NORTH MAHARASHTRA UNIVERSITY, JALGAON

'A' Grade
NAAC Re-Accredited
(3rd Cycle)

SYLLABUS

Master of Science
in
Microbiology

Part-II
(Semester – III and IV)

w. e. f. June 2016 -2017

NORTH MAHARASHTRA UNIVERSITY, JALGAON

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.)
SEMESTER – III				
Theory courses				
MB-301	Applied and Environmental Microbiology	**04**	**100**	**03**
MB-302	Molecular Biology and Bioinformatics	**04**	**100**	**03**
MB-303	Pharmaceutical Microbiology	**04**	**100**	**03**
Laboratory courses				
MB-304	Methods in Biostatistics and Bioinformatics	**04+04**	**100**	**06**
MB-305	Methods in Applied Microbiology	**04+04**	**100**	**06**
SEMESTER – IV				
Theory courses				
MB-401	Fermentation Technology	**04**	**100**	**03**
MB-402	Applied Molecular Biology	**04**	**100**	**03**
MB-403	Agricultural Microbiology	**04**	**100**	**03**
Laboratory courses				
MB-404	Methods in Biotechnology	**04+04**	**100**	**06**
MB-405	Laboratory course (Project Dissertation)	**04+04**	**100**	**06**

Instructions:

1. **Each theory course has to be completed in 50 lectures of 60 min duration each in one semester.**
2. **Semester III 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 and 60 marks-external examinations).**
5. **Seminar activity in each semester should be conducted and made compulsory to each student.**
6. **The student will have to carry out the research based project work in lieu of practical in the fourth semester in the department.**

SEMESTER III

MB-301: Applied and Environmental Microbiology		Lectures
Unit I	**Food Microbiology** • Methods of sampling and investigation • Preparation of dilutions • Offline and online approach of microbial analysis • Detection and enumeration of indicator bacteria, pathogenic and toxigenic microbes • Mycotoxins • Microbiological examination of specific foods o Meat and meat products o Milk and milk products • Food intoxications: Causes, pathogenesis and prevention and control	**10**
Unit-II	**Microbiological treatment of waste water** • Principles and need for biological waste water treatment • Conventional treatment process Primary- Sedimentation or settling Biological treatment process: Aerobic suspended-growth, Aerobic attached-growth (TF, RBC, PBR), Anaerobic suspended growth and Anaerobic attached growth - Advanced tertiary process: Solids removal, Biological nitrogen removal, Biological phosphorus removal and Disinfection • Waste water treatment for distillery and antibiotic industries • Solid waste management o Composting: Principle, chemistry and biology of composting, technology of composting, criteria of compost maturity, applications of compost o Biomethanation: Feedstocks, BMP, microbiology of biomethanation, biochemistry of methane synthesis.	**10**
Unit- III	**Biological conversion of Lignocellulosic waste** • Composition, structure of lignocelluloses and issues • Pre-treatment of lignocellulosic material: Physical, Chemical and Biological • Fermentation: Submerged, SSF, SHF, SScF fermentation • Applications in lignocellulosic ethanol production	**10**
Unit- IV	**Bioremediation and biodegradation of xenobiotics** • Concept of biodegradability and bioconversion • Principles for measuring biodegradability • Mechanism of biodegradation / bioremediation • Methods for bioremediation: Intrinsic, Biostimulation, and Bioaugmentation • Impediments to microbial degradation of compounds • Biodegradation of xenobiotics o Biochemical/ physiological approach o Molecular techniques o Toxicological risk assessments	**10**

Unit- V:	**Biomarkers and Bioreporters** • Concept and approaches to metagenomics analysis, ecological inference • Biomarker gene (antibiotic and heavy metal resistance genes, ice-nucleation, bioluminescence genes, green fluorescent genes) • Bioreporter genes • Biosensor	**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) Essesntials 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.

MB-302: Molecular Biology and Bioinformatics		**Lectures**
Unit I:	**Basic molecular biology** • DNA: topological properties (linking, writhing, twisting number), Structure of super helix, Base flipping, Palindrome, Inverted repeats and stem and loop. • Overview of DNA replication • RNA: Structure, types and functions • Denaturation and renaturation kinetics of nucleic acids • Proteins: Domain and motifs Histone proteins, • DNA –Protein interactions - helix-loop-helix, helix-turn-helix, leucine zipper, Zinc finger motifs,	**10**
Unit II	**Transcription** • Types of RNA polymerase (prokaryotic and eukaryotic), Process of transcription • mRNA processing, editing: capping, adenylation, splicing, RNA transport	**10**

	• Transcriptional regulation: transcriptional bursting/pulsing, specificity factors, enhancers, repressors, activators and general transcription factors • Post-transcriptional modifications: RNA degradation, nuclear transport, mRNA localization, anti-sigma factors, RNAi (siRNA, miRNA and CRISPR mechanism)	
Unit III:	**Translation**	**10**
	• Genetic code and its properties • Ribosome (structure and composition), Activation of tRNA, tRNA synthetase • Steps: Initiation: factors and their regulation, Elongation,Termination • Inhibitors • Post translational modification of proteins and protein degradation • Translational regulation: Cytoplasmic polyadenylation, UTR sequence elements, RNA binding proteins, ribosomal regulation, non-sense mediated RNA decay, 5` decapping	
Unit IV	**Protein targeting and degradation**	**10**
	• Signal hypothesis • Signal sequences in bacteria • Membrane and Lysosomal protein targeting • HSP and Chaperons • Protein degradation	
Unit V	**Basic Bioinformatics**	**10**
	• Biological databases :Nucleic acid databases (GenBank, EMBL, DDBJ) • Protein sequence database (UniProt, PDB) • Scoring matrices, local. global and multiple sequence alignment • Database search for homologous sequences, BLAST • Phylogenetic analysis: Overview and tree construction methods	

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, 4th 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.
- Berg JM, Tymoczko, JL, Stryer, L (2012) Biochemistry 7th 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, 4th edn., McMillan Worth Publ. Inc. NY.
- Russell, PJ (1998) Genetics, 5th 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, 7th 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, 2nd 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.
- 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.

MB-303: Pharmaceutical Microbiology		**Lectures**
Unit I	**Antibiotics and Synthetic antimicrobial agents**	**10**
	Mechanism of action, microbial resistance, therapeutic, prophylactic usage and adverse reactions • Antibiotic and Synthetic antimicrobial agents: β-lactam, aminoglycosides, tetracyclines, ansamycins, macrolides • Antifungal antibiotics: Griseofulvin • Antiviral drugs: Amantidines, Nucleoside analogues, Interferons • Peptide antibiotics • Synthetic antibiotics: Sulphonamides, Chloramphenicol, Quinolone	
Unit II	**Microbial aspects of pharmaceutical products**	**10**
	• Microbial contamination • Microbial spoilage (Types and factors) and preservation • Sterilization of pharmaceuticals (survivor curve, D, Z, F value) o Methods: Heat, Gaseous, Radiation, Filtration o Disinfectants	
Unit III	**Regulatory aspects and quality assurance in pharmaceuticals**	**10**
	• GMP in pharmaceuticals • FDA regulation and pharmacopeia • Design of sterile product manufacturing unit • Quality control in pharmaceuticals: In-process and final product control and ICH process • Sterilization control and sterility validation	
Unit V	**Production of Biopharmaceuticals**	**10**
	• Asperaginase, and Clinical dextran • Vaccines (DNA/ multivalent subunit/ bacterial) • Viral vaccines: Live attenuated, Inactivated, , Live recombinant Virion subunit vaccines, production of viruses for vaccines, Virus-like particles, Synthetic peptide vaccines, • Immunosera	

Unit VI	**Drug design**
	• Rational drug design
	  o Lead drug and Pro-drug
	  o Structure based and combinatorial approach
	  o Peptidomimetic and strategies for drug discovery
	• Drug delivery : Concept and approaches
		10

References:

- Hugo, WB and Russell, AD (2003/1998) Pharmaceutical Microbiology, 6th 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, 3rd edn., Taylor and Francis, London (ISBN: 0-415-28288 PB).
- Haider, SI (2006) Validation Standard Operating Procedures, 2nd edn., CRC Press Taylor and Francis Group, NY (ISBN: 0-8493-9529-1).
- Dutton CJ, Haxell MA, McArthur HAI and Wax RG (2002) Peptide Antibiotics, Marcel Dekker Inc., NY, USA (ISBN: 0-8247-0245-X)
- Seth SD (2004) Textbook of Pharmacology, 2nd edn., Elsvier, New Delhi (ISBN: 81-8147-553-4).
- Bhatia R and Ichhpujani RL (1995) Quality Assurance in Microbiology, CBS Publishers, New Delhi (ISBN: 81-239-0387-1).
- Chakraborty C and Bhattacharya A (2004) Pharmacogenomics: An approach to New Drug Development. Biotech Books, New Delhi (ISBN: 81-7622-105-8).

MB- 304: Methods in Biostatistics and Bioinformatics	
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, χ2-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
11	Primer designing using biological software
12	Demonstration of multivariate analysis of process parameters using statistical tools.

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, Hydrabad.

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- Bliss, C. I. K. (1967) Statistics in Biology, Vol. 1, McGraw-Hill, New York.
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- Baxevanis, A. D. and Ouellette, B. F. F. (2001) *Bioinformatics: A practical guide tothe 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	Demonstration of a typical lignocellulosic bioconversion process using SSF/SHF/SScF

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).
- Primrose, SB and Wardlow, AC (1982) Source Book for Experiments for the Teaching of Microbiology, Academic Press, London (ISBN: 0-12-565680-7).
- Sawhney, SK and Singh, R. (2001) Introductory Practical Biochemistry, Narosa Publ. House, Chennai.

SEMESTER – IV

MB - 401: Fermentation Technology		Lectures
Unit I	**Underlying principles, Upstream processing** • Metabolic pathways and control mechanisms • Fermentation- kinetics of batch and continuous culture • Designing of medium and strain improvement • Microbial growth kinetics and measurement of cell growth • Stoichiometry of microbial growth and product formation	**10**
Unit II	**Bioreactor (Design and Application) and its operation** • Design and construction materials of bioreactor • Parameters involved in fermentation process monitoring • Aeration and agitation for mass transfer • Strategy for medium sterilization, maintenance of aseptic/axenic condition • Control of process parameters and overview of process automation • Scale up and production economics	**10**
Unit III	**Downstream processing and product recovery** • Biomass harvesting: centrifugation, filtration • Cell disruption: ultrasonication, thawing, enzymatic way. • Product extraction: Liquid –liquid, supercritical fluid extraction, ultrafiltration, Three phase partitioning • Product purification and characterization: Chromatography-adsorption, size exclusion, affinity, ion exchange, reverse phase, HPLC **Quality practices and audit** • Quality practices- concept of SOP, GLP and role of FDA • Biosafety aspects of handling infectious organisms • IPR: Patents, copyrights, trademarks, geographical indications • Patenting biological materials, transgenic materials • Patent regulatory bodies at National and International level	**10**
Unit IV	**Microbial Products I** • Enzymes: Protease, asparginase • Organic acids: citric acid, lactic acid • Amino acids: Lysine, aspartic acid • Polysaccharides: Alginate, Hyaluronic acid	**10**
Unit V	**Microbial Products II** • Antibiotics: Penicillin, streptomycin • Ethanol: 1st, 2nd and 3rd generation • Vaccines production: DPT, MMR • Recombinant proteins: Insulin, Monoclonal antibodies • Nucleotides: IMP, GMP	**10**

References:

- Mukhopadhyay, S.N. (2004) Process Biotechnology Fundamentals, 2nd edn., Viva Books, Mumbai, (ISBN: 81-7649-496-8).
- Shuler M.L.and Kargi F (2008) Bioprocess Engineering-Basic Concepts, 2nd Edn. Prentice-Hall

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- Food Safety and Standards act (Government of India), 2006.
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- Rhem, HJ, Reed, G, Puhler, A. and Stadler, P. (1997) Biotechnology, 2nd edn., VCH Publ. Germany.
- Singh, KC (2004) Intellectual Property Rights on Biotechnology, BCIL, New Delhi.
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- Okafor Nduka (2007) Modern Industrial Microbiology and Biotechnology, Science Publishers, USA.

MB-402: Applied Molecular Biology		Lectures
Unit I	**Tools of molecular biology (or rDNA technology)** • **Enzymes:** Restriction endonucleases and its types, DNA methylases, DNA polymerase, DNA ligases, Kinases, Phosphatases, topoisomerase • **Cloning vectors:** Choice and its properties, Bacterial vectors: plasmid, Bacteriophage, Cosmids, Phagmids, BACs. Eukaryotic vectors: YACs, Ti, SV40 • **Cloning hosts:** Prokaryotic and eukaryotic hosts: properties	**10**
Unit II	**Methods in rDNA technology** • Vector mediated and chromosomal integration • Genomic and cDNA library construction • Gene transfer techniques: Transfection, Electroporation, Microinjection, Biolistic • **Screening, analysis and confirmation of rDNA** o Genetic methods o Hybridization techniques – Dot Blot, Colony, Dip stick, Plaque o Immunochemical methods o Plus and minus screening, HRT and HART o Analysis – Restriction mapping, Blotting techniques o Confirmation by genetic marker and reporter genes • **Applications of genetic engineering**	**10**
Unit III	**Microbial Genomics** • **Concept of -** Genome density, GC content, CPG Islands, Isochores, codon usage bias, cDNAs and ESTs, Contigs, epigenomics • **Structural, Functional, Application and Comparative Genomics:** o Methods for whole genome sequencing, gene annotation o Gene and SNP identification o Genome mapping (Conjugation, Recombination and	**10**

	complementation) and map integration • Genome editing using CRISPR-*cas* system	
Unit IV	**Protein Engineering and Proteomics**	**10**
	• **Protein identification and Expression Mapping:** 2D-gel electrophoresis, Mass Spectrophotometry and isotope labelling • **Protein-ligand docking** • **Experimental approach to Protein-Protein interaction mapping:** o Yeast and Bacterial 2-hybrid systems o Protein-ligand interactions o Protein fragment complement assays • **Protein arrays and chips:** Antibody and peptide arrays	
Unit V	**Techniques in Molecular biology**	**10**
	• DNA Sequencing : Sanger, Maxum 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)] • PCR: Basics, Reverse transcriptase PCR, Real time PCR, Applications • Analysis of polymorphism: RFLP, RAPD, AFLP, SSCP, DGGE • Analysis of gene expression : SAGE, Microarray	

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- Nicholl, D.S.T. (2002) An Introduction to Genetic Engineering, 2nd edn., Cambridge University Press, Cambridge, UK (ISBN: 81-7596-101-5 paperback).
- Malacinski, G.M. (2003) Essential of Molecular Biology, 4th edn, Jones & Barlett Publishers, Boston (ISBN: 0-7637-2133-6).
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- Weaver, RF (1999) Molecular Biology, WCB McGraw Hill Co., Inc., NY (ISBN: 0-321-0038-2).
- Timothy, Palzkill (2002) Proteomics. Springer US, ISBN 978-0-7923-7565-4.
- Channarayappa (2006) Molecular Biotechnology: Principles & Practice, Universities Press (India) Pvt. Ltd, Hyderabad (ISBN: 81-7371-501:7).

MB-403: Agricultural Microbiology		**Lectures**
Unit I	**Microbial ecology** • Basic microbial ecology • Microbial interactions • Microbial communities • Methods to quantitative microbial ecology	**10**
Unit II	**Microbial interactions with plant roots** • Rhizosphere and its anatomy	**10**

	• Mycorrhizae (VAM, OM, EM, Ectomycorrhizae) • Plant Growth Promoting Rhizobacteria (PGPR) • Strategies for rhizosphere and mycorrhizae community study **Microbial interaction with aerial plant structure** • Phylloplane, Stems/ flowers, leaf buds • Approaches for studies **Leguminous root nodules** • Nodulation process and mechanism of nitrogen fixation • Strategies to study infection process, root nodulation and N_2 fixation	
UnitIII	**Pathogenic interactions with plants** • Plant defence mechanisms (structural, biochemical, HR, SAR) • Microbial pathogenicity mechanisms in virus, bacteria, fungal pathogens • Genetic basis of plant-pathogen interactions • 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	**10**
Unit IV	**Microbial Biocontrol Agents** • Strategies for plant disease management • Biopesticides: BT, Siderophore and *Trichoderma; Pseudomonas* • Biocontrol of post-harvest diseases • Control of plant pathogens by genetic engineering	**10**
Unit V	**Current approaches** • Integrated Plant Nutrition through biofertilizers • Phytoremediation: Rhizodegradation • Rhizosphere engineering • Microbial reclamation of saline and sodic soils	**10**

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- Stanier, RY, Ingraham, JL, Wheelis, ML and Painter, PR (1993) General Microbiology, 5th edn., The McMillan Press Ltd., London (ISBN: 0-333-41768-2).
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- Coyne, MS (2004) Soil Microbiology: An Explanatory Approach, Delmar/Thomson Asia Pvt. Ltd., Singapore (ISBN: 981-240-203-9).
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- Buchnan, BB, Gruissem, W and Jones, RL (2000) Biochemistry and Molecular Biology of Plants, IK International Pvt. Ltd., New Delhi (ISBN:81-88237-11-6).

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- Chincholkar, SB and Mukerjii, KG (2007) Biological Control of Plant Diseases, Haworth Press Inc., London (ISBN: 1-56022-328-6).

MB-404: Methods in Biotechnology	
1	Isolation and estimation of RNA / mRNA from bacteria/ yeast/ fungi
2	Determination of Tm 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

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- Sawhney, SK and Singh, R. (2001) Introductory Practical Biochemistry, Narosa Publ. House, Chennai.
- Aneja, KR (2005) Experiments in Microbiology, Plant Pathology and Biotechnology, International Publshers, New Delhi (ISBN: 81-224-1494-X).
- Tablot, N. (2005) Molecular and Cellular Biology of Filamentous Fungi, Practical Approach, Indian Edn., Oxford University Press, New Delhi (ISBN: 0-19-567943-1).
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- Sambrook and Russell Molecular Cloning Vol I, II and III, CSHL Press, USA.
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- Dubey R. C., Maheshwari D. K. (2005) Practical Microbiology, S.Chand&Co, New Delhi

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.

Epilogue

Skills imparted: The curriculum is designed to instill basic and applied knowledge of the subject to the students. One of the major objectives considered during designing is to make technically educated human resource. Basic microbiology, molecular biology, microbial physiology may help to find out unseen facts in various environmental, agriculture, food and pharmaceutical sectors. The subjects like genetic engineering, applied microbiology, microbial biochemistry, pharmaceutical microbiology, fermentation technology and biochemical techniques are designed to impart theoretical and practical knowledge of modern scientific advances in the field. Further to enhance skillful human resource with precision, the course like biostatistics and bioinformatics are included. The subject like Microbial biotechnology would give not only the practical knowledge of industry and industrial processes but also make aware the students with the global environmental problems like pollutions, contamination and bioremediation. Practical courses are based on theory courses and are designed to improve research oriented skills of students.

Job opportunity: The designed curriculum offers job opportunities in various sectors like,

- Pharmaceutical industry : Clinical, medicine, vaccine, QC division
- Biotech industry: Recombinant product, QC, QA
- Agrochemical and pesticide industry
- Chemical industry: synthesis, testing
- Environmental protection industry and Agencies
- Research leading to Ph. D. degree
- Self entrepreneurship
- Marketing of biological and pharmaceutical products