Maharshi Dayanand Saraswati University, Ajmer

Syllabus
Scheme of Examination and Course Outline

FACULTY OF SCIENCE
M.Sc. (Microbiology)
Semester I Examination December 2009
Semester II Examination June 2010
Semester III Examination December 2010
Semester IV Examination June 2011

Scheme of Examination and Course Outline 2008-09

1. Eligibility: Candidate having obtained minimum 50% marks in aggregate in B.Sc./B.Sc. (Hons)/B.Sc. B.Ed. in any discipline of biology/B.Sc. (Ag).

2. The scheme of the course: M.Sc. (Microbiology) shall be run under semester scheme. A total of sixteen theory papers (4 compulsory in each of the four semesters) of 3 hrs. duration and maximum 50 marks each are prescribed.

3. Question papers (Theory): The paper setter shall set total 10 questions (of equal marks) for each theory paper, out of which the examinee shall be asked to attempt any five questions.

4. A combined practical examination (Maximum 200 marks with break up as below) shall be conducted at the end of semester II and IV. Thus examination of practical course in semester I shall be combined with Semester II and that of Semester III shall be combined with semester IV.

a. Experimental work (Max. marks 100, 6 hrs. duration) shall be performed by each candidate as per the question paper set on the basis of the courses mentioned for practical in the syllabus. (Concerned department depending upon the facilities available with them can modify syllabus up to a maximum of 30%).

b. Date wise, signed record (maximum 20 marks) of the experiments conducted by each student throughout the academic session shall be placed by him/her before the examining panel on the day of practical examination.

c. Viva voce (30 marks) and Project work/Review essay (Max marks 50 for each semester): In Semester I, the students shall submit and present a review essay. The essay assignment is intended to assist in achieving a better understanding of some aspects of the subject through critical reading and analysis of current research literature on a specific subject.

Essay Format and Requirements: Topics for essays shall be decided by the departmental committee and displayed on the notice board. Students shall give prioritized choices of three topics. Based on this the departmental committee shall assign the topic as well as supervisor to each student. An up-to-date and in-depth review of the current state of knowledge in some aspects of the subject matter should be written according to the style of an article in Indian Journal of Microbiology. One must consult the "Instruction to Authors" for this journal, available at the departmental library for preparation of essay. *One may find it useful to first prepare an outline (such as a Table of Contents indicating the major subheadings) of the essay and discuss it with the supervisor before proceeding with essay writing.* The essay should be a review of recent scientific research literature, consisting of at least 20 original research articles. Textbooks can be quoted, but not counted as one of the 20 articles. The review article, including tables, figures, and references must not exceed 20 pages (A 4 size) of double-spaced typing. Photocopies of figures and tables shall not be accepted. One should prepare his/her own tables and figures for illustration. Working in

groups of 2 or more shall be encouraged, although this is not an absolute requirement. Whether working alone or as a team, the requirements for the essay are the same. It is, therefore, useful and highly recommended to engage in constructive criticism and discussion of partner's portion of the essay. Submitted essays will not be returned. One may, of course, review the essays after they have been marked.

In second semester students are expected to prepare a research plan as directed by the supervisor and present the same in front of the departmental committee. In third and fourth semester the student is expected to carry out the research work and present the results before the departmental committee. However such internal evaluation in all semesters will constitute only 30% of the marks.

The write ups of all semesters shall be evaluated at the time of practical examination by the panel of examiners. The final project report shall be presented in the format of original research paper following the instruction to authors for the "Indian Journal of Microbiology on A4 size paper. The Project work is intended to make the students learn scientific and methodical planning and conduction of experiments and preparation of reports.

5. Scheme of papers

Semester I

S. No.	Theory/Practical	Subject of the Paper	Marks for subheads	Internal Assessment	External Assessment	Maximum Marks
A	Theory					
	101	Bacteriology		10	40	50
	102	Microbiological Techniques and Eukaryotic Microbiology		10	40	50
	103	Molecular Biology		10	40	50
	104	Biochemistry		10	40	50
B	Combined Practical					100
		Practical	50			
		Viva voce	15			
		Record	10			
		Project work	25			
	Sub Total (Semester I)					300

Semester II

S. No.	Theory/Practical	Subject of the Paper	Marks for sub heads if any	Internal Assessment	External Assessment	Maximum Marks
A	Theory					
	205	Virology		10	40	50
	206	Microbial Ecology and Biology of Extremes		10	40	50
	207	Microbial Genetics and Recombinant DNA Technology		10	40	50
	208	Fermentation Technology		10	40	50

B	Combined Practical					100
		Practical	50			
		Viva voce	15			
		Record	10			
		Project work	25			
	Sub total (Semester II)					300

Semester III

S. No.	Theory/Practical	Subject of the Paper	Marks for sub heads if any	Internal Assessment	External Assessment	Maximum Marks
A	Theory					
	309	Microbial Physiology and Development		10	40	50
	310	Immunology		10	40	50
	311	Medical Microbiology		10	40	50
	312	Biostatistics and Computational Biology		10	40	50
CP	Combined Practical					100
		Practical	50			
		Viva voce	15			
		Record	10			
		Project work	25			
	Sub total (Semester III)					300

Semester IV

S. No.	Theory/Practical	Subject of the Paper	Marks for sub heads if any	Internal Assessment	External Assessment	Maximum Marks
A	Theory					
	413	Food Microbiology		10	40	50
	414	Environmental Microbiology		10	40	50
	415	Bioprocess engineering and Technology		10	40	50
	416	Bioinformatics & Microbial Genomics		10	40	50
B	Combined Practical					100
		Practical	50			
		Viva voce	15			
		Record	10			
		Project work	25			
	Sub total (Semester IV)					300
	Grand total (Semester I+II+III+IV)					1200

6. Criteria to Pass: The number of papers and the maximum marks for each paper/practical are shown in the scheme above. It will be necessary for a candidate to pass in the theory as well as in the practical part of a paper/subject separately.

A candidate for a pass at each of the Semester Examinations shall be required to obtain

(i) at least 36% marks in the aggregate of all the papers prescribed for the examination* and

(ii) at least 36% marks in Combined practical examination each year,

*provided that if a candidate fails to secure at least 25% marks in each individual paper at the examination and also in the Project work/Seminar, wherever prescribed, he/she shall be deemed to have failed at the examination

not withstanding his/her having obtained the minimum percentage of marks required in the aggregate for the examination.

7. Division shall be awarded only at the end of the examination of the final semester on the combined marks obtained in all semesters taken together, as noted below:

First division: on >60% marks and

Second division: on >48% marks.

8. Due Paper: If a candidate passes only in 2 papers in Semester I or III or in 3 papers in Semester II or IV, he/she will be allowed to appear in the due paper only with the students appearing in the same paper next year.

9. Division after due paper: If a candidate clears any paper(s) prescribed for a semester's examination after a continuous period of three years, then for the purpose of working out his/her division the minimum passing marks only viz. 25% (36% in case of practical) shall be taken into account in respect of such paper(s)/practical(s) cleared after expiry of the aforesaid period of three years; provided that in case where a candidate requires more than 25% marks in order to reach the minimum aggregate as many marks out of those actually secured by him/her will be taken into account as would enable him/her to make up the deficiency in the requisite minimum aggregate.

Course Content

Semester I

A. Theory

101. Bacteriology

Section A

History and scope of Microbiology. Microbial diversity. Prokaryotes, Eukaryotes. Archaebacteria and eubacteria. Morphology and ultrastructure of bacteria. Shapes and arrangement of bacteria.

Cultivation of bacteria , Nutritional types Growth and its kinetics. Asynchronous, synchronous, batch and continuous cultures. Measurement of growth and factors affecting growth. Maintenance and preservation of pure cultures.

Section B

Basis of classification of bacteria. Phylogenetic and phenetic approaches. Chemotaxonomy, Molecular/Genetic approaches. Numerical taxonomy and Polyphasic approach in taxonomy. Major groups of bacteria according to Bergey's Manual of Systematic Bacteriology.

Characteristics of important genera and salient features of the physiology of Archaebacteria, Parasitic associations of bacteria. *Bdellovibrio* and its interperiplasmic growth cycle. Spirocahetes, Rickettsia and unicellular endospore forming eubacteria. Chlamydias. Mollicutes. Myxobacteria.

Section C

Characteristics of important genera and salient aspects of the physiology of Gram positive fermentative eubacteria. Actinomycetes and related eubacteria, Photosynthetic eubacteria, Chemoautotrophs. Methophilic eubacteria. Gram negative eubacteria. Mycobacteria and other gliding bacteria. Enteric group and related eubacteria. Gram negative anaerobic bacteria. Prosthecate and stalked eubacteria.

Text Books:

1. Salle A.J. Principles of Bacteriology.
2. Brock T.D., Madigan M.T. Biology of microorganisms. Prentice Hall.
3. Pelczar M.J., Chan E.C.S., Kreig N.R. Microbiology. McGraw Hill.
4. Stanier RY, Ingraham J.L., Wheelis M.L., Painter P.R. 1999. General Microbiology. MacMillan Education Ltd., London.
5. Schlegel. General Microbiology. Cambridge University Press, Cambridge.
6. Prescott. Microbiology
4. Priest. Bacterial Taxonomy

References:

1. Bergey's Manual of Determinative Bacteriology. 9/e
2. Bergey's Manual of Systematic Bacteriology (2/e) P.H.A. Sneath, N.S. Mair, M. Elizabeth (eds).
3. Balows A., Thuper A.G., Dworkin M., Harder W., Schleifer K. 1991. The Prokaryotes. Spriger-Verlag.
4. Birge E.A. 1992. Modern Microbiology. Wm. C. Brown, Oxford.
5. Gunsales I.C., Stanier R.Y. The Bacteria. Vol. I, II, III. Academic Press.
6. Joklik W.K., Zinssers. Microbiology. Mc Graw Hill.

102. Microbiological techniques and Eukaryotic Microbiology

Section A

Aseptic techniques: Principles and methods of Sterilization and Disinfection. isolation and purification of microorganisms. Environmental and nutritional requirements. Culture Medium and its types.

Observing microorganisms: Principles and use of microscope. Bright filed, Dark field, Phase contrast, fluorescence, interference, Confocal, Atomic Force and Electron microscopes. Stains and staining techniques. Enumeration of microorganisms, *in situ* studies, sampling, isolation techniques and determination of biomass and growth.

Section B

General features of fungi. Classification up to class level with their distinctive features. Life cycle of selected fungi (*Aspergillus, Penicillium*, Yeasts). Nutrition and cultivation of fungi. Structure of fungal cells and growth. Effect of

environment on growth. Prevention of fungal growth. Dormancy and reproduction in fungi. Spore diversity. Importance of fungi.

Section C

Algae: General characteristics. Classification up to class level with their distinctive features. Thallus organization. Nutrition, cultivation and reproduction. Types of life histories. Blooms and toxic algae. Control of algal growth. Importance of algae. Lichens.

Protozoa: Classification up to class level with their distinctive features. Body coverings and skeletons. Locomotive organelles and locomotion. Nutrition, Reproduction, cultivation. Importance of protozoa.

Text Books:

1. Burnett J.H. Fundamentals of Mycology. Edwar Arnold, Crane Russak.
2. Charlie M. and Watkinson S.C. The Fungi. Academic Press.
Moore E. Landeekeer. The Fundamentals of Fungi. Prentice Hall.
4. Venkataraman G.S., Goyal S.K., Kaushik, B.D. and Rouchoudhary, P.Algae-Form and Function.
5. Alexopolous C.J. and Mims C.W. 1979. Introduction to Mycology (3/e). Wiley Eastern, New Delhi.
6. Kotpal R.L. Protozoa.

103. Molecular Biology

Section A

Basic features of the genetic code. Breaking the code. Evolution of genetic code, Juke's doublet codon theory. Mitochondrial code. Protein synthesis: steps, Role of various factors in the above steps. Inhibitors, Synthesis of exported proteins on membrane -bound ribosomes, signal hypothesis. *In vitro* transcription and translation systems.

Nucleic acids as genetic information carriers: experimental evidence. DNA structure: historical aspects and current concepts, melting of DNA. DNA replication: general principles, various modes of replication, isolation and properties of DNA polymerases, proof reading, continuous and discontinuous synthesis. Asymmetric and dimeric nature of DNA polymerase III and simultaneous synthesis of leading and lagging strands, DNA polymerase, exonuclease activity in eukaryotic DNA polymerases. Superhelicity in DNA, linking number, topological properties, mechanism of action of topoisomerases.

Section B

Initiation of replication of single stranded DNA. Construction of replication fork in test tube. Retroviruses and their unique mode of DNA synthesis. Relationship between replication and cell cycle. Inhibitors of DNA replication (blocking precursor synthesis, nucleotide polymerization, altering DNA structure) DNA damage and repair: types of DNA damage (deamination, oxidative damage, alkylation, pyrimidine dimers). Repair pathways-methyl-directed mismatch repair,

very short patch repair, nucleotide excision repair, base excision repair, recombination repair, SOS system.
Structural features of RNA (rRNA, tRNA and mRNA) and relation to function. Initiator and elongator class of tRNA, ribosome binding site on mRNA and corresponding site on rRNA, peptidyl transferase activity of 23 S rRNA. Transcription: general principles, basic apparatus, types of RNA polymerases. Steps: Inititaion, elongation and termination, inhibitors of RNA synthesis. Polycistronic and monocistronic RNAs. Control of transcription by interaction between RNA polymerases and promoter regions, use of alternate sigma factors. Controlled termination, attenuation and antitermination.

Section C

Regulation of gene expression: Operon concept, catabolite repression, instability of bacterial RNA, positive and negative regulation, inducers and corepressors. Negative regulation- *E. coli lac* operon; Positive regulation: *E. coli ara* operon, Regulation by attenuation- *his* and *trp* operons; antitermination- N protein and *nut* sites in I. DNA binding proteins, enhancer sequences and control of transcription. Identification of protein-binding sites on DNA. Global regulatory responses: heat shock response, stringent response and regulation by small molecules such as ppGpp and cAMP, regulation of rRNA and tRNA synthesis.
Maturation and processing of RNA: Methylation, cutting and trimming of rRNA, capping, polyadenylation and splicing of mRNA, cutting and modification of tRNA degradation system. Catalytic RNA, Group I and group II intron splicing. RNase P.

Text Books:

1. Lewin 2000. Genes VII. Oxford University Press.
2. *E. coli* and *Salmonella*: Cellular and molecular biology. 2/ed.
3. Lodish, Berk, Zippursky. Molecular Cell Biology. W.H. Freeman.
5. Matsudaira, Baltimore, Darnell 2000. 4/e.

104. Biochemistry

Section A

Composition of living matter. Biochemistry of bacterial, animal and plant cell. Specialized components of microorganisms and their structure and function. Biomolecules: Structure, function, diversity and distribution. Cellular environment. Water, its structure and properties. Physiological buffers. pH. pH indicators. Redox potential and redox indicators. Solutions and other concepts.
Bioenergetics: Basic aspects: entropy, enthalpy, bonding energy. Phosphorylation. Flow of energy through biosphere. Strategy of energy production in the cell, oxidation – reduction reactions, coupled reactions and group transfer. ATP production. Structural features of biomembranes. Transport, free energy and spontaneity of reaction. G, G^0, G' and equilibrium. Strategies of metabolism.

Section B

Instrumentation: Centrifugation, Colorimetry, Photometry, Nephelometry, Vis, UV-Vis and IR spectroscopy, Flame photometry. Electrophoresis, Chromatography: PC, TLC, Column chromatography, GC and HPLC.
Structural features, constituting units, nomenclature, classification and chemistry of macromolecules: Nucleic acids, peptidoglycan, chitin; Carbohydrates, specific reference to cellulose, agar agar, alginic acid, agarose, carragenan, pectins, sialic acid, blood group polysaccharides, bacterial cell wall polysaccharides; Lipids, pigments, vitamins and hormones.

Section C

Structural features, constituting units, nomenclature, classification and chemistry of proteins
Enzymes as biocatalysts. Enzyme classification. Specificity. Active site, Activity unit. Isozymes, Enzyme kinetics. Michaelis-Menten equation for simple enzymes. Determination of kinetic parameters, multistep reactions and rate limiting steps. Enzyme inhibition, allosterism, kinetic analysis of allosteric enzymes. Principles of allosteric regulation and other methods of enzyme regulation.

Text Books:

1. Stryer L. 2001. Biochemistry 5/e, W.H. Freeman. New York.
2. Zubey G.L., Parson W.W. and Vance D.E. 1994. Principles of Biochemistry. Wm. C. Brwon, Oxford.
3. Lehninger 2000. Principles of Biochemistry. 3/e. Nelson and Cox (Worth) Pub.
4. Harper's Biochemistry 1999. Mc Graw Hill.

B. Combined Practical

CP I. General Microbiology

Laboratory rules and safety regulations. First Aid.
Microscopy. Microscope and its operations. Components, Adjustments, Light sources, Microscopic measurements (Micrometry). Calibration. Observation of various types of microbes under phase contrast, dark field and fluorescence.
Preparation of glassware. Washing and sterilization techniques. Wet heat, dry heat, filter types, Laminar flow chamber types. CDC safety levels. Asepsis concepts and practice. Efficacy of HEPA filter, UV, disinfectants, dry heat. Survival curves for UV and dry heat.
Preparation of culture media. Culture techniques (Spreading, streaking, pour plating, pouring a plate, plugging glassware, transferring and inoculating microorganisms) Adjustment of pH, buffers, pure culture techniques. Preparation of slants. Subculturing and techniques to preserve and maintain pure cultures.
Microbial growth measurements. Cell count. Turbidity measurement. Percentage transmission. Optical density. Serial dilution and numerical exercises. Standard Plate count.
Types of dyes. Preparation. Staining techniques. Simple, Gram's, Capsule, Negative, Flagella, spore and nuclear. Determining motility in organisms. Morphological, nutritional and cultural characteristics of bacteria.

References:
1. Coss R.C. Experimental Microbiology, Laboratory Guide. Kalyani Pub., Ludhiana.
2. Cappuccino JG, Sherman, N 1996. Microbiology- A Laboratory Manual. Benjamin/ Cummings.
3. Atlas. Hand Book of Microbiological Media.

CP II. Analytical Biochemistry

Measurement: Criteria of reliability. Precision, Accuracy, Sensitivity, Specificity and numerical exercises.
Preparation of solutions: Normal, Molar, Molal, Percent, ppm, ppb and numerical problems based on these.
Principles of colorimetry: Verification of Beer's law. Estimation of a selected protein, Finding out I_{max}. Relation between O.D. and percentage transmission.
Isolation and quantification of DNA from microorganisms or other sources.
pH, pK, Henderson-Hasselbalch equation. Preparation of buffers.
Determining chlorophyll, phycobillins, carotenoids
Separation of amino acids by paper chromatography. Separation of sugars by TLC.
Isolation of phospholipids and their separation by thin layer chromatography.
FAME profiling using GC.
Separation of haemoglobin and/or blue dextran by gel filtration. Ion exchange chromatography. CM Cellulose and/or DEAE cellulose.
Determining carbohydrates, proteins, DNA, RNA.
Production of glycerol and mannitol under stress.
Enzyme assay (protease/amylase/cellulose).

SEMESTER II

205. Virology

Section A

General Virology: Acellular living entities. Brief outline of the discovery of viruses. Virus, their nature, structure, diversity and mode of replication. Nomenclature and classification of viruses. Viral genome, their types and structures.

General Methods of Diagnosis and Serology: Cell cultures. Cultivation of viruses in embryonated eggs. Serological methods- Haemagglutination and Haemagglutination inhibition. Complement fixation, Immunofluorescence methods, ELISA and radioimmunoassays. Physical and chemical assays, Infectivity assays.

Section B

Bacterial viruses: Bacteriophage structure, organization and life cycles (Lysogenic and Lytic). One step growth curve. Transcription. DNA replication.

Eclipse phase. Phage production. Burst size. Bacteriophage typing. Applications in bacterial genetics. Brief details on M_{13}, Mu, T_4, T_7 and Lambda.

Animal Viruses: Classification, nomenclature and structure of animal and human viruses. Life cycle of RNA viruses: Picorna, Orthomyxo, Paramyxo, Toga and arbo- virus, Rhabdo, Rota, HIV and oncogenic viruses. DNA viruses: Pox, Herpes, Adeno, SV 40, Hepatitis viruses. Viral vaccines (Conventional, genetic recombinant vaccines used in National Immunization programs with examples. Newer generation vaccines including DNA vaccines with examples). Interferons and antiviral drugs.

Section C

Plant viruses: Classification and nomenclature. Effects of viruses on plants (appearance, histology, physiology and cytology) Common virus diseases of plants: Paddy, cotton, tomato and sugarcane. Life cycle, Type species of plant viruses like TMV, Cauliflower Mosaic Virus and Potato Virus X. Transmission of plant viruses, diagnostic techniques in seeds, seed stocks and diseased plants. Prevention of crop loss due to virus infection. Virus-free planting material. Vector control. Physical and biochemical defense mechanisms in plants against viral pathogens. Mechanisms of disease resistance and host-parasite relationship.

Text Books:

1. Morag C. and Timbury M.C. 1994. Medical virology. X/e. Churchill Livingstone, London.
2. Dimmock N.J., Primrose S.B. 1994. Introduction to Modern Virology.IV/e. Blackwell Scientific, Oxford.
3. Conrat H.F., Kimball P.C. and Levy J.A. 1994. Virology-III/e. Prentice Hall, New Jersey.
4. Mathews R.E. 1992. Fundamentals of Plant Virology. Academic Press, San Diego.
5. Topley and Wilson 1995. Text book on Principles of Bacteriology, Virology and Immunology. Edward Arnold, London.
6. Lennetter E.H. 1984. Diagnostic procedures for viral and Ricketssial diseases. American Public Health Asso., New York.
7. Hayes W. 1985. The genetics of Bacteria and their viruses. Blackwell Scientific Publishers, London.

206. Microbial Ecology and Biology of Extremes

Section A

Ecological principles: Distribution, Abundance, Frequency, Ecological Niche and guild. Substrate groups and nutritional strategies. Resource partitioning and successions. Biomonitoring. Ecological indicators and Biomarkers. Biomagnification. Pollution and its indicators.

Introduction to microbial diversity. Conventional and molecular methods of studying microbial diversity. Measures of diversity. Species richness versus Diversity Index. Unculturable and culturable bacteria.

Section B

Abiotic-abiotic and abiotic-biotic interactions. Symbiosis of bacteria-protozoa, algae- invertebrates, Bacteria -plants, insect endosymbionts. Rumen microbiology.Theory of Endosymbiogenesis. Parasitism, mutualism, competition. Stress and strain. Constant and fluctuating stress. Strategies to survive stress. Density dependent and density independent stresses. Life strategies: r- and K-selection. Stresses in arid soils and rocks. Microbiology of extreme environments. Extremophiles and their types. Mechanisms and adaptations in acidophilic, alkalophilic, barophilic, osmophilic and oligotrophic organisms.

Section C

Microbial diversity of hot and cold deserts. Desert varnish, rhizosheath, cryptobiotic crust. Rock crusts. Epilithic, endolithic and hypolithic microbiota. Biotechnological potential of desert microorganisms. Hypersaline environments, their microbial diversity. Saline playas of Rajasthan and their microbial diversity. Physiological and molecular mechanisms to tolerate desiccation, salt stress, cold, heat and radiations. Applications of extremophiles.

Text Books:

1. Johri BN. 2000. Extremophiles. Springer Verlag, New York.
2. Yanagita. Natural Microbial Communities.
3. Odum E.P. Basic Ecology
4. Cowld D. 1999. Microbial diversity.

207. Microbial Genetics and Recombinant DNA Technology

Section A

Gene as unit of mutation and recombination. Molecular nature of mutations. Spontaneous mutation-origin. Gene transfer mechanisms - transformation, transduction, conjugation and transfection. Mechanisms and applications. Genetic analysis of microbes. Bacteria and yeast.
Genetic and molecular methods in bacterial taxonomy: G+C ratio, Nucleic acid hybridization. DNA-DNA and DNA-RNA hybridization. PCR-method and application. 16S, 23S rRNA and IGS sequencing, TGGE, DGGE.

Section B

DNA sequencing methods: Dideoxy and other chemical methods. Sequence assembly. Automated sequencing. Genome sequencing and physical mapping of genomes. Molecular aspects of recombination, complementation and heterozygotic analysis. Mechanical control models. Core techniques and essential enzymes used in rDNA technology. Restriction digestion, ligation and transformation. Unit 4. Plasmids, F-factors description and their uses in genetic analysis. T_i plasmid. Colicins and *col* factors. Plasmids as vectors for gene

cloning. Replication of selected plasmids: compatability. Transposons and their uses in genetic analysis. Cloning vectors-plasmids, phages, phasmids and cosmids. Cloning strategies. Cloning and selection of individual genes, gene libraries: cDNA and genomic libraries. Specialized cloning strategies. Expression vectors, Promoter probe vectors, vectors for library construction-artificial chromosomes. YAC, BAC.

Genetic disorders in man and future of control and cure. Viral vectors: Herpes simplex, Vaccinia and others. Antisense RNA technology. Microbial genetics and design of vaccines. BCG and design of vaccine for TB and leprosy, DNA vaccines, design and advantages.

Text Books:

1. Maloy *et al*. 1994. Microbial Genetics, Jones & Bartlett Pub.
2. Dale J.W. 1994. Molecular Genetics of Bacteria. John Wiley & sons
3. Streips & Yasbin. 1991. Modern Microbial Genetics. Niley Ltd.
4. Old & Primrose. 1994. Principles of Gene Manipulation. Blackwell Scientific Pub.
5. Sambrose & Russell. 2000. Molecular cloning. 3 volumes. CSH Press
6. 2000. Genome Analysis. 4 volumes. CSH Press

208. Fermentation Technology

Section A

Microbial Fermentations: Metabolic pathways and metabolic control mechanisms. Industrial production of citric acid, lactic acid, enzymes (alpha-amylase, lipase, xylase, pectinases, proteases), acetone- butanol, lysine and glutamic acid. Vitamin B_{12} and riboflavin fermentation.

Section B

Microbial production of therapeutic compounds (beta-lactam, aminoglycosides, ansamycins (Rifamycin), peptide antibiotics, quinolinones). Biotransformation of steroids.

Modern trends in microbial production of bioplastics (PHB, PHA), bioinsecticides (thuricide), biopolymer (dextran, alginate, xanthan, pullulan), Biofertilizers (*Azotobacter*, *Rhizobium*, Cyanobacteria, Mycorrhiza and Phosphate solubilizing microorganisms).

Section C

Alcoholic brews: Types and their production.

Biofuels. Useful features of biofuels. Gasohol. Production of ethanol from sugar, molasses, starch and cellulosic materials. Ethanol recovery. Biogas production (biomethanation). Algae as biodiesel feedstock and its production. Microbial production of hydrogen gas. Microbial Fuel Cell.

Immobilization. Techniques for whole cell and enzyme immobilization. Application and advantages of cell and enzyme immobilization in pharmaceutical, food and fine chemical industries.

References
1. Biotechnological Innovations in Chemical Synthesis. BIOTOL. Publishers / Butterworth
- Heinemann.
2. Industrial Microbiology by G. Reed (Ed), CBS Publishers (AVI Publishing Co.)
3. Biology of Industrial Microorganisms by A.L. Demain.
4. Genetics and Biotechnology of Industrial Microorgansims by C.l. Hershnergey, S.W. Queener and Q. Hegeman. Publisher. ASM. Ewesis ET. Al. 1998. Bioremediation Principles. Mac Graw Hill.
5. Annual Reports in Fermentation Processes by D. Pearlman, Academic Press.
6. Fundamentals of Biochemical Engineering by Bailey and Ollis.
7. Annual Review of Microbiology by Charles E. Cliffton (Volumes)
8. Biotechnology, A textbook of industrial Microbiology by Creuger and Creuger, Sinaeur
associates.
9. Manual of industrial Microbiology and Biotechnology 2nd edition by Davis J.E. and Demain A.L. ASM publications.

B. Combined Practical

CP III. Eukaryotic Microbiology, Virology & Molecular Biology

Identification of cyanobacterial, algal and fungal morphotypes.
Measurement of growth in algae and fungi.
Single colony isolation and checking genetic markers.
Demonstration of Diauxie.
Demonstration of photoreactivation of DNA damage.
One step growth curve of bacteriophage T4. Spontaneous and induced mutations. Isolation of antibiotic resistant and auxotrophic mutants.
Selective enrichment of auxotrophic and antibiotic (tel^r) mutants.
Genetic mapping by conjugation and P 1 transduction.
Transposon mutagenesis.
Gene fusion using bacteriophage Mu.
Isolation of chromosomal DNA from E.coli. Estimation of DNA by spectrophotometry. Plasmid DNA isolation and restriction digestion. Agarose gel electrophoresis.
DNA cloning using plasmid vectors and in *E. coli* expression vectors.
Analysis of recombinant proteins using polyacrylamide gel electrophoresis.
Southern and Northern blotting.
Restriction mapping-plasmids.
PCR analysis.
DNA sequencing. Sanger's method.

References:
1. Miller JH 1992. Short course in bacterial genetics. CSH Laboratories.

2. Murray et al. 1994. Methods for General and Molecular Bacteriology. ASM Press.
3. Silhavy T. 1994. Experiments with gene fusions. Cold Spring Harbour Lab Press.
4. Ausbel *et al*. 2000. Current protocols in molecular biology.
5. Sambrrok & Russell 2001. Molecular cloning Vol. I-III. CSH Press.

CP IV. Ecology, Extremophiles & Industrial Microbiology

Sampling from various environments and for various purposes.
Sample treatment or preservation.
Determination of abundance, frequency, diversity and performance index.
Winogradsky column
Competition and succession
Antibiosis
Production of ethanol.
Quantification of ascorbic acid and alcohol.
Preparing cynaobacterial and rhizobial biofertilizer.

Semester III

309. Microbial Physiology and Development

Section A

Microbial metabolism and fueling reactions. Catabolic principles and breakdown of carbohydrates. Lipids, proteins and nucleic acids. Basic aspects of hormones and vitamins. Transport in cells. Cell-cell signaling mechanisms.
Brief account of photosynthetic and accessory pigments-chlorophyll, bacteriochlorophyll, rhodopsin, carotenoids, phycobilliproteins; Carbohydrates-anabolism, autotrophy, oxygenic and anoxygenic photosynthesis. Autotrophic generation of ATP, Fixation of carbon di oxide. Calvin cycle. C3, C4 pathway. Chemolithotrophy-Sulfur, iron, hydrogen, nitrogen oxidations. Methanogenesis, Luminiscence.

Section B

Respiratory metabolism- Embden Mayer Hoff pathway, Entner Doudoroff pathway. Glyoxylate pathway. Kreb's cycle. Oxidative and substrate level phosphorylation. Reverse TCA cycle. Gluconeogenesis. Pasteur effect. Fermentation of carbohydrates. Homo- and heterolactic fermentations. ETC-Electron carriers. Artificial electron donors. Inhibitors, Uncouplers.

Section C

Assimilation of nitrogen, dinitrogen, nitrate nitrogen, ammonia, synthesis of major amino acids. Polyamines. Synthesis of polysaccharides. Cell wall and membrane chemistry in bacteria, algae and fungi. Peptidoglycan. Biopolymers as cell components. Cell division. Synthesis of cell wall and its regulation in bacteria.

Microbial development. Sporulation and morphogenesis. Hyphae versus yeast forms and their significance. Multicellular organization of selected microbes, dormancy. Biosynthesis of amino acids, fatty acids and nucleotide bases.

Text Books:
1. Caldwell, DR 1995. Microbial physiology and metabolism. Brown Pub.
2. Moat AG & Foster JW 1999. Microbial Physiology. Wiley
3. Stanier RY, Ingraham JL and Wheelis, ML and Painter PR 1986. General Microbiology. Mac Millan Education Ltd., London
4. Brun Y V, and Shimkets LJ 2000. Prokaryotic development. ASM Press.

310. Immunology

Section A

Specific and nonspecific defence mechanisms in microorganisms, invertebrates and vertebrates. Immune response to bacterial infection in man. Immune response: Humoral, cellular, actively acquired, passively acquired. Natural or innate immunity. Determinants of innate immunity. Species and strains. Individual differences. Influence of age, hormonal influence, nutritional factors, mechanical barriers and surface secretions. Non specific immune mechanisms. Surface defence, Tissue defence, Opsonization, Inflammatory reactions, Hormone balance, Tissue metabolites with bactericidal properties (lysozymes, nucleins, histones, protamines) Basic peptides of tissues-Leukins, Phagocytins, Lecterin, Heme compounds) Interferon, Properdin and complement. , Acute phase proteins.
Immune system: Organs and cells involved in immune system and immune response. Lymphocytes, their subpopulation, their properties and functions, Membrane bound receptors of lymph cells. Helper T cells in immune response. T cell suppression in immune response. Antigens, structure, properties and types of antigens, antigen specificity, haptens. Adjuvants-antigen specificity, form, dose and route of entry of antigen. Vaccines and toxoids.

Section B

Complements- Structure, properties and functions. Complement pathways and biological consequence of complement activation.
Immune tolerance and autoimmunity. Cytokines. Defects in immunoglobulin synthesis and cell mediated immunity. Primary defects. Secondary defects. Defective phagocyte mechanisms. Immunosuppression-Specific, nonspecific.
Antigen-antibody reactions: *In vitro* methods-agglutination, precipitation, complement fixation, immunofluorescence, ELISA, Radioimmunoassays. *In vivo* methods- Skin tests and immune complex tissue demonstrations. Applications of these methods in diagnosis of microbial diseases.
Immunity to infection: Immunity to Microbial infections. Prophylaxis. Vaccines. Immunoglobulins, Structure, heterogeneity, types and subtypes, properties. Antibody production and control. Diversity of antibodies and its generation. Theories of antigen recognition. Cellular interaction in the induction of antibody

formation. Cellular interactions in the induction of immune T cells. Lymphoid cell interactions. *In vivo*-immune memory.

Section C

Major Histocompatibility Complex and Tumor Immunology: Structure and functions of MHC and HL-A system. Gene regulation and Ir-genes. HL-A and tissue transplantation. Tissue typing methods for organ and tissue transplantations in humans. Graft versus host recation and rejection. Autoimmunity-theories, mechanism and diseases with their diagnosis. Tumor immunology-Tumor specific antigens. Immune response to tumors. Immunodiagnosis of tumors. Detection of tumor markers. Alphafoetal proteins, Carcinoembryonic antigen etc.

Hypersensitivity reactions: Antibody mediated hypersensitivity. Type I-Anaphylaxis. Type II- Antibody dependent cell cytotoxicity. Type III- Immune complex mediated reactions. Type IV-Cell mediated hypersensitivity reactions. The respective diseases, immunological methods of their diagnosis. Lymphokines and cytokines-their assay methods.

Text Books:

1. Henderson *et al*. 1999. Cellular Microbiology. Wiley.
2. de Bruijn *et al*. 1998. Bacterial genomics. Chapman & Hall.
3. Dorman C.J. 1994. Genetics of bacterial virulence. Blackwell.
4. Barrett J.T. 1983. Textbook of immunology: An introduction to immunochemistry and immunology. Mosby, Missouri.
5. Boyd R.F. 1984. General Microbiology. Times Mirror/Mosby (College Pub, St. Louis).
6. Davis, Dulbecco. Microbiology.
7. Broude A.I. 1981. Medical Microbiology and infectious diseases. W.B. Saunders & Co., Philadelphia.
8. Chapel and Haeney 1984. Essential of Clinical Immunology. Blackwell Sci.

References;

1. Clark W.R. 1991. The experimental foundations of modern immunology. John Wiley
2. Mackie & McCartney. Medical Microbiology. 14/e.
3. Bailey & Scott's Diagnostic Microbiology.
4. Franklin TJ, Snow GA. 1981.Biochemistry of antimicrobial action. Chapman & Hall, New York.
5. Roitt IM. 1995. Essential Immunology. Blackwell Sci. Oxford.
6. Roth J.A. 1985. Virulence mechanisms of bacterial pathogens. American Society for Microbiology. Washington D.C.
7. Smith CGC. 1976. Epidemiology and infections. Medowfief Press Ltd. Shildon, England.
8. Stiem F. 1980. Immunological disorders in infants and children. W.B. Saunders & Co. Philadelphia.
9. Todd IR. 1990. Lecture notes in immunology. Blackwell Sci. Pub. Oxford.
10. Roitt IM, Brostoff and Male 1995. Immunology 4/e Gower Medical Pub Co..

11. Kuby J 1994. Immunology. 2/e. W.H. Freeman and Co., New York.

311. Medical Microbiology

Section A

History of medical microbiology. Normal microbial flora of human body and its role. Sources, vehicles and reservoirs of infection. Exogenous and endogenous infection. Mechanism of bacterial adhesion, colonization and invasion of mucous membranes of respiratory, enteric and urogenital tracts. Establishment of infection, spreading, tissue damage and anti-phagocytic factors. Role of aggressins (Hyaluronidase), coagulase, fibrinolysins or kinase, depolymerizing enzymes (Mucinase, lipases, proteases, nucleases, collagneases, neuraminidase), organotropisms, variation and virulence. Mode of spread of infection. Respiratory, skin, wound and burn infection,venereal infections, alimentary tract infection, arthropod-borne blood infections and laboratory infections. Pathogenesis: Microbial pathogenicity, transmissibility, infectivity and virulence. Opportunistic pathogens, true pathogens. Toxigenicity. Invasiveness.

Section B

Classification of medically important microorganisms. Causal organisms, diagnosis, symptoms, toxic components, etiology and disease development in man with reference to TB, leprosy, typhoid, cholera, diphtheria, gonorrhoea, tetanus, syphilis, trachoma, amoebic & bacterial dysentery, malaria, chicken guinea and kala azar. Diagnosis, symptoms, etiology, treatment, prevention and disease development in man with reference to Hepatitis, Cancer, HIV, Dengue, Polio, Mumps, Small pox, Chicken pox, Measles, SARS, Infectious hepatitis and AIDS. Dermatophytes. Dimorphic fungi. Opportunistic fungal pathogens. Description and classification of pathogenic fungi and their laboratory diagnosis.

Section C

Causal organisms, symptoms and diagnosis of New Castle (Ranikhet), bird flue, and salmonellosis in poults, rinderpest, anthrax, foot and mouth disease, mastitis and tympany in cattle. Hog cholera.

Antimicrobial therapy. Antibiotics and their classification, mode of action. Drug resistance. Methods of drug susceptibility testing. Antibiotic assay in body fluids. Brief account on available vaccines and schedules. Passive prophylactic measures. Nosocomial infections. Common types of hospital infections, their diagnosis and control. Principles of disinfection. Disinfectants and their mode of action.

Text Books:

1. Ananthnarayanan R and Jayaram C.K. 1997.Textbook of Microbiology. Orient Longman.

2. Mackie and McCartney. 1996. Medical Microbiology. Vol.1. Microbial Infection, Vol. 2. Practical Medical Microbiology. Churhill Livingstone.
3. Shanson DC. Wright PSG1982. Microbiology in Clinical Practice.
4. Baron EJ, Peterson LR and Finegold SM. 1990. Bailey and Scott's Diagnostic Microbiology. Mosby

312. Biostatistics and Computational Biology

Section A

Introduction: Meaning and scope of statistics. Concepts: Data, investigation and its types, aims, objectives, hypothesis, items, observation. Population, universe, parameter and statistics, sample, sampling methods, treatment, controls, variation, variability and variables, replications. Assumptions, bias, repeatability. Descriptive statistics- Classification and tabulation of data. Proportion and count data. Graphic representation and frequency distribution. Statistical inference. Measures of Central Tendency- Mean, mode median. Measures of dispersion- Mean, deviation, standard deviation, variance and coefficient of variance.

Section B

Probability. Normal, binomial distribution and Poisson distribution. Hypothesis testing: Statement of hypothesis, Null and alternate hypothesis. Confidence limits, Types of error, Standard Error. Parametric and Non parametric tests of significance: goodness of fit, Student's t- , F -, chi square.
Correlation (Pearson's and Spearman's), testing significance of correlation coefficient. Linear regression. Coefficient of determination.

Section C

Analysis of variance: Analysis of covariance. One way and two way ANOVA. Critical difference or least significant difference. Kruskaal Wallis' H-, Wilcoxon's T-and Mann Whitney's U- test. Experimental designs. Statistical modeling. Resource utilization models. Ordination techniques and their use.

Computers, their organization: Hardware, software. Operating system (command line and WIMP), Elementary idea of language hierarchy. Data processing and presentation (Spreadsheet and statistical analysis). LIMS, CAL, Computers in taxonomy, clinical microbiology, fermentation technology, simulation and modeling. Computers as audio visual aid and as word processor. Use of internet.

Text Books:

1. Bliss C.I.K. 1967. Statistics in Biology. Vol. I. Mc Graw Hill, New York.
2. Campbell R.C. 1974. Statistics for Biologists. Cambridge University Press, Cambridge.
3. Hewitt W. 1977. Microbiological assay. Academic press, New York.
4. Lutz W. 1967. Statistical methods as applied to immunological data. Pp. 1163-1206. In: D.M. Weir (ed). Handbook of Experimental Immunology. Blackwell Pub., Oxford.

5. Hardlaw A.C. 1982. (i) Four point parallel line assay of penicillin pp. 370-379. (ii) Microbiological assay of a vitamin-nicotinic acid. Pp. 214-233. In: S.B. Primrose and A.C. Waardlaw (eds) Sourcebook of experiments for the teaching of microbiology. Academic Press, London.
6. Wardlaw A.C. 1985. Practical statistics for experimental biologists. John Wiley and sons, New York.
7. Ron White. 2000. How computers work. Techmedia.
8. Preston Gralla 2000. How the internet work. Techmedia
9. Holmes D., Moody, P. Dine D. 2006. Research Methods for the Biosciences. Oxford University Press.

B. **Combined Practical**

CP V. Microbial Physiology & Computational Biology

Biochemical characterization of microorganisms: Oxygen requirement: aerobic, microaerophilic, facultatively anaerobic and anaerobic, Oxidase, catalase, TSI test, Starch, casein and gelatin hydrolysis, H_2S production, MRVP test, Indole test, Tolerance to salt and temperature.
To study constitutive and adaptive enzymes in *E.coli*.
Demonstration of utilization of sugars by oxidation and fermentation techniques.
Demonstration of the influence of oxygen, carbon dioxide, temperature on the growth of bacteria.
Nutrition requirements of bacteria by employing appropriate culture techniques.
Measurement of ATP in a given bacterial suspension by bioluminiscence method and correlation of the same by viable count method.
Factors affecting enzyme activity: Temperature, substrate concentration and pH using any stable enzyme and kinetics of enzyme activity.
Study of isoenzymes of lactate dehydrogenase by PAGE.
Statistical exercises based on the experiments.
Using electronic worksheets and statistical software for analytical purposes.

References:
1. Alcamo I.E. 2001. Laboratory fundamentals of Microbiology. Jones and Bartlett.

CP VI. Medical Microbiology and Immunology

Fixation of smears for microscopy by different methods
Different staining techniques:
Simple (Loeffler's polychrome methylene blue and Negative staining). Gram's staining, Zeihl-Neelsen method for AFB, Fluorochrome staining, Leishman's stain, Giemsa's stain. Special staining methods to demonstrate granules, capsules and spores.
Preparing antibiogram for given microorganisms.
Determining blood group ABO and Rh factor.

Probiotic and its quality determination.
Dermatophyte slides.
Determination of susceptibility of teeth to dental caries.
RBC, WBC, TLC, DLC.
Determining phenol coefficient of given disinfectant.
Preparation of culture media. Simple tissue culture methods for growing different pathogenic microorganisms.
Conventional and rapid methods of isolation and identification of pathogenic bacteria and fungi.
Anaerobic cultivation.
Principles of automated methods for diagnostic microbiology
Drug susceptibility testing by various methods
Diagnostic immunological principles and methods
Precipitation, agglutination, immunodiffusion, immunoelectrophoresis, Widal test, Haemagglutination and ELISA.
Separation of serum proteins by electrophoresis.
Separation and characterization of lymphocytes from blood.
Demonstration of lymphocyte subpopulations.

References:
1. Hudson & Hay. Practical immunology
2. Todd & Stanford. Diagnostic methods in microbiology.

Semester IV

413. Food Microbiology

Section A

Food as substrate for microorganisms: Microorganisms important in food microbiology-Molds, Yeasts and bacteria. General characteristics, classification and importance. Principles of food preservation. Asepsis-Removal of microorganisms (anaerobic conditions, high temperatures, low temperature, drying). Factors influencing microbial growth in food. Extrinsic and intrinsic factors. Chemical preservatives and food additives. Canning, processing for heat treatment-D, Z and F values and working out treatment parameters.

Section B

Contamination and spoilage: Cereals, Sugar products, vegetables, fruits, meat and meat products. Milk and milk products, Fish and sea foods, poultry, spoilage of canned foods. Detection of spoilage and characterization.
Food-borne infections and intoxications: Bacterial and non bacterial with examples of infective and toxic types- *Brucella, Bacillus, Clostridium, Escherichia, Salmonella, Shigella, Staphylococcus, Vibrio, Yersinia*. Nematodes, protozoa, algae, fungi and viruses. Foodborne outbreaks. Laboratory testing procedures. Prevention measures. Food sanitation in manufacture and retail trade.

Section C

Food fermentation: Bread, Cheese, Vinegar, Fermented vegetables. Fermented dairy products. Experimental and industrial production methods. Spoilage and defects of fermented dairy products. Oriental fermented foods, their quality, standards and control.
Food produced by microbes: Fermented foods. Indian fermented foods. Microbial cell as food (SCP), SCO. Mushroom cultivation. Production of yeast (Baker's yeast as food and fodder. Food control agencies and its regulations. Plant sanitation. Employees' health standards. Waste treatment. Disposal. Quality control. Genetically modified foods.

Text Books:
1. Adams MR and Moss MO 1995. Food Microbiology. Royal Society of Chemistry Pub., Cambridge.
2. Frazier WC and Westhoff DC 1988. Food Microbiology. Tata Mc Graw Hill Pub Comp. New Delhi.
3. Stanbury PF, Whittaker A and Hall SJ 1995. Principles of fermentation technology. 2/e Pergamon Press.
4. Banwart GJ 1989. Basic Food Microbiology. CBS Pub and distributors, Delhi.
5. Hobbs BC and Roberts D 1993. Food Poisoning nad Food Hygiene. Edward Arnold (A division of Hodder and Stoughton) London.
6. Robinson RK. 1990. Dairy Microbiology. Elsevier Applied Sciences, London.

414. Environmental Microbiology

Section A

Geomicrobiology: Biogeochemical cycles of Carbon, Nitrogen, Phosphorus, Sulfur Cycles. Geomicrobiology of Iron, Magnesium, Manganese and Calcium. Bioleaching and biomining. Fossil fuel microbiology-Petroleum prospecting, migration, MEOR. Petroleum degradation.

Soil Microbiology: Soil, its formation, physical and chemical characteristics. Microflora of various soils. Rhizosphere and phyllosphere. Biofertilizers versus fertilizers. Biological nitrogen fixation. Nitrogenase and its regulation. Symbiotic and non symbiotic nitrogen fixation. Mycorrhiza. PGPR. Process, structure, biochemistry and genetics of *Rhizobium*-legume, *Frankia*-nonlegume, and *Anabaena-Azolla* symbiosis.

Section B

Aquatic microbiology: Freshwater (Ponds, lakes, streams) and marine habitats (estuaries, mangroves, deeps sea, brackish water, hydrothermal vents, salt pans, coral reefs). Zonations of aquatic ecosystems. Upwelling. Potability of water. Microbial assessment of water quality. Water purification. Water borne diseases. Eutrophication. Algal/cyanobacterial blooms and toxic algae. Subterranean microbes. Ground water contamination.

Biofilms in natural and man made environments. Biodeterioration: Paper, leather, wood and textile. Metal corrosion, Bioaccumulation of metals and detoxification, biosorption, scavenging. Biodegradation of Xenobiotics (Pesticides

and dyes). Biological altrenatives: biopesticides, biosurfactants, biocolours and biofuel. GMO and their impact.

Section C

Bioremediation and Bioaugmentation: Wastes, their types and characterization. Methods of treatment-Physical, chemical, biological-aerobic and anaerobic (Oxidation ponds, HRABP, ASP, Trickling Filter, Fluidized Bed Reactor, Biogas, Rotating contactor).

Solid waste treatment (Agricultural/urban): Saccharification, gasification, composting, vermicompost, mushroom compost, ensilage. Utilization of solid wastes- food (SCP, mushroom, yeast), fuel (ethanol, methane-biogas plant), manure (composting). Non biodegradable solid waste and its management.

Flue Gas Management: Treatment strategies and microbiological options. Fuel desulfurization.

Text Books:

1. Alexander M 1971. Microbial Ecology. John Wiley & Sons Inc., New York.
2. Alexander M. 1977. Introduction to Soil Microbiology. John Wiley & Sons New York.
3. Eldowney Ec S., Hardman DJ. and Waite S 1993. Pollution: Ecology and biotretament. Longman Scientific Technical.
4. Baker KH and Herson DS 1994. Bioremediation. Mc Graw Hill Inc., New York.
5. Erneasst WC 1982. The environment of the deep sea. Vol.II J.G. Morin Rubey.
6. Marshall KC 1985. Advances in Microbial Ecology. Vol.8 Plenum Press.
7. Burns RG and Slater JH 1982. Experimental Microbial Ecology. Blackwell Scientific Pub, Oxford.
8. Norris JR and Pettipher GL 1987. Essays in agricultural and food microbiology. John Wiley & Sons, Singapore.
9. Burges A and Raw F 1967. Soil Biology. Academic Press, London.
10. Vanghan D and Malcolm RE. 1985. Soil Organic Matter and Biological Activity. Martinus Nighoff W. Junk Pub.
11. Buckman H. and Brady N.C. The nature and properties of soil. Eurasis Pub. House (P.) Ltd. New Delhi.
12. Brock TD and Madigan. Biology of Microorganisms. Prentice Hall Int. Inc.
13. Michel R. 1999. Introduction to environmental microbiology.
14. Ehrlich. Geomicrobiology.
15. Atlas & Bartha. Microbial Ecology
16. Satyanarayana & Johri. Extremophiles
17. Mayer & Mayer. Environmental Microbiology
18. Indu Shekhar. Environmental Biotechnology

415 Bioprocess Engineering & Technology

Section A

Bioreactors: Design of a basic fermenter, individual parts, baffles, impellers, foam separators, sparger, culture vessel, cooling and heating devices,

probes for online monitoring, measurement and control of process. Reactors for specialized applications: Tube reactors, packed bed reactors, fluidized bed reactors, cyclone reactors, trickle flow reactors, their basic construction and types for distribution of gases.

Transport phenomena in fermentation: Gas- liquid exchange and mass transfer, oxygen transfer, critical oxygen concentration, determination of Kla, heat transfer, aeration/agitation and their importance. Sterilization of Bioreactors, nutrients, air supply, products and effluents.

Section B

Fermentation process: Growth of cultures in the fermenter. Importance of media in fermentation. Media formulation and modification. Batch culture, Fed-batch and continuous culture. Kinetics of growth with respect to substrate utilization. Specific growth rate. Steady state in a chemostat. Yield of biomass and product. Inoculum development. Storage of cultures for repeated fermentations, scaling up of process from shake flask to industrial fermentation.

Down stream processing: Biomass separation by centrifugation, filtration, flocculation and other recent developments. Cell disintegration: Physical, chemical and enzymatic methods. Methods of extraction of the product. Purification of the product: Concentration by precipitation, ultra-filtration, reverse osmosis. Drying and crystallization.

Section C

Prospecting: Isolation and screening microbial cultures, Screening for primary and secondary metabolites, enrichment and specific screening for the desired product.

Strain improvement: Mutation and screening of improved cultures, random and strategic screening methods, strategies of strain improvement for primary and secondary metabolites with relevant examples. Use of recombinant DNA technology and protoplast fusion techniques.

Production of recombinant molecules in heterologus system, problems associated with strain improvement program, improvement of characters other than products and its application in the industry.

Preservation of cultures.

1. Principles of Fermentation Technology by Stanbury, P.F., Whitekar A. and Hall. 1995., Pergaman. McNeul and Harvey.
2. Fermentations - A practical approach. IRL.
3. Bioprocess Technology: Fundamentals and Applications. Stockholm KTH.
4. Biochemical Reactors by Atkinson B., Pion, Ltd. London.
5. Biotechnology - A Text Book of Industrial Microbiology by Cruger.
6. Fermentation Biotechnology: Industrial Perspectives by Chand.
7. Biochemical Engineering Fundamentals by Bailey and Ollis, Tata McGraw Hill, N.Y.
8. Biotechnology. Volume 3. Edited by H. J. Rehm and G. Reed. Verlag Chemie. 1983.

9. Advances in Biochemical Engineering by T.K. Bhosh, A.Fiechter and N. Blakebrough.
Springer Verlag Publications, New York.
10. Biotechnology- A textbook of Industrial Microbiology by Creuger and Creuger, Sinaeur
Associates.
11. Bioprocess Engineering Kinetics, Mass Transport, Reactors, and Gene expressions by
Veith, W.F., John Wiley and Sons.
12. Applied Microbiology Series.
13. Industrial Microbiology by L.E. Casida, Wiley Eastern
14. Bioseparation: Down stream processing for Biotechnology by Belter, P.A. Cussler, E.L.
and Hu, W.S., John Wiley and Sons, N.Y.
15. Separation process in Biotechnolgy by Asenjo, J.A. Eds. Marcel Dekkar, N.Y.
16. Bioprocess Engineering Principles by Doran, Acad. Press, London.
17. Bioreaction Engineering Principles by Nielsen, J. and Villadsen, plenum Press, N.Y.
18. Fermentation, Biocatalysis and bioseparation, Encyclopedia of Bioprocess Technology by Chisti, Y., Vol. 5, John Wiley and Sons, N, Y.
19. Cussler E L 1984. Diffusion. Cambridge University Press.

416. Bioinformatics & Microbial Genomics

Section A

Whole genome analysis: Preparation of ordered cosmid libraries. Bacterial artificial chromosome libraries. Shotgun libraries and sequencing. Conventional sequencing (Sanger, Maxum and Gilbert methods). Automated sequencing.
Sequence analysis: Computational methods. Homology algorithms (BLAST) for proteins and nucleic acids. Open reading frames. Annotations of genes, conserved protein motifs related structure/function (PROSITE, PFAM, ProfileScan). DNA synthesis of repeats (direct and inverted). Palindromes. Folding programs.

Section B

Bioinformatics and its scope. Public domain databases for nucleic acid and protein sequences (EMBL, GenBank). Database of protein structures (PDB). Identifying protein sequence from DNA sequence. Searching databases for similar or new sequences. Similarity analysis. Genome projects.
Unit 4. Introduction to sequence alignment. Optimal alignment methods. Substitution scores and gap penalties. Database similarity searching: FASTA, BLAST. Pairwaise and multiple alignment. Phylogenetic analysis.

Section C

DNA microarray: Printing of oligonucleotides and PCR products on glass slides. Nitrocellulose paper. Whole genome analysis for global patterns of gene expression using fluorescent labeled cDNA or end labeled RNA probes. Analysis of single nucleotide polymorphisms using DNA chips.

Text Books:

1. Peruski Jr. and Peruski 1997. The internet and the new biology: Tools for Genomic and Molecular Research. (ASM Press).
2. Hunt SP and Liveey R (ED).2000. Functional genomics: practical approach (OUP).
3. Schena M. DNA microarrays: A practical approach (OUP).

Combined Practical

CP VII. Environmental, Food Microbiology & Fermentation Technology

Production of sauerkraut, yoghurt.
Quantification of lactic acid.
Microbial flora before and after pasteurization: DMC.
Quality of milk by MBRT and resazurine test.
Coliform test for food/water quality.
Available pH, soil moisture, Eh, conductivity, Water extractable cations, organic carbon, Kjeldahl nitrogen in soil.
Water stable aggregates formation in soil.
Determination of microbial activity in soil by CO_2 evolution method.
Isolation of *Rhizobium*. Use of desiccation vial and Leonard jar. Bacteroid staining.
Observing mycorrhiza.
Immobilization of cells.
Mathematical problems based on experimental work being done in Microbiology.

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