

DEPARTMENT OF MICROBIOLOGY
UNIVERSITY OF PUNE

M. Sc. (MICROBIOLOGY)

REVISED SYLLABUS
FOR
CREDIT BASED
POST GRADUATE COURSE IN MICROBIOLOGY

M. Sc. Part II – w. e. f. June 2009

GENERAL INSTRUCTIONS

1. Eligibility: B. Sc. with Microbiology as principal subject and performance at entrance examination.
2. A full Master's degree course in Sciences would be of 100 credits, where one credit course of theory will be of one clock hour per week, running for 15 weeks and one credit for practical course will consist of 15 clock hours of laboratory exercises
3. For M.Sc. in Microbiology a student should take admission in the Microbiology Department and complete at least 75% courses identified in the syllabus structure of Microbiology. If students so desires remaining 25% courses can be chosen from courses offered by other Departments with credit structure.
4. Course No. are designed to indicate the subject, semester, course serial number, credits assigned and the nature as theory or practicals.
 - MB indicates the subject, Microbiology
 - 1st digit indicates the semester
 - Last digit indicates the credits assigned to the course.
 - Middle number indicates the serial number. The serial number beginning with zero signifies that the course is a practical course.
eg. MB 1.1.1 means 1st semester, 1st paper with one credit
whereas, MB 1.01.5 means 1st semester, 1st practical course with five credits
5. Practicals will be conducted throughout the academic year.
6. Some of the credit courses could consist of Seminars, Survey, field work, Special laboratory training in Research Laboratories etc.
7. The in semester and end semester examinations will be of 50% marks each. This will ensure that the students work regularly through the semester.
8. Question paper for each theory course will include at least one problem based on research reports (Mathematical / Data Interpretation / Comment type) related to concerned course.
9. Each course will be evaluated for 25 marks per credit of which 50 % will be based on continuous / internal evaluation.

Credit	Continuous/Internal Assessment Marks	End Assessment Marks
1	12	13
2	25	25
3	37	38
4	50	50
5	62	63

10. Results at the end of the semester will be declared using a grade point system.
11. The formula for GPA will be based on weighted average. The final GPA will not be printed unless a student passed courses equivalent to minimum 100 credit hours. Total credit hours means sum of credit hours of the courses which a student has passed.
12. A seven point grade system (guided by the Government of Maharashtra Resolution No. UGC-1298/ [4619]/UNI. 4 dt December 11, 1999 and the University regulations) will be followed. The corresponding grade table is as indicated

Explanation of Grades and Grade Point Average (GPA)

Marks Obtained	Grade	Grade Points
100-75	O Outstanding	06
74-65	A Very Good	05
64-55	B Good	04
54-50	C Average	03
49-45	D Satisfactory	02
44-40	E Pass	01
39 and less	F Fail	00

Final Grade Points

Grade Points	Final Grade
05.00-6.00	O
04.50-4.99	A
03.50-4.49	B
02.50-3.49	C
01.50-2.49	D
00.50-1.49	E
00.00-0.49	F

Common formula for GPA:

$$\text{GPA (Grade Point Average)} = \frac{\text{Total of (Grade Points Earned X Credit hours for each course)}}{\text{(Total Credit Hours)}}$$

'B' Grade is equivalent to at least 55% of the marks as per GR No. UGC-1298/[4619]/UNI. 4 dt December 11, 1999

13. If the GPA is higher than the indicated upper limit in the third decimal digit, then the student be awarded higher final grade (e.g. a student getting GPA of 4.492 may be awarded 'A').
14. There will be only final compilation and moderation at CGPA (Final) level done at the Department. While declaring the result, the existing relevant ordinances are applicable. There is also a provision for verification and revaluation. In case of verification the existing rules will be applicable. The revaluation result will be adopted if there is a change of at least 10% marks and in the grade of the course.
15. For grade improvement minimum 30 credit courses should be taken by the student. These courses will be from the parent Department.
16. The above circular supersedes all previous circulars on the credit system being operated at Department of Microbiology, University of Pune.

M. Sc. (Microbiology) Curriculum

Semester III

Course no.	Title	Total credits
MB 3.1.1	Carbohydrate Metabolism	1
MB 3.2.1	Nucleic acid metabolism	1
MB 3.3.1	Amino acid metabolism	1
MB 3.4.1	Lipid metabolism	1
MB 3.5.2	Environmental Biotechnology	2
MB 3.6.1	Agricultural Biotechnology	1
MB 3.7.1	Gene transfer	1
MB 3.8.2	Genetic Code	2
MB 3.9.2	T cell receptor and Immunoglobulins	2
MB 3.10.1	Immune system	1
MB 3.11.1	Basic aspects of bioengineering	1
MB 3.12.1	Gene expression Transcription	1
MB 3.13.1	Gene expression Translation	1
MB 3.14.1	Gene regulation	1
MB 3.15.2	Genetic engineering	2
	Theory credits	19
Practicals		
MB 3.01.2	Analytical Biology	2
MB 3.02.2	Fungal genetics and Microbial Technology	2
MB 3.03.2	Genetics	2
MB 3.04.2	Biochemical Techniques II	2
	Practical credits	8
	Total Credits	27

Semester IV

Course no.	Title	Total credits
MB 4.1.2	Disease control in crops	2
MB 4.2.1	Evolution	1
MB 4.3.2	Mathematics for Biologists	2
MB 4.4.1	Plasmid Biology and mobile DNA elements	1
MB 4.5.2	Clinical immunology	2
MB 4.6.1	Biofilms: formation and their applications	1
MB 4.7.1	Waste water technology	1
MB 4.8.1	Downstream processing during fermentation	1
MB 4.9.1	Immobilized cells and enzymes	1
MB 4.10.2	Sensors and biosensors	2
MB 4.11.1	Pharmacology and drug design	1
MB 4.12.1	Antimicrobial agents and chemotherapy	1
MB 4.13.1	Microbial pathogenicity and epidemiology	1
MB 4.14.1	Molecular biology of Bacteriophages	1
MB 4.15.1	Cellular and metabolic regulation	1
MB 4.16.1	Advanced Techniques in Taxonomy	1
	Theory credits	20
Practicals		
MB 4.01.8	Dissertation	8
	Practical credits	8
	Total Credits	28

Department of Microbiology
University of Pune

Revised Syllabus for M.Sc. II Credit Course – w.e.f. June 2009

Course no.	Title	Description	Total credits	References
		M.Sc. II Sem III Theory		
MB 3.1.1	Carbohydrate metabolism	<ol style="list-style-type: none"> 1. Glycolysis and gluconeogenesis 2. Co-ordination regulation of glycogen synthesis and breakdown. 3. Interconversion of sugars. 4. Relationship of carbohydrate, nucleic acid and amino acid metabolism. 5. Peripheral metabolism (pectinases, chitinases, cellulases, amylases). 	1	1. Nelson D. L. and Cox M. M. (2005) <i>Lehninger's Principles of Biochemistry</i> , Fourth edition, W. H. Freeman & Co. New York.
MB 3.2.1	Nucleic acid metabolism	<ol style="list-style-type: none"> 1. De Novo biosynthesis of purine nucleotide, Salwage pathway, regulation of purine nucleotide biosynthesis. 2. De Novo biosynthesis of pyrimidine. Regulation of pyrimidine nucleotide biosynthesis. 3. Ribonucleotide reductase and its role in nucleic acid metabolism. 4. Allosteric regulation of aspartate transcarbamase. 	1	1. Nelson D. L. and Cox M. M. (2005) <i>Lehninger's Principles of Biochemistry</i> , Fourth edition, W. H. Freeman & Co. New York.
MB 3.3.1	Amino acid metabolism	<ol style="list-style-type: none"> 1. Overview of amino acid biosynthesis relationship between glycolysis, citric acid cycle, pentose phosphate pathway and various amino acids. 2. Biosynthesis of following amino acid - Pyruvate family 	1	1. Nelson D. L. and Cox M. M. (2005) <i>Lehninger's Principles of Biochemistry</i> , Fourth edition, W. H. Freeman & Co. New York.

Course no.	Title	Description	Total credits	References
		<ul style="list-style-type: none"> - α keto glutarate family - serine family - aspartate - aromatic amino acid 3. Importance of glutamine synthetase and it's role in amino acid metabolism. 4. Regulation of amino acid biosynthetic Pathway (aspartate family). 5. Biological amines.		
MB 3.4.1	Lipid metabolism	1. Biosynthesis of fatty acids. 2. Biosynthesis of phospholipids. 3. Sterol biosynthesis 4. Lipid degradation: phospholipases, lipases, fatty acid oxidation.	1	1. Nelson D. L. and Cox M. M. (2005) <i>Lehninger's Principles of Biochemistry</i> , Fourth edition, W. H. Freeman & Co. New York.
MB 3.5.2	Environmental Biotechnology	1. Environmental and Natural Resource Management: (02) Natural resources: Water and Land. Components and structure of the environment; Levels of organization in nature - Food chain and Trophic structure; Biogeochemical Cycles; Interdependence of man and environment. 2. Concept, causes and consequences of human Impact on the natural environment and prevention of pollution: i) Pollution phenomena: (08) a) Air and water pollution. b) Radiation pollution. c) Global warming. d) Green house effect. e) Pollution due to e-wastes. f) Biomedical wastes. g) Noise Pollution. ii) Pollution prevention: (10)	2	1).Andrew, W. 1996. Biotechnology for Waste and Wastewater Treatment. Noyes Publications, Westwood, N.J., USA. 2).Barnum, S.1998. Biotechnology, An Introduction, Wadsworth Publishing Co. pp 1-198. 3).Becker, E. W. 1994. Microalgae: Biotechnology and Microbiology. Cambridge University Press, Cambridge, England. 4).Baker, K. H. 1994. Bioremediation. McGraw-Hill, New York, NY. CPCB and MPCB Publications for Compliance Limits (Available with MPCB Offices) 5).Eckenfelder, W. W. 2000. Industrial water pollution control. McGraw-Hill Boston, USA. 4). Eddy, M. Wastewater Treatment, Disposal and Reuse. McGraw-Hill, Inc. 5). Kim, L. 1993. Advanced Engineered Pesticides. Marcel Dekker, Inc., New York. 6). Nduka, O. 2007. Modern Industrial Microbiology and Biotechnology, Science Publishers. pp 1-519.

Course no.	Title	Description	Total credits	References
		<ul style="list-style-type: none"> a) Industrial effluent and solid waste treatment processes. b) Biomedical waste management. c) Environmental Impact Assessment (EIA). d) Value added products from waste (Microbial biomass, biofuels, etc) <p>3. Global and Indian scenarios of environmental economics. (06)</p> <ul style="list-style-type: none"> a) Environmental Economics: Introduction to WTO and International Trade, Environmental Trade Barriers, Green GDP, Natural Resource and Green Accounting, and Biodiversity Registers. b) Environmental Status Reports (National and for Maharashtra State) c) State of the Environment in major cities of India (Air and Water Quality Standards). Compliance standards as laid down by CPCB, State Governments and WHO. d) Green Marketing. <p>4. Standards and codes for environmental management (04)</p> <ul style="list-style-type: none"> 1. ISO – 14001 b) OHSAS – 18001 <p>c) BS / ISO Guideline on Corporate Social Responsibility (CSR) Management (ISO-26000).</p>		<ul style="list-style-type: none"> 7). Ralph, M. 1993. Environmental Microbiology. John Wiley and Sons. 9). Ignacimuthu, S. J. 1995. Basic Biotechnology, Tata McGraw-Hill Publishing Co. Ltd. pp 1-301. 10). Varshney, C. F. Water Pollution and Management. 11) Higgins, B. Economic Development-Problems, Principles and Policies. 12) Lee, J. S. and Newman, M. E. 1992. Aquaculture- An Introduction. Interstate Publishers, Inc. Danville, Illinois.
MB 3.6.1	Agricultural Biotechnology	<p>Production, mechanism of action and mode of application of the following:</p> <ul style="list-style-type: none"> 1) Plant growth promoting pseudomonads: Siderophore production. 2) Biological control agents: <i>Bacillus thuringiensis</i>, <i>Trichoderma</i>, Baculoviruses and Chitinase producing fungi. 3) Geomicrobiology - Microbial 	1	<ul style="list-style-type: none"> 1. Ignacimuthu, S. J. 1995. Basic Biotechnology, Tata McGraw-Hill Publishing Co. Ltd. pp 1-301. 2. Pepler HL (1979). Microbial Technology, Vol I and II, Academic Press Press New York.

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		transformation of manganese, copper, Uranium and sulfur.		
MB 3.7.1	Gene transfer	<p>A) Gene transfer in the environment- horizontal vertical gene transfer, need for gene transfer, mechanisms of gene transfer</p> <p>B) Transformation Transformation- natural and artificial. Uptake of DNA in Gram positive and Gram negative bacteria, competence factors, mechanism of uptake, and recombination</p> <p>C) Conjugation Bacterial conjugation- F plasmid – structure and functions. Origin of conjugation – Hfr and f strains. Interrupted and uninterrupted mating – time map and recombination map. Mechanism of conjugation in <i>E. coli</i>, <i>Pseudomonas</i>, <i>Streptomyces</i>. Conjugative transposons</p> <p>D) Transduction Transduction – generalized and specialized transduction – λ phage and P1 phage – mechanism of gene transfer through λ and P1 phages. Cotransduction- transduction mapping.</p>	1	<ol style="list-style-type: none"> 1. Benjamin Lewin. (2004) <i>Genes VIII</i>, Pearson Education Inc. NJ 2. James D. Watson. (1987) <i>Molecular Biology of the Gene</i>, The Benjamin Cummings Publishing Company Inc. Fourth Edition 3. Gardner EJ, Simmons MJ and Snustad DP. (1991). <i>Principles of Genetics</i>. 8th Ed. John Wiley & Sons Inc. 4. Lorenz MG, Wackernagel W. (1994). Bacterial gene transfer by natural genetic transformation in the environment. <i>Microbiol Rev</i>. 58(3): 563- 602. 5. Salyers AA, Shoemaker NB, Stevens AM, and Li L. (1995). Conjugative Transposons: an Unusual and Diverse Set of Integrated Gene Transfer Elements. <i>Microbiological Reviews</i>, 59 (4): 579–590 6. Dubnau D. (1999). DNA uptake in bacteria. <i>Annu. Rev. Microbiol</i>. 53:217-244. 7. Chen I, Dubnau D. (2004). DNA uptake during bacterial transformation. <i>Nat Rev Microbiol</i>. 2(3): 241- 249. 8. Thomas CM and Nielsen KM. (2005). Mechanisms of, and barriers to, horizontal gene transfer between bacteria. <i>Nature Reviews – Microbiology</i>. 3: 711-721
MB 3.8.2	Genetic Code	Historical approach, deciphering the genetic code, characteristics of genetic code, altered code in mitochondria, codon usage.	2	<ol style="list-style-type: none"> 1. Benjamin Lewin. (2004) <i>Genes VIII</i>, Pearson Education Inc. NJ 2. James D. Watson. (1987) <i>Molecular Biology of the Gene</i>, The Benjamin Cummings Publishing Company Inc. Fourth Edition

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MB 3.9.2	T cell receptor, Immunoglobulins	T-Cell and B cell receptor: Structure and function of T cell (TCR) and B cell receptor, T cell accessory membrane molecules (CD and adhesion molecules) signal transduction by TCR/CD3). Genetic basis of diversity and immunoglobulins. Class switching, idiotypic network.	2	<ol style="list-style-type: none"> 1. Pathak S. S. and Palan V. (1997) <i>Immunology - Essential and Fundamental</i>, Pareen Publications Bombay. 2. Roitt Evan, Brostoff J. Male D. (1993) <i>Immunology</i> 6th Ed., Mosby & Co. London. 3. Roitt M. (1984) <i>Essentials of Immunology</i>, P. G. Publishers Pvt. Ltd., New Delhi. 4. Roitt I. M. (1988) <i>Essentials of Immunology</i>, ELBS, London. 5. Kuby J. (1996) <i>Immunology</i> 3rd Ed. W. H. Freeman & Co.
MB 3.10.1	Immune system	Central and peripheral organs. Lymph nodules, lymph nodes etc. T cells and their subtypes. B cells, APC, natural killer cells. Introduction to experimental animals in immunological research: SCID mice, nude mice, athymic mice, Balb C mice etc.	1	<ol style="list-style-type: none"> 1. Pathak S. S. and Palan V. (1997) <i>Immunology - Essential and Fundamental</i>, Pareen Publications Bombay. 2. Roitt Evan, Brostoff J. Male D. (1993) <i>Immunology</i> 6th Ed., Mosby & Co. London. 3. Roitt M. (1984) <i>Essentials of Immunology</i>, P. G. Publishers Pvt. Ltd., New Delhi. 4. Roitt I. M. (1988) <i>Essentials of Immunology</i>, ELBS, London. 5. Kuby J. (1996) <i>Immunology</i> 3rd Ed. W. H. Freeman & Co.
MB 3.11.1	Basic aspects of bioengineering	<ol style="list-style-type: none"> 1. Basic aspects of bioengineering: <ol style="list-style-type: none"> a) Design of fermenter/ bioreactors- Design aspects of flask, stirred tank reactor, Air-lift fermenter, Tower fermenter. b) Kinetics of operation of bioreactors, Batch, Fed-batch, Continuous processes. c) Design and operation of immobilized cell reactors. 2. Aeration and agitation of fermentation broth: <ol style="list-style-type: none"> a) Aeration- theory of oxygen transfer in bubble aeration, Oxygen transfer kinetics, determination of K_{La}. 	1	<ol style="list-style-type: none"> 3. Stanbury PF and Whittaker A. (1984) <i>Principles of Fermentation technology</i>. Pergamon press 4. Pepler HL (1979). <i>Microbial Technology</i>, Vol I and II, Academic Press New York. 5. Prescott SC and Dunn CG. (1983). <i>Industrial Microbiology</i>. Reed G. AVI tech books. 6. Doran Pauline (1995) <i>Bioprocess Engineering Principles</i>, Academic Press. 7. ----- (1992) <i>Operational Modes of Bioreactors</i>, BIOTOL series, Butterworths Heinemann. 8. Lydersen B., N. a. D' Elia and K. M. Nelson (Eds.) (1993) <i>Bioprocess Engineering: Systems</i>,

Course no.	Title	Description	Total credits	References
		<p>b) Agitation- Design of impellers and their hydrodynamics.</p> <p>c) Fermentation broth rheology and power requirements for agitation – Concept of Newtonian and non-Newtonian fluids, effect of broth rheology on heat, nutrient and oxygen transfer, Reynold's number, power number, aeration number.</p> <p>3. Monitoring of process variables:</p> <p>a) Use of various types of sensors and biosensors for monitoring environmental parameters (pressure, pH, temperature, DO, DCO₂ etc.)</p>		<p><i>Equipment and Facilities</i>, John Wiley and Sons Inc.</p> <p>9. Van Damme E. J. (1984) <i>Biotechnology of Industrial Antibiotics</i>, Marcel Dekker Inc. New York.</p>
MB 3.12.1	Gene expression Transcription	<p>I) Prokaryotic transcription Structure of bacterial RNA polymerase, Typical bacterial promoter, role of sigma factor, transcription-Initiation, elongation and termination events (Rho dependent, Rho independent termination)</p> <p>II) Eukaryotic transcription Eukaryotic RNA polymerases- I, II, III, Promoter sequences, TATA box, Hogness box, CAAT box, TBP as a universal factor, CpG islands, Enhancers, Insulators, Initiation, termination of transcription</p> <p>III) Transcription factors, DNA binding domains, Homeodomain, Zinc fingers, Helix turn helix motif, Leucine zippers, Triple helix and its significance.</p> <p>IV) RNA processing in eukaryotes RNA splicing- group I, group II introns, Lariat formation, Sn RNA, spliceosomes, yeast t-RNA splicing, m-RNA, r-RNA</p>	1	<p>1. Benjamin Lewin. (2004) <i>Genes VIII</i> Pearson Education Inc. NJ</p> <p>2. Hayes William (1984). <i>The Genetics of Bacteria and their Viruses</i>, CBS pub, New Delhi.</p> <p>3. Russel Peter. <i>Essential Genetics</i>. 2nd Edn, Blackwell Science Pub.</p> <p>4. Watson JD. (1987) <i>Molecular Biology of the Gene</i>, 4th Ed. The Benjamin Cummings Publishing Company Inc.</p> <p>5. Friefelder D. (1995). <i>Molecular Biology</i>, 2nd Edn. Narosa Publishing House</p>

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		processing, RNA editing, guide RNAs		
MB 3.13.1	Gene expression Translation	<ol style="list-style-type: none"> Structure of RNAs in prokaryotes and eukaryotes. <ul style="list-style-type: none"> t-RNA: Structure, modified bases in t-RNA, amino acyl t-RNA synthetase. r-RNA: Ribosomal structural components, comparison of eukaryotic, prokaryotic ribosomes, active centers of ribosome. m-RNA: Translation process in prokaryotes and eukaryotes.- initiation, elongation, termination of translation Co-translational/ post-translational modifications, Molecular chaperons. Protein trafficking,, Leader sequences and protein localization, Anchor sequences, Protein splicing –inteins, exteins 	1	<ol style="list-style-type: none"> Benjamin Lewin. (2004) <i>Genes VIII</i> Pearson Education Inc. NJ Hayes William (1984). <i>The Genetics of Bacteria and their Viruses</i>, CBS pub, New Delhi. Russel Peter. <i>Essential Genetics</i>. 2nd Edn, Blackwell Science Pub. Watson JD. (1987) <i>Molecular Biology of the Gene</i>, 4th Ed. The Benjamin Cummings Publishing Company Inc. Friefelder D. (1995). <i>Molecular Biology</i>, 2nd Edn. Narosa Publishing House
MB 3.14.1	Gene regulation	<p>Regulation of gene function:</p> <ol style="list-style-type: none"> Positive/negative control General concept exemplified with the help of lactose operon, induction/ repression, coordinate expression of genes Control in Arabinose operon. Tryptophan operon, attenuation control, Internal promoters in Histidine operon Double promoters in galactose operons. 	1	<ol style="list-style-type: none"> Benjamin Lewin. (2004) <i>Genes VIII</i> Pearson Education Inc. NJ Russel Peter. <i>Essential Genetics</i>. 2nd Edn, Blackwell Science Pub. Watson JD. (1987) <i>Molecular Biology of the Gene</i>, 4th Ed. The Benjamin Cummings Publishing Company Inc.
MB 3.15.2	Genetic engineering	<ol style="list-style-type: none"> Cutting and joining of DNA molecules: restriction enzymes, E. coli and T4 DNA ligase. Use of natural cohesive termini, homopolymer tails and adaptors and linkers to make R- DNA. Vectors – λ, M13 plasmid, BAC and YAC, cosmid etc. Genomic library – C DNA library. 	2	<ol style="list-style-type: none"> Benjamin Lewin. (2004) <i>Genes VIII</i>, Pearson Education Inc. NJ James D. Watson. (1987) <i>Molecular Biology of the Gene</i>, The Benjamin Cummings Publishing Company Inc. Fourth Edition R.W. Old & S. B. Primrose () <i>Principles of Gene Manipulation : An Introduction to Genetic</i>

Course no.	Title	Description	Total credits	References
		5. Some useful techniques in recombinant DNA technology: agarose gel electrophoresis, southern and northern blots, RFLP, PCR, Sanger's dideoxy sequencing etc. 6. Transgenomics: Transgenic plants, transgenic animals (dolly, polly), cloning of whole animal, human cloning for therapeutic purpose.		<i>Engineering.</i> 4. Sambrook J, Fritsch EF, Maniatis T. (1989). In: Molecular Cloning: A Laboratory Manual (2nd ed). CSH Press, USA.
		Total Credits	19	
M.Sc. II Sem III Practicals				
MB 3.01.2	Analytical Biology	1. Statistical analysis of data 2. Problems based biological experiments in genetics, immunology, environmental microbiology, molecular biology, etc	2	
MB 3.02.2	Fungal genetics and Microbial Technology	1) Isolation of high yielding cellulolytic regulatory mutants. 2) Isolation of Overgrowth mutants of <i>T. harzianum</i> . 3) Liquifaction and saccharification of cellulose. 4) Spawn and biomass production and chemical analysis of biomass. 5) Polysaccharide production optimization. 6) Targeted screening of bioactive metabolite producers. 7) Slope ratio and parallel line assays for bioactive metabolites.	2	1).Cuskey, S. M., Montenecourt, B. S. and Eveleigh, D. E.1983. Screening for cellulolytic mutants. Chapter 2, 32-48 in Liquid Fuel Developments (Ed. Donald L. W.) CRC Series in Bioenergy Systems. 2).Eveleigh, D. E., and Montenecourt, B. S. 1979. Increasing yield of extracellular enzymes. Adv. Appl. Microbiol. 25, 57-74. 3).Nduka,O. 2007. Modern Industrial Microbiology and Biotechnology, Science Publishers.pp 1-519. 4).Silman, R. W., Bryan, W. L. and Leathers, T. D. 1990. A comparison of polysaccharide from strains of <i>A. pullulans</i> . FEMS Microbiology Letters 71, 65-70.
MB 3.03.2	Techniques in Genetics and molecular biology	1. Use of metabolic pools for auxotroph isolation. 2. Isolation of plasmid DNA 3. Restriction mapping. 4. Enzymatic Amplification of DNA by PCR: Standard Procedures and Optimization 5. Cloning of DNA fragments into plasmid vectors. 6. Identification of recombinants by blue and	2	

Course no.	Title	Description	Total credits	References
		white colony screening using X Gal, ONPG, IPTG chromogenic substrates. 7. Isolation and one step growth curve of bacteriophages.		
MB 3.04.2	Biochemical Techniques II	1. Fluctuation test. 2. Ouchterlony technique 3. Enzyme-Linked Immunosorbent Assays (ELISA). 4. Radioisotopes – half life calculation.	2	Principles and techniques of practical biochemistry. Ed Keith Wilson and John Walker. Cambridge University Press.
		Practical credits	8	
		Total Credits	27	
M.Sc. II Sem IV Theory				
MB 4.1.2	Disease control in crops	Managing crop diseases through cultural practices, Biological control agents in plant disease control, Induced resistance for plant disease control, The use of compost extracts in plant disease control, The use of host plant resistance in disease control, Exploitation of tolerance in plant disease control, Plant disease control through the use of variety mixtures, Biofumigation as a means of controlling plant disease, Sulphur-induced resistance in plant disease control, Bacteriophages as agents for the control of plant pathogenic bacteria, Controlling plant disease using biologically-based and environmentally-friendly approaches: making it work in practice	2	1).Chet, I. 1993. Biotechnology in Plant Disease Control. Wiley-Liss, New York, NY. 2).Bhojwani, S. S. 1990. Plant Tissue Culture: Applications and Limitations. Elsevier, Amsterdam.
MB 4.2.1	Evolution	1. History and development of evolutionary theory, Neo-Darwinism: Spontaneous mutation controversy, evolution of rates of mutation, types of selection, levels of selection, group selection and selfish gene.	1	1. Ridley Mark (2004). <i>Evolution</i> . Blackwell Science Ltd. 2. Strickberger M. W. (2000). <i>Evolution</i> . Jones & Bartelette Publications.

Course no.	Title	Description	Total credits	References
		<p>2. Sociobiology, kin selection, evolutionary stability of cooperation, sociality and multicellularity in microorganisms , Game theory. Co-evolutionary strategies, host parasite co-evolution, Neutral evolution and molecular clocks, phylogeny and molecular distances.</p> <p>3. Molecular evolution: origin of life, the origin of new genes and proteins. Evolution of life histories, ageing, evolutionary trade offs, r and k selection, Evolutionary origin of biochemical disorders: The case of insulin resistance.</p>		
MB 4.3.2	Mathematics for Biologists	Numbers, variables (independent, dependent and continuous), Definition of Mathematical Function: linear, geometric and exponential functions; differentiation and integration of simple functions, graphs, plots.etc.	2	Arya J.A and Lardner R.W. (1979) Mathematics for Biological Sciences. Prentice Hall Inc.
MB 4.4.1	Plasmid Biology and mobile DNA elements	<p>Origin and evolution of plasmids, plasmid nomenclature, properties and categories of plasmids, plasmid replication, Techniques in plasmid biology- isolation of plasmids, incompatibility grouping, curing of plasmids, mapping of plasmids, plasmid vectors.</p> <p>i) Transposable elements in bacteria, IS elements, composite transposons, replicative, non-replicative transposons, Mu transposition,</p> <p>ii) transposition like events in retroviruses/retrotransposons, Ty elements in yeast,</p> <p>iii) Controlling elements in Tn A and Tn 10 transposition, SINES and LINES,</p> <p>iv) Role of transposons in recombination</p>	1	<p>1. Grinsted J and Bennet PM. Plasmid Technology. In : Methods in Microbiology. Vol 21 2nd Ed. 1988. Academic Press</p> <p>2. Benjamin Lewin. (2004) <i>Genes VIII</i> Pearson Education Inc. NJ</p> <p>3. Watson JD. (1987) Molecular Biology of the Gene, 4th Ed. The Benjamin Cummings Publishing Company Inc.</p> <p>4. Sambrook J, Fritsch EF, Maniatis T. (1989). In: Molecular Cloning: A Laboratory Manual (2nd ed). CSH Press, USA.</p>

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MB 4.5.2	Clinical immunology	<p>A. Tumor Immunology : Cellular adaptation and properties of cancer cells, escape mechanisms of tumor from host defense, immune response to tumor – role of cells of immune system, Immuno- surveillance theory, tumor antigens, cancer immunotherapy, immuno-diagnosis of tumors – biochemical and immunological tumor markers (detection of tumor markers)</p> <p>B. Disorders of immune system Immunodeficiency disorders – Phagocytic deficiencies, humoral deficiencies, cell mediated deficiencies, and combined deficiencies, complement deficiencies, Autoimmunity, Rheumatic diseases: Systemic Lupus Erythomatosus, Rheumatoid arthritis, Multiple myeloma, Myasthenia gravis.</p> <p>C. Oncogenes and Cancer: i) Types of cancers- Carcinoma, Sarcoma, Lymphoma, Leukemia, Germ cell tumor etc. ii) Immortalization/ transformation, metastasis, oncogenes, proto oncogenes, tumor suppressor genes, iii) transforming viruses, V-onc and C- onc genes, Ras pathway, Gene translocation, Cmyc signal transduction, Src kinase tumor suppressors, RB and p53 protein , Apoptosis, DNA methylation and cancer Tumor markers.</p>	2	<p>a) Chatterji C. C. (1992) <i>Human Physiology</i> Vol. 1 &2, Medical Allied Agency, Calcutta.</p> <p>b) Guyton A. C. and Hall J. E. (1996) <i>Text Book of Medical Physiology</i>, Goel Book Agency, Bangalore.</p> <p>c) Baron D. N. <i>Short Text book on Chemical Pathology</i>, ELBS, London.</p> <p>d) Austyn J. M. and Wood K. J. (1993) <i>Principles of Molecular and Cellular Immunology</i>, Oxford University Press,</p> <p>e) Barret James D. (1983) <i>Text Book of Immunology</i> 4th edition, C. V. Mosby & Co. London.</p> <p>f) Boyd William C. (1966) <i>Fundamentals of Immunology</i>, Interscience Publishers, NY.</p> <p>g) Talwar G. P. (1983) <i>Handbook of Immunology</i>, Vikas Publishing Pvt. Ltd. New Delhi.</p> <p>h) Pathak S. S. and Palan V. (1997) <i>Immunology - Essential and Fundamental</i>, Pareen Publications Bombay.</p> <p>i) Roitt Evan, Brostoff J. Male D. (1993) <i>Immunology</i> 6th Ed., Mosby & Co. London.</p> <p>j) Roitt M. (1984) <i>Essentials of Immunology</i>, P. G. Publishers Pvt. Ltd., New Delhi.</p> <p>k) Roitt I. M. (1988) <i>Essentials of Immunology</i>, ELBS, London.</p> <p>l) Kuby J. (1996) <i>Immunology</i> 3rd Ed. W. H. Freeman & Co.</p>
MB 4.6.1	Biofilms: formation and their applications	<p>STRUCTURE AND PROPERTIES OF BIOFILMS: Study of Quorum Sensing: Cell- Cell Communication Amongst Endophytic Nitrogen Fixing Bacteria Of plants, A New Approach to Studying Biofilms, Does Biofilm Formation Constitute a Form of Microbial Development? GRAM-NEGATIVE BACTERIA</p>	1	<p>1). Davies DG, Parsek MR, Pearson JP, Iglewski BH, Costerton JW, Greenberg EP. 1998. The involvement of cell-to cell signals in the development of a bacterial biofilm. <i>Science</i> 280 (5361):295–98</p> <p>2). O’Toole GA, Kolter R. 1998. The initiation of biofilm formation in <i>Pseudomonas aeruginosa</i></p>

Course no.	Title	Description	Total credits	References
		<p>:Regulation of Initial Attachment, Biofilm Formation Proceeds via Multiple Convergent Genetic Pathways, Early Attachment Events, Maturation of the Biofilm , Detachment and Return to the Planktonic Growth Mode, Similarity of <i>M. xanthus</i> Fruiting Body Development, and <i>P. aeruginosa</i> Biofilm Formation; GRAM-POSITIVE BACTERIA AND MULTISPECIES BIOFILMS: Clinical Relevance, Early Attachment Events, Maturation, Leaving the Biofilm; FUNGAL BIOFILMS: Initial Attachment :</p> <p>BIOFILMS IN PLANT-ASSOCIATED HABITATS: In the Phyllosphere (size, composition and localization, impact on survival and bacterial interactions, interaction of plants with epiphytic biofilms,) , In the Rhizosphere (ubiquity and importance for rhizosphere bacteria, impact of rhizosphere biofilms on plant biology,) , Within Plant Tissues, biofilms, airborne dissemination, and cosmopolitanism, biofilms and management of plant health and food quality, Biofilms and waste treatment.</p>		<p>WCS365 proceeds via multiple, convergent signaling pathways: a genetic analysis. <i>Mol. Microbiol.</i> 28:449–61</p> <p>3).Morris, C. E. and Monier, J. M. 2003.THE ECOLOGICAL SIGNIFICANCE OF BIOFILM FORMATION BY PLANT-ASSOCIATED BACTERIA. <i>Annu. Rev. Phytopathol.</i> 41:429–53</p> <p>4).O’Toole, G. , Kaplan, H. B. and Kolter, R. , 2000. BIOFILM FORMATION AS MICROBIALDEVELOPMENT. <i>Annu. Rev. Microbiol.</i> 2000. 54:49–79</p>
MB 4.7.1	Waste water technology	<ol style="list-style-type: none"> 1. Wastewater treatment system (unit process): Physical screening, flow equalization, mixing, flocculation, flotation, granular medium filtration, adsorption. 2. Chemical precipitation, gas transfer, disinfection, dechlorination 3. Biological: (aerobic and anaerobic, suspended and attached growth processes.) Working treatment systems and their analysis (reactions and kinetics, mass balance analysis, reactor types, hydraulic character of reactors, selection of reactor type,) Critical operating parameters like DO, hydraulic retention time, mean cell 	1	<ol style="list-style-type: none"> 1. Tchobanoglous G. and F. L. Burton. (1991). <i>Wastewater Engineering, Treatment, Disposal and Reuse.</i> 3rd Ed., 2. Metcalf and Eddy (Eds). Tata Mac Graw Hill Publishing Co. Ltd. New Delhi.

Course no.	Title	Description	Total credits	References
		<p>residence time, F/M ratio etc.</p> <p>4. Effluent disposal, control and reuse. Water pollution control, Regulation and limit for disposals in the lakes, rivers, oceans, and land. Direct and indirect reuse of treated effluents and solid wastes.</p> <p>5. Current industrial wastewater treatment and disposal processes (Textile, dyestuff, dairy, paper and pulp manufacturing industries)</p>		
MB 4.8.1	Downstream processing during fermentation	<p>1) Growth and product formation during fermentation:</p> <p>2) Concept of primary (growth associated) and secondary (growth non-associated) metabolites and their control, kinetics of growth and product formation (growth rate, yield coefficient, efficiency etc.)</p> <p>3) Production, Recovery, Assay and Applications of</p> <ol style="list-style-type: none"> Vitamin C Antibiotics (Cycloheximide, Tetracyclins) Microbial enzymes (Penicillin acylase, Chitinase, Lipase) Recombinant and synthetic vaccines. 	1	<p>1. Basic Biotechnology edited by Colin Ratledge and Bjorn Kristiansen (Second edition)</p> <p>2. Doran Pauline (1995) <i>Bioprocess Engineering Principles</i>, Academic Press.</p> <p>3. ----- (1992) <i>Operational Modes of Bioreactors</i>, BIOTOL series, Butterworths Heinemann.</p> <p>4. ----- (1992) <i>Bioreactor Design and Product Yield</i>, BIOTOL series, Butterworths Heinemann.</p> <p>5. Lydersen B., N. a. D' Elia and K. M. Nelson (Eds.) (1993) <i>Bioprocess Engineering: Syatems, Equipment and Facilities</i>, John Wiley and Sons Inc.</p> <p>6. Peppler H. J. and D. Perlman (1970) <i>Microbial Technology</i> Volume 1 and 2, Academic Press New York.</p> <p>5. Wiseman A.(1985) <i>Topics in Enzyme and Fermentation - Biotechnology</i>, Vol. 1 and 2, John Wiley and Sons, New York.</p> <p>6. Van Damme E. J. (1984) <i>Biotechnology of Industrial Antibiotics</i>, Marcel Dekker Inc. New York.</p> <p>7. Ehrilich M. L. (1981) <i>Geomicrobiology</i>, Marcel Dekker Inc., New York and Basel.</p>
MB 4.9.1	Immobilized cells and enzymes	<p>1) Immobilization</p> <p>2) Changes in physical and chemical properties</p>	1	<p>1. Enzymes and immobilized cells in</p>

Course no.	Title	Description	Total credits	References
		<p>when an enzyme undergo upon immobilization.</p> <ul style="list-style-type: none"> - Enzyme's catalytic activities. - Stability of enzymes. - Kinetic properties of enzymes. <p>3) Techniques and Support for Immobilization</p> <ol style="list-style-type: none"> 1. Carrier-Binding Method <ul style="list-style-type: none"> - Physical adsorption - Ionic binding - Covalent binding 2. Cross-Linking Method 3. Entrapping Method 4. Entrapping method <ul style="list-style-type: none"> - Lattice type - Microcapsule type <p>4) Properties of immobilized biomass.</p> <p>5) Applications of immobilized enzymes</p> <ol style="list-style-type: none"> I) Immobilized enzymes in bioprocess. <ol style="list-style-type: none"> a) Immobilized enzymes in organic solvents. b) Immobilization of enzymes for the fabrication of biosensors. c) Immobilized enzymes for the regeneration of cofactors. d) Immobilized multienzymes and enzyme-cell co-immobilization <p>6) Modified methods of cell immobilization</p> <p>7) Types of reactors use for cell immobilization</p> <p>8) Uses of immobilized cells</p>		<p>biotechnology by Allen I. Laskin.</p> <ol style="list-style-type: none"> 2. S. V. Ramakrishna and R. S. Prakasham Microbial fermentations with immobilized cells (Biochemical and Environmental Engineering, Indian Institute of Chemical Technology, Hyderabad 500 007, India) 3. S.F. D'souza Immobilized enzymes in Bioprocess Nuclear Agriculture and biotechnology Division, BARC, Trombay, Mumbai, India 4. <i>Ichiro Chibata and Tetsuya Tosa</i> Use of immobilized cells Annu. Rev. Biophys. Bioeng. 1981.10:197-216.
MB 4.10.1	Sensors and biosensors	Basic principles and operation of biosensors, types of biosensors and applications of biosensors.	1	
MB 4.11.1	Pharmacology and drug design	A] Study of major groups of pharmacologically active molecules of plant , animal and microbial origins: Physical and chemical properties, metabolic activity,	1	1. Goldstein A., Aronow L., and Kalman S. M. (1969) <i>Principles of Drug Action, The Basis of Pharmacology</i> , Harper international edition New York.

Course no.	Title	Description	Total credits	References
		<p>identification of drug target/receptors, elucidation of the mechanism of drug action, Drug interactions, toxicity and adverse reactions, toxicity testing, assays for mutagenicity, carcinogenicity, pyrogenicity and allergy testing.</p> <p>Extraction, Purification and characterization of bioactive molecules:</p> <ol style="list-style-type: none"> 1. Extraction: Hot and cold extraction methods, Solvent extraction. 2. Purification: Analytical and preparative procedures. 3. Characterization: Physical and chemical characterization methods for alkaloids, steroids, flavenoids, terpenoids, saponins, protein peptides and amino acids etc. Steps towards commercialization of drug, Regulations on drug, FDA. <p>B] Modern drug discovery tools: Cheminformatics and molecular modeling: Combinatorial biocatalysis, combinatorial biosynthesis.</p>		<ol style="list-style-type: none"> 2. Burn J. H. (1957) <i>Principles of Therapeutics</i>, Blackwell Scientific Pub. O. Ltd. Oxford. 3. Iyengar M. A. (1974) <i>Pharmacology of Powdered Crude Drugs</i>, Manipal. 4. Kokate C. K., Purohit A. P., Gokhale A. B. (2000) <i>Pharmacology</i>, 4th Ed., Nirali Prakashan. 5. Osol Arther (1975) <i>Remington's Pharmaceutical Sciences</i>, 15th Ed., Mack Pub. Co., Pennsylvania. 6. Goodman Gillman's <i>The Pharmacological basis of therapeutics</i>. (2001) Ed. Hardman JG, Limbird LE (Tenth Edition) McGraw Hill press New York. 7. <i>Applied biopharmaceutics and pharmacokinetics</i> (1999) Ed. Sargel L. (IV Edition) Prentice-Hall International, London. 8. <i>Fundamentals of experimental pharmacology</i>. (1984) Ed. Ghosh MN. Scientific book agency, Calcutta. 9. <i>Text book of receptor pharmacology</i>. Eds. Forman JC, Johansen TJ CRC Press, New York 1996. 10. <i>Drug Discovery and Evaluation –Pharmacological assays</i>. (1997) Ed. Vogel HG & Vogel WH. Springer-New York.
MB 4.12.2	Antimicrobial agents and chemotherapy	<ol style="list-style-type: none"> 1. An outline of the historical development of antimicrobial agents. Reasons for studying the biochemistry and molecular biology of antimicrobial compounds. Uncovering the molecular basis of antimicrobial action. Current trends in the discovery of antimicrobial drugs. 2. Antimicrobial assays in liquid and solid media, susceptibility testing in liquid and solid media. 	2	<ol style="list-style-type: none"> 1. Burn J. H. (1957) <i>Principles of Therapeutics</i>, Blackwell Scientific Pub. O. Ltd. Oxford. 2. Iyengar M. A. (1974) <i>Pharmacology of Powdered Crude Drugs</i>, Manipal. 3. Kokate C. K., Purohit A. P., Gokhale A. B. (2000) <i>Pharmacology</i>, 4th Ed., Nirali Prakashan. 4. Osol Arther (1975) <i>Remington's Pharmaceutical Sciences</i>, 15th Ed., Mack Pub. Co., Pennsylvania. 5. Goldstein A., Aronow L., and Kalman S. M. (1969) <i>Principles of Drug Action, The Basis of Pharmacology</i>, Harper international edition New York.

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		<p>3. Antibiotics that inhibit peptidoglycan biosynthesis. Drugs that interfere with the biosynthesis of the cell wall of mycobacteria. Fungal cell wall as a target for antimicrobial drugs.</p> <p>4. Ionophoric antibiotics. Antifungal agents that interfere with the function and biosynthesis of membrane sterols.</p> <p>5. Inhibitors of nucleic acid biosynthesis.</p> <p>6. Inhibitors of protein biosynthesis.</p> <p>7. Nitroheterocyclic antimicrobial agents. A unique antifungal antibiotic- griseofulvin, antiviral agents, antiprotozoal agents.</p> <p>8. Attack and defense: drug transport across cell walls and membranes.</p>		<p>6. Satoskar R. S. & S. D. Bhandarkar (1991) <i>Pharmacology and Pharmacotherapeutics</i>, 12th Ed., Vol. 1 & 2, Popular Prakashan, Mumbai.</p> <p>7. Chatwal G. P. (2003) <i>Biopharmasceutics and Pharmacokinetics</i>, Himalaya Publishing House, Mumbai.</p> <p>8. Micheles P. S., Y. L. Khmelnsley, J. S. Dordick and D. S. Clark, (1998), <i>Combinatorial Biocatalysis, A Natural Approach to Drug Discovery</i>, Trends in Biotechnol. 16, 197.</p> <p>9. Altreuter D., and D S. Clark, (1999), <i>Combinatorial Biocatalysis: Taking the Lead From Nature</i>, Curr. Opin. Biotechnol. 10, 130.</p>
MB 4.13.1	Microbial pathogenicity and epidemiology	<p>1) Virulence factors: Mechanism of adhesion, colonization and invasion of host tissues by bacterial pathogens, measurements of virulence.</p> <p>2) Mechanisms of bacterial resistance to host cellular and humoral defenses.</p> <p>3) Microbial toxins: Characteristics, purification, Mode of action and assay (in vivo, in vitro) of diphtheria, cholera, tetanus toxins and endotoxins of Gram negative bacteria.</p> <p>4) Medical mycology – pathogenesis of fungi, structural dimorphisum and role of extra cellular products in fungal infection.</p> <p>5) Anaerobic bacterial infections in human beings and therapy.</p>	1	<p>1) Virulence mechanisms of bacterial pathogens (Second edition) by Roth, Bolin, Brogden Minion and Michael</p> <p>2) Medical Microbiology edited by Samuel Baron. Fourth edition. (University of Texas Medical Branch of Galvesion)</p> <p>3) Medical Microbiology: an Introduction to infectious diseases. Sherris, John C, Ed, Elsevier Publication IInd edition.</p>

Course no.	Title	Description	Total credits	References
		<p>6) Host defence mechanisms – non specific defence mechanism, phagocytosis and antibody production and sensitization of T-cells.</p> <p>7) Epidemiology:</p> <p>a) Concept of epidemic, endemic and pandemic</p> <p>b) Spread of certain infections in a population.</p> <p>c) Chain of infection</p> <ul style="list-style-type: none"> - Etiologic agent - Method of transmission - Host <p>d) Epidemiological methods</p> <ul style="list-style-type: none"> - Descriptive - Analytical - Experimental epidemiology. <p>e) Measurement of infection rate.</p> <p>f) Epidemic investigation</p>		
MB 4.14.1	Molecular Biology of Bacteriophages	DNA replication in T phages, lambda phage, different mutants in phages: rapid lysis mutants (rI, rII, rIII), Conditional mutants e.g clear plaque mutants, mechanism of packing DNA in phage heads, Lambda- lytic cascade and lysogenic repression; M13 replication.	1	<ol style="list-style-type: none"> 1. Birge,E.A. (2006) Bacterial and Bacteriophage Genetics. 5th Edition. Sriger Publications 2. Moat A. G., C J. W. Foster, P. Spector. Microbial Physiology 4th Edition 3. Benjamin Lewin. (2004) <i>Genes VIII</i> Pearson Education Inc. NJ 4. Russel Peter. Essential Genetics. 2nd Edn, Blackwell Science Pub. 5. Watson JD. (1987) Molecular Biology of the Gene, 4th Ed. The Benjamin Cummings Publishing Company Inc.
MB 4.15.1	Cellular and metabolic regulation	Regulation at different levels: translational, post-translational, regulation at enzyme level. Feedback inhibition and repression, allosteric regulation, TCA cycle – aerobic, anaerobic, operation under non glucose carbon source. Strategies of Feedback inhibition, sequential and consorted feedback, isoenzymes.	1	<ol style="list-style-type: none"> 1. Nelson D. L. and Cox M. M. (2005) <i>Lehninger's Principles of Biochemistry</i>, Fourth edition, W. H. Freeman & Co. New York.

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		Signal transduction mechanism – quorum sensing		
MB 4.16.1	Advanced Techniques in taxonomy	Molecular systematics, DNA fingerprinting, Gene sequencing methods: 16S rDNA sequencing, Multilocus sequence typing (MLST), pyrosequencing, Sequencing by ligation, SOLiD sequencing etc	1	
		Theory Credits	20	
MB 4.01.8	Dissertation		8	
		Total Credits	28	