbert and high throughput [Polony, 454 pyrosequencing, Illumina (Solexa), Massively parallel signature sequencing (MPSS), SOLiD, Ion Torrent semiconductor, single molecule, Single molecule real time (SMRT)]</li> <li>● PCR: Basics, Reverse transcriptase PCR, Real time PCR, Applications</li> <li>● Analysis of polymorphism: RFLP, RAPD, AFLP, SSCP, DGGE</li> <li>● Analysis of gene expression : SAGE, Microarray</li> </ul>	

#### References:

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<b>MB-403 Agricultural Microbiology</b>		<b>Lectures</b>
<b>Unit I</b>	<b>Microbial ecology</b> <ul style="list-style-type: none"> <li>● Basic microbial ecology</li> <li>● Microbial interactions</li> <li>● Microbial communities</li> </ul>	<b>10</b>

	<ul style="list-style-type: none"> <li>• Methods to quantitative microbial ecology</li> </ul>	
<b>Unit II</b>	<p><b>Microbial interactions with plant roots</b></p> <ul style="list-style-type: none"> <li>• Rhizosphere and its anatomy</li> <li>• Mycorrhizae (VAM, OM, EM, Ectomycorrhizae)</li> <li>• Plant Growth Promoting Rhizobacteria (PGPR)</li> <li>• Strategies for rhizosphere and mycorrhizae community study</li> </ul> <p><b>Microbial interaction with aerial plant structure</b></p> <ul style="list-style-type: none"> <li>• Phylloplane, Stems/ flowers, leaf buds</li> <li>• Approaches for studies</li> </ul> <p><b>Leguminous root nodules</b></p> <ul style="list-style-type: none"> <li>• Nodulation process and mechanism of nitrogen fixation</li> <li>• Strategies to study infection process, root nodulation and N<sub>2</sub> fixation</li> </ul>	<b>10</b>
<b>Unit III</b>	<p><b>Pathogenic interactions with plants</b></p> <ul style="list-style-type: none"> <li>• Plant defence mechanisms (structural, biochemical, HR, SAR)</li> <li>• Microbial pathogenicity mechanisms in virus, bacteria, fungal pathogens</li> <li>• Genetic basis of plant-pathogen interactions</li> <li>• Region-specific plant diseases (etiology, symptoms and control): Red rot of sugarcane, Sigatoka disease of banana, Banana bunchy top, Tikka disease of groundnut, Powdery mildew, Rust</li> </ul>	<b>10</b>
<b>Unit IV</b>	<p><b>Microbial Biocontrol Agents</b></p> <ul style="list-style-type: none"> <li>• Strategies for plant disease management</li> <li>• Biopesticides: BT, Siderophore and <i>Trichoderma</i>; <i>Pseudomonas</i></li> <li>• Biocontrol of post-harvest diseases</li> <li>• Control of plant pathogens by genetic engineering</li> </ul>	<b>10</b>
<b>Unit V</b>	<p><b>Current approaches</b></p> <ul style="list-style-type: none"> <li>• Integrated Plant Nutrition through biofertilizers</li> <li>• Phytoremediation: Rhizodegradation</li> <li>• Rhizosphere engineering</li> <li>• Microbial reclamation of saline and sodic soils</li> </ul>	<b>10</b>

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<b>MB-404 Methods in Biotechnology</b>	
1	Isolation and estimation of RNA / mRNA from bacteria/ yeast/ fungi
2	Determination of T <sub>m</sub> and % (G+C) of DNA
3	DNA fingerprinting through southern blotting
4	Gene transfer using electroporation
5	Demonstration of GFP marker cloning and expression
6	Fermentative production / biotransformation of antibiotic/ steroid
7	Estimation of penicillin/ streptomycin by microbiological/ chemical assay
8	Analysis of biogas digested slurry for organic C, COD, lignin, Fatty acids and N
9	Nodulation of legume by Rhizobium using Leonard Jar/ Pot assay
10	Production and detection of siderophore produced by bacteria / fungi
11	Isolation of VAM spores from soil
12	Isolation of microbes from Rhizosphere / Phyllo-plane/ PGPR
13	Demonstration of Acetylene Reduction Assay for nitrogen fixation

#### References:

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**MB-405      Laboratory course (Project Dissertation)**

The project allotted during the Forth semester and it is expected that the students will design experiments and collect experimental data to deduce conclusions. At the end, they will submit a detailed thesis for evaluation. The students should be introduced to research methodology in the beginning through few lectures.

The approach towards the execution of project should be as follows:

1. Selection of topic relevant to priority areas of biotechnology.
2. Collection of literature from libraries, internet, on-line journals, etc.
3. Planning of research experiments
4. Performing the experiments with scientific and statistical acceptability.
5. Presentation of observations and results.
6. Interpretation of results and drawing important conclusions.
7. Discussion of obtained results with respect to literature reports.
8. Preparation of report (thesis) containing introduction, materials and methods, results and discussion, conclusions, bibliography.
9. Presentation of research data in a bound form.
- 10.**