

**Kavayitri Bahinabai Chaudhari
North Maharashtra University, Jalgaon**

Syllabus

M. Sc. II (Semester III and IV)

Microbiology

(Affiliated Colleges)

June 2019 -2020

M. Sc. Part: II Microbiology

Prelude

The need for trained and skilled human resource is a prerequisite in the higher education. This coerces the necessity to acquire thorough knowledge of theoretical concepts and hands-on laboratory methods of the subject. On this streak, the present syllabus of M.Sc. part II in the subject Microbiology has been prepared as per the guidelines of UGC and cultivate a theoretical and practical know how of different fields of Microbiology. The contents of syllabus have been prepared to accommodate the fundamental aspects as well as advanced developments in various disciplines of Microbiology and to complement the needs of various applied sectors of Microbiology. Beside this, the graduate students will be enlightened with knowledge in the newer areas of Environmental, Molecular, Pharmaceutical, Agricultural Microbiology, etc. Post graduate students will surely have an urge to endure research studies in Microbiology and contribute significantly in the development.

The present syllabus is restructured to cater the present and future needs of Microbiology in research field, Industrial Sector, Environmental Sector, etc., with more emphasis on imparting hands-on skills. Hence, the curriculum is endowed with more experiments that shall run hand-in-hand with theory. The extensive appendix is furnished for each course to support know how and suffice the inquisitive of the students. The detailed syllabus of each paper is appended with a list of suggested readings.

Learning objectives

To acquaint students with:

- Basic concepts, principles and methods of molecular biology, bioinformatics, biostatistics
- Concepts in food microbiology and food intoxications
- Solid and liquid waste management, bioconversion of lignocellulose waste, Bioremediation of xenobiotics
- Mechanisms in molecular biology, genome expression of microorganisms and bioinformatics tools
- Trends in pharmaceutical microbiology, synthetic antimicrobial agents, and pharmaceutical products
- Regulation and quality assurance in pharmaceutical and food microbiology
- Concepts in drug design and delivery, IPR, rDNA technology, proteomics
- Process in fermentation technology viz. upstream, fermentation and downstream protocols
- Basic and applied aspects of microbial ecology: pathogen interaction, biocontrol of plant diseases.

Course structure

Duration: The duration of M.Sc. (Microbiology) degree program shall consist of TWO years divided into four semesters. Each semester consists of 90 working days.

Medium of instruction: The medium of instruction for the course shall be English.

Eligibility: B.Sc. with principle subject Microbiology.

Structure of syllabus for M.Sc. (Part- II) Microbiology

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
Semester – III 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
Semester – IV Laboratory courses				
MB-404	Methods in Biotechnology	04+04	100	06
MB-405	Laboratory course (Project Dissertation)	04+04	100	06

Instructions:

- Each theory and practical course has to complete in 50 lectures, respectively of 60 min duration,
- Each theory and practical course will be of 100 marks comprising of 40 marks internal (20 marks of 2 internal examinations) and 60 marks external examination.
- Theory examination (60 marks) will be of three hours duration for each theory course. There shall be 5 questions each carrying equal marks (12 marks each). The pattern of question papers shall be:
 - Question 1 (12 marks): 6 sub-questions, each of 3 marks; answerable in brief and based on entire syllabus, attempt any 4 out of 6 questions.
 - Question 2, 3 and 4 (12 marks each): based from Unit I & II, III & IV, V & any Unit I to IV, respectively, each question has 3 sub-questions of 6 marks each and answer only 2 sub-questions from each Q2, Q3, and Q4.
 - Question 5 (12 marks): answer only 3 out of 5 in brief, based from all 5 units, Each 4 marks.
- **Internal examination** (40 marks each semester): Internal assessment of the student by respective teacher will be comprehensive and continuous, based on written test. The written test shall comprise of both objective and subjective type questions.
- **Practical Examination:** Practical examination shall be conducted by the respective college at the end of the semester. Practical examination will be of minimum 5 – 6 hours duration and shall be conducted as per schedule (10 am to 5 pm on schedule date or can be scheduled 10 am -1pm/ 2 – 5 pm for 2 consecutive days) in case of microbiology practicals where incubation condition, allied aspect are essential. There shall be 5 marks for laboratory log book and well written journal, 10 marks for viva voce and minimum three experiments (major and minor). Certified journal is compulsory to appear for practical examination. There shall be one expert and two examiners (external and internal) per batch for the practical examination
- Equivalence for M.Sc. (Microbiology) is given below:

Old Syllabus (w. e f. AY 2016-2017) Semester III (Pattern 60:40)	New Syllabus (w. e. f. AY 2019 -20) Semester III (Pattern 60:40)
MB-301 Applied and Environmental Microbiology	MB-301 Applied and Environmental Microbiology
MB-302 Molecular Biology and Bioinformatics	MB-302 Molecular Biology and Bioinformatics
MB-303 Pharmaceutical Microbiology	MB-303 Pharmaceutical Microbiology
MB-304 Methods in Biostatistics and Bioinformatics	MB-304 Methods in Biostatistics and Bioinformatics
MB-305 Methods in Applied Microbiology	MB-305 Methods in Applied Microbiology
Semester IV (Pattern 60:40)	Semester IV (Pattern 60:40)
MB-401 Fermentation Technology	MB-401 Fermentation Technology
MB-402 Applied Molecular Biology	MB-402 Applied Molecular Biology
MB-403 Agricultural Microbiology	MB-403 Agricultural Microbiology
MB-404 Methods in Biotechnology	MB-404 Methods in Biotechnology
MB-405 Laboratory course (Project Dissertation)	MB-405 Laboratory course (Project Dissertation)

M. Sc Part II (Semester III) Microbiology

MB-301: Applied and Environmental Microbiology		Lectures
Unit I	Food Microbiology <ul style="list-style-type: none"> • Methods of sampling : random, representative, attribute sampling • Preparation of dilutions • Offline and online approaches of microbial analysis • Detection and enumeration of indicator bacteria, pathogenic and toxigenic microbes • Mycotoxins, sources, pathogenesis, prevention, extraction and detection • Microbiological examination of specific foods <ul style="list-style-type: none"> ○ Meat and meat products ○ Milk and milk products • Food intoxications: Causes, pathogenesis, prevention and control 	10
Unit-II	Microbiological treatment of waste water <ul style="list-style-type: none"> • Principles and need for biological waste water treatment • Conventional treatment process • Primary- Sedimentation or settling • Biological treatment process: Aerobic treatment: (a) Suspended growth – Oxidation lagoons, activated sludge and membrane bioreactor (b) Attached growth TF, RBC, PBR Anaerobic treatment: (a) Suspended growth – UASB, USB, Clarigester (b) Attached growth (EGSB, AF, FBR) • Advanced tertiary process: Solids removal, Biological nitrogen removal, Biological phosphorus removal and Disinfection (Clarification, Ozonation) • Waste water treatment for distillery and antibiotic industries 	10
Unit-III	Biological conversion of Lignocellulosic waste <ul style="list-style-type: none"> • Structure and composition of lignocelluloses, Degradation of lignin, cellulose and hemicellulose, impediments of degradation • Pre-treatment of lignocellulosic material: Physical, Chemical and Biological (Microbial and enzymatic) and related issues • Fermentation: Submerged, SSF, SHF, SScF • Applications in lignocellulosic ethanol production 	10
Unit-IV	Bioremediation and biodegradation of xenobiotics <ul style="list-style-type: none"> • Concept of biodegradability and bioconversion • Principles for measuring biodegradability • Mechanism of biodegradation / bioremediation: cometabolism, mineralization, conjugation • Bioremediation treatments: Intrinsic, Biostimulation, and Bioaugmentation, Rhizostimulation, bioleaching • Methods for microbial treatments of pollution: Bioreactors, Biopiles, landfilling, Bioventing, biosparging • Impediments to microbial degradation of compounds • Biodegradation of xenobiotics <ul style="list-style-type: none"> ○ Biochemical/ physiological approach ○ Molecular techniques and monitoring of bioremediation ○ Methods for soil bioremediation 	10
Unit-	Microbial waste management	10

V:	<ul style="list-style-type: none"> • Solid waste management ○ Composting: Principle, steps, chemistry, microbial succession and biology of composting, technologies of composting (aerobic: windrow, aerated static pile, in vessel composting; Anaerobic composting) criteria of compost maturity, applications of compost ○ Anaerobic digestion: Feedstocks, Principle, methane potential, requirements of anaerobic digestion, microbiology of biomethanation, biochemistry of methane synthesis, process, dry and wet digestion, factor affecting methanogenesis, and Types of anaerobic digesters (fixed dome, floating dome, low rate and high rate digesters) 	
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Suggested Readings:

- Singh A and Ward OP. (2004) Biodegradation and Bioremediation, Springer-Verlag,, Berlin (ISBN: 3-540-21101-2).
- Hurst CJ (2002) Manual of Environmental Microbiology, ASM Press, Washington D.C. (ISBN: 1-55581-199-x).
- Demain AL and Davies JE (1999) Manual of Industrial Microbiology and Biotechnology, ASM Press, Washington D.C. (ISBN: 1-55581-128-0).
- Martin AM (1998) Bioconversion of waste materials to Industrial Products, Blackie Academic and Professional, London (ISBN: 0-7514-0423-3).
- Harrigan WF and McCance ME (1994) Laboratory Methods in Food and Dairy Microbiology. Academic Press, London.
- Mossel, DAA, Correy JEL, Struijk CB and Baird RM (1995) Essentials of the Microbiology of Foods, John-Wiley and Sons Inc., New York.
- Satyanaraya U (2005) Biotechnology, Books and Allied (P) Ltd., Kolkata.
- Hobbs B and Roberts D (1993) Food Poisoning & Food Hygiene, Edward Arnold, London.
- Baker KH and Herson DS (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 RG and Reed G (1984) Biotechnology, Vol.1-8, Verlag-Chemie, Weinheim.
- Forster CF (1985) Biotechnology and waste water treatment, Cambridge University Press, Cambridge.
- Maier R Pepper IL and Gerba CP (2000) Environmental Microbiology, Academic Press, London.

MB-302: Molecular Biology and Bioinformatics		Lectures
Unit I:	<p>Basic molecular biology</p> <ul style="list-style-type: none"> • DNA: topological properties (linking, writhing, twisting number), • Structure of super helix, Negative supercoiling in eukaryotes • Base flipping, Palindrome, Inverted repeats and stem and loop. • Overview of DNA replication • RNA: Structure, types, functions and Folding of RNA • 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	10

	<ul style="list-style-type: none"> • RNA polymerase (prokaryotic and eukaryotic), • Process of transcription, Promoters and Transcription factors • mRNA processing, editing: capping, adenylation, splicing, Exon shuffling, RNA Editing, mRNA transport • Regulation of Transcription: repressors and inhibitors • Transcriptional bursting/pulsing, specificity, enhancers, activators, co-activators and general transcription factors • Post-transcriptional modifications: RNA degradation, RNA interference, Post transcriptional gene silencing, anti-sigma factors (siRNA, miRNA, DICER, RISC) • Antisense RNA technology 	
Unit III:	Translation	10
	<ul style="list-style-type: none"> • Genetic code and its properties • Steps in translation: Initiation, Elongation, Termination • RNA-RNA interaction in translation, polyribosomes • Ribosome (structure and composition), Activation of tRNA, tRNA synthetase • Regulation of translation: Cytoplasmic polyadenylation, UTR sequence elements, RNA binding proteins, ribosomal regulation, non-sense mediated RNA decay, 5` decapping • Post translational modifications: phosphorylation, glycosylation, ubiquitination, S-Nitrosylation, Methylation, N-Acetylation, Lipidation 	
Unit IV	Protein targeting and degradation	10
	<ul style="list-style-type: none"> • Signal hypothesis • Signal sequences in bacteria • Signal sequence recognition mechanism • Membrane and Lysosomal protein targeting • HSP and its role, molecular Chaperons • Protein degradation 	
Unit V	Basic Bioinformatics	10
	<ul style="list-style-type: none"> • Concept, need, goal, applications of bioinformatics • Biological databases: Concept, types and limitations • Nucleic acid databases: GenBank, EMBL, DDBJ, Swiss prot, PIR • Protein database (UniProt, PDB, MMDB) • Bioinformatics tools: Homology and sequence similarity, protein function analysis, structure analysis, sequence analysis, protein structure prediction • Scoring matrices (PAM, BLOSSUM), • Sequence alignment: local, global, pair-wise and multiple sequence • Example of bioinformatics tool: BLAST • Phylogenetic analysis: Overview and tree construction methods • Data mining: concept, softwares and applications in Bioinformatics 	

Suggested Readings:

- 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 & Batielt, 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 and

Co., New York.

- Wink M. (2006) An Introduction to Molecular Biotechnology, Wiley-VCH Verlag GmbH and 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 and 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).
- 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).
- Xiong Jin (2006) Essential Bioinformatics, 1st edition, Cambridge University Press

MB-303: Pharmaceutical Microbiology		Lectures
Unit I	Antibiotics and Synthetic antimicrobial agents Mechanism of action, microbial resistance, therapeutic, prophylactic usage and adverse reactions <ul style="list-style-type: none"> • 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 • Anticancer drugs 	10
Unit II	Microbial aspects of pharmaceutical products <ul style="list-style-type: none"> • Microbial contamination • Microbial spoilage (Types and factors) and preservation • Sterilization of pharmaceuticals (survivor curve, D, Z, F value) <ul style="list-style-type: none"> ○ Methods: Heat, Gaseous, Radiation, Filtration ○ Disinfectants 	10
Unit III	Regulatory aspects and quality assurance in pharmaceuticals <ul style="list-style-type: none"> • GMP in pharmaceuticals and GLP • FDA regulation and pharmacopeia (India and USA) • Design of sterile product manufacturing unit: Class A and clean room • Quality control in pharmaceuticals: In-process and final product (antibiotics, immune sera, vaccines, biopharmaceuticals) control • ICH process • Sterilization control and sterility validation 	10
Unit IV	Production of Biopharmaceuticals	10

	<ul style="list-style-type: none"> Asparaginase, 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 and monoclonal antibodies 	
Unit V	Drug design	10
	<ul style="list-style-type: none"> Rational drug design <ul style="list-style-type: none"> Concept and steps of drug design Lead drug and Pro-drug with examples Structure based and combinatorial approach Computer aided drug design and softwares Peptidomimetic Strategies for drug discovery and clinical trial Drug delivery: Concept and methods of drug delivery, novel methods 	

Suggested Readings:

- 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., Elsevier, 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, Chi ² -test using MS-Excel/ suitable software
7	Exploring Biological databases – Genbank & Protein Data Bank
8	Structural predication of protein using ExPASy software
9	Primary and tertiary structure analysis of protein/ DNA using BLAST
10	Multiple sequence alignments using Clustal W
11	Phylogenetic tree analysis using MEGA
12	Primer designing using biological software
13	Demonstration of multivariate analysis of process parameters using statistical tools.

Suggested readings:

- Bailey NTJ (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.
- Gupta SC (2019) Fundamentals of Statistics, Himalaya Publishing House, New Delhi.
- Bliss CIK (1967) Statistics in Biology, Vol. 1, McGraw-Hill, New York.
- Gore A, Paranjpe S and Kulkarni M (2009) Statistics for everyone, SIPF Academy Publishers, Nashik.
- Baxevanis AD and Ouellette BFF (2001) Bioinformatics: A practical guide to the analysis of genes and proteins. Second Edition. John Wiley & Sons, New York.
- Ewens WJ. and Gregory RG (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 SA (Eds.). (2000) Methods in Molecular Biology, Volume 132.
- Stephen Misener, Stephen A. Krawetz (1999) Bioinformatics: Methods and Protocols. Humana Press, New Jersey.
- Mount DW (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 using chemical and biological indicator
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 Limit Test (analysis of water, raw material, finished product, packaging material, Excipients)
7	Environmental monitoring of samples from production areas and personnel.
8	Evaluation of quality of media/reagents for Growth promotion tests.
9	Endotoxin/pyrogen using LAL (water, in-process, final product)
10	Validation of efficiency of laminar air flow
11	Lignocellulosic saccharification using SSF/SHF/SScF and its assessment
12	Production of biogas using feedstock and detection using water displacement method/ GC
13	Evaluation of microbial spoilage of refrigerated and canned food

Suggested Readings:

- 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.

M.Sc. Part II (Semester IV) Microbiology

MB - 401: Fermentation Technology		Lectures
Unit I	Upstream processing <ul style="list-style-type: none"> • Microbial growth kinetics and measurement of cell growth • Stoichiometry of microbial growth and product formation • Metabolic pathways and control mechanisms • Fermentation- kinetics of batch and continuous culture • Designing of medium • Strain improvement: Isolation and improvement of industrial strains 	10
Unit II	Bioreactor (Design and Application) and its operation <ul style="list-style-type: none"> • Design and Construction materials of Bioreactor • Types of Bioreactor • Strategy for medium sterilization, maintenance of aseptic condition • Parameters involved in fermentation process monitoring: Aeration and agitation system, Sterility, pH, Temperature, foam, DO, etc. • Scale up and Mass and Heat transfer during fermentation • Overview of process automation and Production economics 	10
Unit III	Downstream processing and IPR <ul style="list-style-type: none"> • Biomass harvesting and removal of solid matter: centrifugation, filtration • Cell disruption: ultrasonication, thawing, enzymatic. • Product extraction: Solvent recovery, Liquid –liquid, supercritical fluid extraction, ultrafiltration, Three phase partitioning, Solvent recovery • Product purification and characterization: Chromatography-adsorption, size exclusion, affinity, ion exchange, reverse phase, HPLC • Quality practices- concept of SOP, GLP and quality assurance • Biosafety: Handling infectious and Recombinant microorganism IPR: <ul style="list-style-type: none"> • Patents, copyrights, trademarks, geographical indications • Patenting biological materials, transgenic materials • Patent regulatory bodies at National and International level 	10
Unit IV	Microbial Products I <ul style="list-style-type: none"> • Enzymes: Protease, Penicillin acylase • Organic acids: Gluconic acid • Amino acids: L glutamic acid • Polysaccharides: Polysaccharides (Alginate and Hyaluronic acid) • Others: Probiotics and Yoghurt, • Antibiotics: Rifamycin • Ethanol: 1st, 2nd and 3rd generation • Nucleotides: IMP, GMP • Heterologous protein production with example 	14

Unit V	Mammalian Cell Products <ul style="list-style-type: none"> • Mammalian cell culture: Media, Production Process, Application • Mammalian cell products: Monoclonal antibodies, Vaccines • Heterologous protein: INF, tissue plasminogen activator (TPA), GMCSF 	6
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Suggested Readings:

- Stanbury, P.F., Whitaker A. and Hall, S.J. (2016) Principles of Fermentation Technology, 3rd Edition, Butterworth-Heinemann, Amsterdam, ISBN: 9780080999531
- Mukhopadhyay SN (2004) Process Biotechnology Fundamentals, 2nd edn., Viva Books, Mumbai, (ISBN: 81-7649-496-8).
- Shuler ML and Kargi F (2008) Bioprocess Engineering-Basic Concepts, 2ndEdn. Prentice-Hall
- Food Safety and Standards Act, Government of India, 2006.
- Moo-Young, MC (2011) Comprehensive Biotechnology, Vol. I, II & III, Elsevier Sci. Publisher, Amsterdam (ISBN: 978- 0-08-088504-9)
- El-Mansi EMT, Bryce CFA, Demain AL and Allman AR (2007) Fermentation Microbiology and Biotechnology, 2nd edn., CRC Taylor and Francis Group, Boca Raton, Florida (ISBN: 0-8493-5334-3).
- Lodish MR (2001) Bioseperation Engineering, Wiley Interscience, NY (ISBN:0-471-24476-7)
- Sree Krishna V. (2007) Bioethics and Biosafety in Biotechnology, New Age International (P) Ltd., Publ., Mumbai (ISBN: 81-224-2085-0).
- 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.
- Okafor Nduka (2007) Modern Industrial Microbiology and Biotechnology, Science Publishers, USA.
- Freshney R. Ian (2010) Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications. John Wiley and Sons, Inc., Hoboken (ISBN:9780470528129)
- Bhatt Sheelendra Mangal (2011) Animal cell culture: concept and application. Alpha Science International, UK

MB-402: Applied Molecular Biology		Lectures
Unit I	Tools of molecular biology (or rDNA technology) <ul style="list-style-type: none"> • 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	10

	<ul style="list-style-type: none"> • Vector mediated and chromosomal integration • Genomic and cDNA library construction • Gene transfer techniques: Transfection, Electroporation, Microinjection, Biolistic • Screening, analysis and confirmation of rDNA <ul style="list-style-type: none"> ○ Genetic methods ○ Hybridization techniques – Dot Blot, Colony, Dip stick, Plaque ○ Immunochemical methods ○ Plus and minus screening, HRT and HART ○ Analysis – Restriction mapping, Blotting techniques ○ Confirmation by genetic marker and reporter genes • Applications of genetic engineering 	
Unit III	Microbial Genomics	10
	<ul style="list-style-type: none"> • Concept of - Genome density, GC content, CPG Islands, Isochores, codon usage bias, cDNAs and ESTs, Contigs, epigenomics • Structural, Functional, Application and Comparative Genomics: <ul style="list-style-type: none"> ○ Methods for whole genome sequencing, gene annotation ○ Gene and SNP identification ○ Genome mapping (Conjugation, Recombination and complementation) and map integration • Genome editing using CRISPR-<i>cas</i> system 	
Unit IV	Protein Engineering and Proteomics	10
	<ul style="list-style-type: none"> • Protein identification and Expression Mapping: 2D-gel electrophoresis, Mass Spectrophotometry and isotope labelling • Protein-ligand docking • Experimental approach to Protein-Protein interaction mapping: <ul style="list-style-type: none"> ○ Yeast and Bacterial 2-hybrid systems ○ Protein-ligand interactions ○ Protein fragment complement assays • Protein arrays and chips: Antibody and peptide arrays 	
Unit V	Techniques in Molecular biology	10
	<ul style="list-style-type: none"> • 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)] • PCR: Basics, Reverse transcriptase PCR, Real time PCR, Applications • Analysis of polymorphism: RFLP, RAPD, AFLP, SSCP, DGGE • Analysis of gene expression : SAGE, Microarray 	

Suggested Readings:

- Nicholl DST (2002) An Introduction to Genetic Engineering, 2nd edn., Cambridge University Press, Cambridge, UK (ISBN: 81-7596-101-5 paperback).
- Malacinski GM (2003) Essential of Molecular Biology, 4th edn, Jones & Barlett Publishers, Boston (ISBN: 0-7637-2133-6).
- Alcamo IE (2001) DNA Technology, Academic Press, London, UK (ISBN: 0-12-048920-1).
- Brown TA (1995) Essential Molecular Biology, Vol. I (A Practical Approach), IRL Press, Oxford.
- Terence A Brown (2015) Gene Cloning and DNA Analysis: An Introduction, 7th Edn.

John Wiley & Sons Ltd, UK. ISBN: 9781405181730.

- Primrose SB and Wardlow AC (1982) Source Book for Experiments for the Teaching of Microbiology, Academic Press, London (ISBN: 0-12-565680-7).
- Sambrook and Russell Molecular Cloning Vol. I, II and III, CSHL Press, USA.
- 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 <ul style="list-style-type: none"> • Basic microbial ecology and its components • Microbial interactions: positive and negative • Microbial communities: concepts, elements and methods of analysis: CLPP, PLFA, DGCE, SSCP, ARDRA, FISH • Methods to quantitative microbial ecology • Indicators of soil health 	10
Unit II	Microbial interactions with plant roots <ul style="list-style-type: none"> • Rhizosphere and its anatomy • Mycorrhizae: VAM, OM, EM, Ectomycorrhiza • Plant Growth Promoting Rhizobacteria (PGPR) • Strategies for rhizosphere and mycorrhizae community study Microbial interaction with aerial plant structure <ul style="list-style-type: none"> • Phylloplane, Stems/ flowers, leaf buds • Strategies for aerial plant structure study Leguminous root nodules <ul style="list-style-type: none"> • Nodulation process and mechanism of nitrogen fixation, <i>nif</i> operon • Strategies to study infection process, root nodulation and N₂ fixation 	10
Unit III	Pathogenic interactions with plants <ul style="list-style-type: none"> • Plant defense 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, Smut and Rust 	10
Unit IV	Microbial Bio control of plant disease <ul style="list-style-type: none"> • Methods of plant disease detection: traditional and innovative • Plant disease control: general strategies and Principal of IDM • Biopesticides: BT, Siderophore and <i>Trichoderma</i>; <i>Pseudomonas</i>, NPV, <i>Beauveria bassiana</i> • Biocontrol of post-harvest diseases • Control of plant pathogens by genetic engineering 	10

Unit V	Current approaches in agriculture microbiology <ul style="list-style-type: none"> • Integrated Plant Nutrition through biofertilizers • Phytoremediation: Rhizodegradation • Rhizosphere engineering • Microbial reclamation of saline and sodic soils • Genetically modified crops • Microbiomes 	10
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Suggested Readings:

- Stanier RY, Ingraham JL, Wheelis ML and Painter PR (1993) General Microbiology, 5th edn., The McMillan Press Ltd., London (ISBN: 0-333-41768-2).
- Atlas RM and Bartha R (1998) Microbial Ecology-Fundamental and Applications, Addison Wesley Longman Inc.
- Lynch and Poole (1984) Microbial Ecology - A Conceptual Approach, Blackwell Scientific Publ., New York.
- Streips UN and Yasbin RE (2002) Modern Microbial Genetics, 2nd edn., Wiley-Liss, USA (ISBN: 0-471-38665-0).
- Coyne MS (2004) Soil Microbiology: An Explanatory Approach, Delmar/Thomson Asia Pvt. Ltd., Singapore (ISBN: 981-240-203-9).
- Kumar HD and Kumar S (2004) Modern concepts of Microbiology, 2nd edn., Vikas Publishing House Pvt. Ltd., New Delhi (ISBN: 81-259-1000-X).
- Hurst CJ, Crawford RL, Knudsen GR, McInerey MJ and Stetzenbach LD (2002) Manual of Environmental Microbiology, 2nd edn., ASM Press, Washington DC (ISBN:1-55581-199-X).
- Ciancio A and Mukerji KG (2007) General Concepts in Integrated Pest and Disease Management, Springer, The Netherlands (ISBN: 978-1-4020-6060-1).
- Buchanan BB, Gruissem W and Jones RL (2000) Biochemistry and Molecular Biology of Plants, IK International Pvt. Ltd., New Delhi (ISBN:81-88237-11-6).
- Boland GJ and Kuykendall LD (1998) Plant-Microbe Interactions and Biological Control, Marcel Dekker Inc., NY, USA (ISBN: 0-8247-0043-0).
- Chincholkar SB and Mukerji 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 T _m and % (G+C) of DNA
3	DNA fingerprinting through southern blotting
4	Fermentative production of alcohol from lignocellulose and its estimation
5	Biotransformation of antibiotic/ steroid
6	Estimation of penicillin by microbiological and chemical assay
7	Estimation of streptomycin by microbiological and 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	Estimation of R:S ratio and assessment of rhizosphere effect.

Note: Perform 12 - 13 experiments.

Suggested readings:

- Aneja KR (2007). Experiments in microbiology, plant pathology and biotechnology. New Age International, New Delhi
- Benson HJ (2002). Microbiological applications; a laboratory manual in general microbiology, 8th Edition, McGraw Hill, New York
- Cappucino J and Sherman NC (1992) Microbiology-A Laboratory Manual, The Benjamin- Cummings Publ. Co., Inc., New York.
- Davis LG, Dibner MD and Battey JF (1986) Basic Methods in Molecular Biology, Appleton and Lange, Norwalk (ISBN: 0-8385-0582-1).
- Hewitt W (1977) Microbiological Assay, Academic Press, New York.
- Janarthanan S and Vincent S (2007) Practical Biotechnology, Universities Press (India) Pvt. Ltd., Hyderabad (ISBN: 13-978-81-7371-582-2).
- Kalaichelvan PT (2006) Microbiology and Biotechnology: A Laboratory Manual, MJP Publ., Chennai (ISBN: 81-8094-008-X).
- 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).
- Sambrook and Russell Molecular Cloning Vol I, II and III, CSHL Press, USA.
- Sawhney SK and Singh R (2001) Introductory Practical Biochemistry, Narosa Publ. House, Chennai.
- Schmauder HP Schweizer M and Schewizer LM (2003) Methods in Biotechnology, Taylor and Francis Ltd., London (ISBN: 0-7484-0430-9).
- Tablot N (2005) Molecular and Cellular Biology of Filamentous Fungi, Practical Approach, Indian Edn., Oxford University Press, New Delhi (ISBN: 0-19-567943-1).
- White D (2000) The Physiology and Biochemistry of Prokaryotes, Oxford University Press, Oxford.

MB-405: Laboratory course (Project Dissertation)

The project is allotted during the Forth semester. The students will get an opportunity to become a part of ongoing research activities in the respective College. The student will explore and gain experience in different sectors of biotechnology viz agriculture, food, medicine and pharmaceutical. The students will acquire skill to write, compile and analyze data, and present the detailed technical/scientific report. At the end of successful project semester training, potentially the students become employable in the industries/organizations.

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 on the topic of research from libraries, internet, on-line journals, Planning of research experiments
3. Performing the experiments with scientific and statistical acceptability.
4. Presentation of observations and results.
5. Interpretation of results and drawing important conclusions.
6. Discussion of obtained results with respect to literature reports.
7. Writing monthly progress report

<p>8. Preparation of report (Dissertation) containing introduction, materials and methods, results and discussion, conclusions, bibliography and submission of at least 3 copies (1 copy retained in the department and after examination submitted to Library, 1 copy submitted to the guide and 1 copy kept with the candidate).</p> <p>9. Presentation of research data during university examination and submission of project dissertation in a bound form.</p>
<p>1. Internal examination (40 marks): Components of continuous internal assessment Submission of monthly progress report and signed by supervisor (at least 4 reports) (2 marks per report = 8 marks), Literature collected, experiment planning and design (10 marks), Experiments conducted (10 marks), outcome of the experiments and viva (8 marks) and regular attendance (4 marks) recorded: Research Supervisor</p> <p>2. External examination (60 marks) and Components of external assessment: Subject matter (5 marks), Review of literature (10 marks), Writing of dissertation submitted in bound form at the time of examination (Title page, Certificate, Plagiarism report, Main content: Abstract, Introduction, Literature, Materials and methods, results and discussion and conclusion with relevant references) (15 marks), Presentation structure (PPT format) (8 marks), Overall presentation reflecting contribution of work (4 marks), Response to questions (15 marks).</p>
<p>Suggested readings: Refer to the journals, reference books, abstracts etc. related to topic</p>

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