SRI SANKARA ARTS AND SCIENCE COLLEGE (AUTONOMOUS)

ENATHUR, KANCHIPURAM – 631 561
CHOICE BASED CREDIT SYSTEM

DEPARTMENT OF APPLIED MICROBIOLOGY
M.Sc. DEGREE COURSE IN APPLIED MICROBIOLOGY
REGULATIONS
(With effect from the academic year 2015-2016)

1. CONDITIONS FOR ADMISSION

A Bachelor's Degree in science with Microbiology, Biochemistry, Chemistry, Life Sciences, Nutrition and Dietetics as their Main Subject of this University or any other Qualification accepted as equivalent thereto are eligible for admission to M.Sc Degree Course.

2. ELIGIBILITY FOR THE AWARD OF DEGREE

A candidate shall be eligible for the award of the degree only if he/she has undergone the prescribed course of study in a college affiliated to the University for a period of not less than two academic years, passed the examination of all the four semesters prescribed earning 90 credits and fulfilled such conditions as have been prescribed therefore

3. DURATION OF THE COURSE

Two years Courses:

The duration of the course is for two academic years consisting of four semesters.

4. EXAMINATIONS

There shall be four semester examinations: first semester examinations at the middle of the first academic year and the second semester examination at the end of the first academic year. Similarly, the third and fourth semester examinations shall be held at the middle and the end of the second academic year, respectively.

5. The following procedure to be followed for Internal Marks:

Theory Papers:	**Internal Marks**
Best Two tests out of 3	10 marks
Attendance	5 marks
Seminar	5 marks
Assignment	5 marks
Total	25 marks

Break-up Details for Attendance

Below 60%	- No marks
60% to 75%	- 3 marks
76% to 90%	- 4 marks
91% to 100%	- 5 marks

Practical:	**Internal Marks**	**- 40**
Attendance		5 marks
Practical Best Test 2 out of 3		30 marks
Record		5 marks
Project:		
Internal Marks		
Best 2 out of 3 presentations		20 marks
Project Report		**80 marks**

6. REQUIREMENTS FOR PROCEEDING TO SUBSEQUENT SEMESTERS:

(i) Candidates shall register their names for the First semester examination after the admission in the PG courses.

(ii) Candidates shall be permitted to proceed from the First Semester upto the Final Semester irrespective of their failure in any of the Semester Examination subject to the condition that the candidates should register for all the arrear subjects of earlier semesters along with current (subject) Semester subjects.

(iii) Candidates shall be eligible to proceed to the subsequent semester, only if they earn sufficient attendance as prescribed therefore by the college from time to time.
Provided in case of candidate earning less than 50% of attendance in any one of the semester due to any extraordinary circumstance such as medical grounds, such candidates who shall produce Medical Certificate issued by the authorized Medical Attendant (AMA), duly certified by the Principal of the College, shall be permitted to proceed to the next semester and to complete the course of study. Such candidate shall have to repeat the missed semester by rejoining after completion of final semester of the course, after paying the fee for the break of study as prescribed by the College from time to time.

7. PASSING MINIMUM:

a) There shall be no Passing Minimum for Internal.
b) For External Examination, Passing Minimum shall be of 50% (Fifty Percentage) of the maximum marks prescribed for the paper.
c) In the aggregate (External + Internal) the passing minimum shall be of 50% for each Paper/Practical/Project and Viva-voce.
d) Grading shall be based on overall marks obtained (internal + external).

8. CLASSIFICATION OF SUCCESSFUL CANDIDATES:

Candidates who secured not less than 60% of aggregate marks (Internal + External) in the whole examination shall be declared to have passed the examination in the First Class.
All other successful candidates shall be declared to have passed in Second Class.
Candidates who obtain 75% of the marks in the aggregate (Internal + External) shall be deemed to have passed the examination in First Class with Distinction, provided they pass all the examinations (theory papers, practicals, project and viva-voce) prescribed for the course in the First appearance.

9. GRADING SYSTEM:

The term grading system indicates a Seven (7) Point Scale of evaluation of the performances of students in terms of marks obtained in the Internal and External Examination, grade points and letter grade.
SEVEN POINT SCALE (As per UGC notification 1998)

GRADE	**GRADE POINT**	**PERCENTAGE EQUIVALENT**
`O' = Outstanding	5.50 – 6.00	75 – 100
`A' = Very Good	4.50 – 5.49	65 – 74
`B' = Good	3.50 – 4.49	55 – 64
`C' = Average	3.00 – 3.49	50 – 54
`D' = Below Average	1.50 – 2.99	35 – 49
`E' = Poor	0.50 – 1.49	25 – 34
`F' = Fail	0.00 – 0.49	0 - 24

10. RANKING:

Candidates who pass all the examinations prescribed for the course in the first appearance itself alone are eligible for Ranking / Distinction.
Provided in the case of candidates who pass all the examinations prescribed for the course with a break in the First Appearance due to the reasons as furnished in the Regulations under "Requirements for Proceeding to subsequent Semester" are only eligible for Classification.

11. PATTERN OF QUESTION PAPER:

PART –A (50 words): Answer 10 out of 12 Questions 10 x 1 = 10 marks
PART –B (200 words): Answer 5 out of 7 Questions 5 x 5 = 25 marks
PART –C (500 words): Answer 4 out of 6 Questions 4 x 10 = 40 marks

12. APPEARANCE FOR IMPROVEMENT:

Candidates who have passed in a theory paper / papers are allowed to appear again for theory paper / papers only once in order to improve his/her marks, by paying the fee prescribed

from time to time. Such candidates are allowed to improve within a maximum period of 10 semesters counting from his/her first semester of his/her admission. If candidate improve his marks, then his improved marks will be taken into consideration for the award of Classification only.

Such improved marks will not be counted for the award of Prizes / Medals, Rank and Distinction. If the candidate does not show improvement in the marks, his previous marks will be taken into consideration. Candidate will be allowed to improve marks in the Practicals, Project, Viva-voce, Field work.

13. TRANSITORY PROVISION:

Candidates who have undergone the course of study prior to the academic year 2017-2018 will be permitted to appear for the examinations under those Regulations for a period of three years i.e., up to and inclusive of April/May 2021 Examinations. Thereafter, they will be permitted to appear for the examination only under the Regulations then in force.

SYLLABUS
(With effect from the academic year 2015-2016)

M.Sc. DEGREE COURSE IN APPLIED MICROBIOLOGY

SCHEME OF EXAMINATION

FIRST SEMESTER

Course component	Name of the Subject	Hour allotment /week	Credits	Exam hour	Maximum Mark		
					Internal	External	Total
Core 1 – theory	Microbial Taxonomy	5	4	3	25	75	100
Core 2 – theory	General Microbiology and Laboratory Animal Science	5	4	3	25	75	100
Core 3 – theory	Immunology	5	4	3	25	75	100
Core 1,2 and 3 – Practical	General Microbiology, Physiology and Immunology	5	4	6	40	60	100
Elective 1 – theory	Metabolic Pathways	4	3	3	25	75	100
Elective 2 – theory	Microbial Diversity	4	3	3	25	75	100
Soft skills	Soft skills I	2	2	3	25	75	100

SECOND SEMESTER

Course component	Name of the Subject	Hour allotment /week	Credits	Exam hour	Maximum Mark		
					Internal	External	Total
Core 4 – theory	Virology	5	4	3	25	75	100
Core 5 – theory	Systematic Medical Bacteriology	5	4	3	25	75	100
Core 6 – theory	Mycology and Parasitology	5	4	3	25	75	100
Core 4,5 and 6 – Practical	Systematic Bacteriology, Mycology, Parasitology and virology	5	4	6	40	60	100
Elective 3 – theory	Industrial & Pharmaceutical Microbiology	4	3	3	25	75	100
Elective 4 – theory	Biostatistics & Bioinformatics	4	3	3	25	75	100
Soft skills	Soft skills 2	2	2	3	25	75	100

THIRD SEMESTER

Course component	Name of the Subject	Hour allotment /week	Credits	Exam hour	Maximum Mark		
					Internal	External	Total
Core 7 – theory	Microbial Genetics	5	4	3	25	75	100
Core 8 – theory	Genetic Engineering	5	4	3	25	75	100
Core 9 – theory	Molecular Biology	5	4	3	25	75	100
Core 7,8 and 9 – Practical	Microbial Genetics, Molecular Biology & Genetic Engineering	5	4	6	40	60	100
Elective 5 – theory	Soil and Agricultural Microbiology	4	3	3	25	75	100
Extra disciplinary Elective 6	Environ-mental Bio-technology	4	3	3	25	75	100
Internship	Internship*	-	2	-	-	-	100
Soft skills	Soft skills 3	2	2	3	25	75	100

FOURTH SEMESTER

Course component	Name of the Subject	Hour allotment /week	Credits	Exam hour	Maximum Mark		
					Internal	External	Total
Core 10 – theory	Food, Dairy and Environmental Microbiology	5	4	3	25	75	100
Core 10 – Practical	Soil, Agricultural, Food and Environmental Microbiology	5	4	6	40	60	100
Elective 7 – theory	Research Methodology	4	3	3	25	75	100
Core Project viva voce	Research Project	14	4	3	40	60	100
Soft skills	Soft skills 4	2	2	3	25	75	100

*Practical Examinations will be conducted in even semester only.

** Internship will be carried out during the summer vacation of the second semester and the report will be evaluated by two examiners within the department of the College. The marks should be included in the third semester statement of marks.

FIRST SEMESTER

CORE 1-THEORY: MICROBIAL TAXONOMY

UNIT I

Taxonomy, systematics, identification: Taxonomical hierarchy- species- type strains: culture collections; binomial nomenclature; systems of classification- phenetic, numerical taxonomy- similarity matrix, dendrograms with examples; phylogenetic with examples; general characteristics used in classification- five kingdom, six kingdom and eight kingdom systems.

UNIT II

Classification of bacteria according to Bergey's Manual of systematic bacteriology 9th edition (up to level of section); characteristics of major sections; classification of archaea, photosynthetic bacteria, *Entrobacteriaceae, Mollicutes.*

UNIT III

Classification of Fungi - characteristics of zygomycetes, ascomycetes, basidiomycetes and dueteromycetes.

UNIT IV

Classification of Protozoa - classical 1980; official system & 1993 Cavalier- Smith. Distinguishing characteristics of ciliates; flagellates; sporozoa; heliozoans; amoeba.

UNIT V

Classification of Algae - major characteristics of chlorophycophyta, crisophycophyta, cryptophycophyta, euglinophycophyta & rhodophycophyta. Classification of viruses - animal viruses, plant viruses and phages.

*****

CORE 2 THEORIES: GENERAL MICROBIOLOGY AND LABORATORY ANIMAL SCIENCE

UNIT I

Microscopy – Its principles and application in the field of Microbiology including the following: Dark field, Phase contrast, Fluorescence microscopy. TEM and SEM. Principles, operation and maintenance of: refrigerated and ultracentrifuges, Spectrophotometer. Lyophilizers. Staining methods – Simple, differential and special methods. Sterilization and disinfection methods and their quality control.

UNIT II

Bacterial Anatomy, Structure, properties and biosynthesis cellular components of bacteria – Sporulation – Growth and nutrition – Nutritional requirements – Growth curve – Kinetics of growth – Batch culture – Synchronous growth – Measurement of growth and enumeration of cells – Pure culture techniques.

UNIT III

Distribution of Algae - Thallus structure in algae - Reproduction in alga - Life cycle patterns in algae - *Chlamydomonas* – *Volvox* (Green algae) - *Nostoc* – *Spirogyra* (BGA) - *Ectocarpus* – *Sargassum* (Brown algae) - *Poly siphonia* – *Batrachospermum* (Red algae).

UNIT IV

Laboratory Animal Science. Modern methods of care, management, breeding and maintenance of laboratory animals. Detailed account of nutrition, handling, uses of different laboratory animals - rabbits, mice, rats, guinea pigs, monkeys, hamsters, fowl, sheep.

UNIT V

Breeding and handling of specific pathogen free Gnotobiotic animals and their maintenance and uses. Transgenic animal models – Methodology and uses. Disposal of animal house wastes and used animals. Laboratory uses of animals with special reference to microbiology, pathogenicity testing, antibody production, toxin/toxoid testing, hypersensitivity testing, maintenance of microbes in animals.

*****

CORE 3 THEORY: IMMUNOLOGY

UNIT I

History and scope of immunology: types of immunity – Innate, acquired, passive and active, Physiology of immune response – Humoral immunity and cell mediated immunity – Lymphoid organs.

UNIT II

Antigen: Types – properties and functions: Immunoglobulin: structure, function and techniques of purification, - Antibody production – regulation and diversity – polyclonal and monoclonal antibodies.

UNIT III

Antigen – antibody reaction including agglutination and precipitation reactions – Enzyme immunoassays –Radio immune assays, Immunofluorescene, Immunoperoxidase. Immunohaematology of blood groups. ABO and RH incompatibility.

UNIT IV

Complement and its role in immune responses. Hypersensitivity – types and manifestations. Autoimmunity. Transplantation immunology and tumor immunology. HLA tissue typing – Major histocompatibility complex – structure and types.

UNIT V

Vaccines: Principles and types. Immunization - its rationale, schedules and importance in public health.

*****

CORE 1,2 AND 3 – PRACTICALS: GENERAL MICROBIOLOGY, PHYSIOLOGY AND IMMUNOLOGY

UNIT I

Microscopic Techniques: Light microscopy: Hay infusion broth. Wet mount to show different types of microbes, hanging drop. Dark field microscopy: To show motility of spirochetes and others. Phase contrast microscopy: To show Eukaryotic Cell division, morphology etc. Fluorescence microscopy: Fluorescent staining for Mycobacteria, auromine, staining, Fluorescent antibody techniques.

UNIT II

Washing and cleaning of glass wares: Sterilization principles methods: moist heat, dry heat, filtration. Quality control check for each method:

UNIT III

Staining Techniques: Smear preparation, simple staining, Gram's staining, Acid fast staining, Metachromatic granule staining, Cell wall, spore, capsule, Flagella, Silver impregnation methods.

UNIT IV

Media Preparation: Preparation of liquid, solid and semisolid media. Agar deeps, slants, plates. Preparation of basal, enriched, selective, enrichment media. Quality control and uses. Preparation of Biochemical test media, media to demonstrate enzymatic activities.

UNIT V

Microbial Physiology: Purification and maintenance of microbes. Streak plates, pour plate, and slide culture technique. Aseptic transfer, growth and growth requirements: Cell number, and cell proteins. Direct counts, viable counts, pour plate, streak plate. Bacterial growth curve – Turbidimetry, Anaerobic culture methods.

UNIT VI

Preparation of Bacterial Antigens (Crude preparation) by homogenization or sonication. Raising polyclonal antisera in experimental animals - rabbit or mouse with bacterial antigens, RBC (Demonstration).

UNIT VII

Agglutination & Haemagglutination reactions: Latex Agglutination -RF, ASLO, CRP. Blood grouping, RH -Typing/IHA/RPHA. Precipitation reactions in gels: SRID -Single radial immunodiffusion. Double immunodiffusion. Immuno electrophoresis and staining of precipitation lines. ELISA technique –HbsAg / or other Viral Markers.

UNIT VIII

Preparation of Lymphocytes from peripheral blood by density gradient centrifugation. Purification of Immunoglobulins: Ammonium sulphate precipitation. Separation of IgG by chromatography using DEAE cellulose or Sephadex. Anaphylactic reactions in Guinea pigs; Arthus reaction in rabbits (Demonstration only). Skin tests.

ELECTIVE 1-THEORY: METABOLIC PATHWAYS

UNIT I

Enzymes – nomenclature, components - Mechanism of enzyme reactions - Factors influencing enzymatic activity - Inhibition of enzyme action - Metabolic channeling – Control of enzyme activity – Regulation of enzyme synthesis.

UNIT II

Principles of Bio energetics - Oxidation –reduction reactions - Generation of energy – Substrate Level and oxidation phosphorylation - Electron transport chain

UNIT III

Carbohydrate catabolism – Glycolysis – Pentose phosphate pathway – ED pathway – The Kreb`s cycle – Energy yield in glucolysis and aerobic respiration – Anaerobic respiration – Lactic acid fermentation – Alcohol fermentation.

UNIT IV

Lipid Metabolism – Oxidation of lipids*;* biosynthesis of fatty acids; triglycerides; phospholipids; sterols. Protein and amino acid catabolism – Oxidation of inorganic molecules – Photophosphorylation.

UNIT V

Bio chemical pathways of energy use – Photosynthetic fixation of CO_2 – Biosynthesis of peptidoglycan – Biosynthesis of lipids – Biosynthesis of amino acids -proline, arginine, aspartic acid, histidine- Interconversions - therionine, isoleucine and methionine; isoleucine ,valine and leucine; serine and lysine; Aspartate and pyruvate. Bio synthesis of purines and pyrimidines.

ELECTIVE – 2 THEORIES: MICROBIAL DIVERSITY

UNIT I

Biodiversity: Introduction to microbial biodiversity- distribution, abundance, ecological niche. Types – Bacterial, Archael and Eucaryal

UNIT II

Thermophiles: classification, hyperthermophilic habitats and ecological aspects. Extremely Thermophilic Archaebacteria, Thermophily, commercial aspects of thermophilies, Applications of thermozymes. Methanogens: Classification, Habitats, applications.

UNIT III

Alkalophiles and Acidophiles - Classification, discovery basin, cell walls and membranes- purple membrane, compatible solutes. Osmoadaptation/ halotolerance. Applications of halophiles and their extremozymes. Barophiles: Classification, high pressure habitats, life under pressure, barophily, death under pressure. Halophiles - Classification, discovery basin, cell walls and membranes- purple membrane, compatible solutes.

UNIT IV

Space Microbiology - Aim and objectives of space research. Life detection methods a) Evidence of metabolism (Gulliver) b) Evidence of photosynthesis (autotrophic and heterotrophic) c) ATP production d) phosphate uptake e) sulphur uptake.

UNIT V

Martian environment (atmosphere, climate and other details). Antartica as a model for Mars. Search for life on Mars, Viking mission, Viking landers, and Biology box experiment. Gas exchange, label release and pyrolytic release experiments. Monitoring of astronauts microbial flora: Alterations in the load of medically important microorganisms, changes in mycological and bacterial autoflora.

*****

SECOND SEMESTER

CORE 4- THEORY: VIROLOGY

UNIT I

Brief outline of virology- discovery of virus- general properties of viruses- general methods of diagnosis and serology- viriods, prions, satellite RNAs and virusoids.

UNIT II

Bacterial viruses - ΦX 174, M13, MU, T4, lambda, Pi; structural organization, lifecycle and phage production. Lysogenic cycle-typing and application in bacterial genetics.

UNIT III

Plant viruses-TMV- general characters- morphology-replication-RNA as its initiator of infection. Cauliflower mosaic virus; Transmission of plant viruses; common viral diseases of crop plants- paddy, cotton, tomato, and sugarcane. Viruses of cyanobacteria, algae, fungi and insects.

UNIT IV

DNA Viruses- Pox viruses, Herpes viruses, Adeno viruses, Papova viruses and Hepadna viruses; RNA Viruses- Picorna, Orthomyxo, Paramyxo, Toga and other arthropod borne viruses, Rhabdo, Rota, HIV and other Hepatitis viruses.

UNIT V

Epidemiology, Diagnosis and Treatment of Viral Diseases; Viral Vaccines and Antiviral agents.

*****

CORE 5 THEORY: SYSTEMATIC MEDICAL BACTERIOLOGY

UNIT I

Philosophy and General approach to clinical conditions of various syndromes – general and specific syndromes. Indigenous normal microbial flora of human body. General attributes and virulence factors of bacteria causing infections.

UNIT II

Host Parasite relationships – Nonspecific host immune mechanisms. Ground rules for collection and dispatch of clinical specimens for microbiological diagnosis.

UNIT III

Morphology, classification, cultural characteristics, Pathogenicity, pathology, Laboratory diagnosis and prevention – Control and treatment of diseases caused by the following organisms: Staphylococci, Streptococci, Pneumococci, Neisseriae (Gonococci & Meningococci), Corynebacterium, Mycobacterium, Clostridium, Bacillus.

UNIT IV

Studies on Salmonella, Shigella, Vibrios, Brucella, Gram negative anaerobes, Spirochetes, Rickettsiae, Chlamydiae, Mycoplasmas and ureoplasmas.

UNIT V

Zoonotic diseases and their control – Hospital acquired infections – Hospital Infection control committee – functions – Hospital waste disposal – Ethical committee – functions.

*****

CORE 6-THEORY: MYCOLOGY AND PARASITOLOGY

UNIT I

Historical introduction to mycology - Structure and cell differentiation. Lichens – ascolichens, basidiolichens, deuterolichens. Fungi as insect symbiont. Morphology, Taxonomy, Classification of fungi.

UNIT II

Dermatophytes and agents of superficial mycoses. Yeasts of medical importance. Dimorphic fungi causing systematic mycoses. Dimatiaceous fungi, opportunistic hyaline hyphomycetes, agents of zygomycosis. Fungi causing Eumycotic mycetoma.

UNIT III

Detection and recovery of fungi from clinical specimens. Newer methods in diagnostic mycology. Immunity to fungal infections. Mycotoxins. Antifungal agents - testing methods and quality control.

UNIT IV

Introduction to Medical parasitology – classification, host-parasite relationships. Epidemiology, life cycle, pathogenic mechanisms, lab diagnosis, treatment, etc. for the following: Protozoa causing human infections – Entamoeba, Aerobic and Anaerobic amoebae. Toxoplasma, Cryptosporidium, Leishmania, Trypanasoma, Giardia, Trichomonas, Balantidium.

UNIT V

Classification, life cycle, lpathogenicity, laboratory diagnosis and treatment for the following parasites: Helminths: cestodes – Taenia solium, T.saginata, T. echinococcus. Trematodes – Fasciola hepatica, Fasciolopsis buski, Paragonimus, Schistosomes. Nematodes: Ascaris, Ankylostoma, Trichuris, Trichuris, Trichinella, Enterobius, Strongyloides, Wuchereria. Other parasites causing infections in immunocompromised hosts and AIDS.

*****

CORE 4,5 AND 6 – PRACTICAL: SYSTEMATIC BACTERIOLOGY, MYCOLOGY, PARASITOLOGY AND VIROLOGY

UNIT I

Collection and transport of clinical specimens -Prerequisites -Proforma -Methodologies. Direct examinations - wetfilms/stainings for Faeces (V.cholerae, Shigella, Salmonella) Pus, Sputum, throat/ear/nasal/wound swabs, CSF and other body fluids. Simple, differential and special staining methods.

UNIT II

Cultivation methods -Transport media - Isolation methods – Basal, differential enriched, selective media & special media for the pathogenic bacteria. Biochemical identification. Tests for the respective bacteria up to species level.

UNIT III

Antibiotic sensitivity tests -Stokes & Kirby Bauer methods - Disc diffusion -Dilution - Agar dilution & broth dilution -MBC/MIC - Quality Control for antibiotics and standard strains.

UNIT IV

KOH preparation of skin / nail scrapings for fungi and scabies mites. Examination of hair infection under UV light. LPCB mount. Special stains for fungi -Gomori, PAS and Methanamine silver stain for sections. Cultivation of fungi and their identification -Mucor, Rhizopus, Aspergillus, Penicillium, Candida, Trichophyton, Microsporum, Epidermophtyon - Slide culture method - Germ tube method, Sugar assimilation / fermentation tests for yeast.

UNIT V

Examination of parasites in clinical specimens - Ova/cysts in faeces - Direct and concentration: methods – Formal, Ether and Zinc sulphate methods - Saturated salt solution method. Blood smear examination for malarial parasites. Thin smear by Leishman's stain - Thick smear by J.B. stain. Wet film for Microfilariae. Identification of common arthropods of medical importance - spotters of Anopheles, Glossina, Phelbotomus, Aedes, etc. Ticks and mites.

UNIT VI

Isolation and characterization of bacteriophage from natural sources – phage titration - T4. Study of virus infected plants. Isolation of viruses - chick embryo - animal tissue culture - fibroblast culture – preparation (demonstration). Spotters of viral inclusions and CPE- stained smears. Viral serology- HAI-ELISA, Western Blotting.

*****

ELECTIVE 3- THEORY: INDUSTRIAL & PHARMACEUTICAL MICROBIOLOGY

UNIT I

Isolation, preservation and improvement of industrially important micro organisms; Raw materials and media design for Fermentation processes; Sterilization; Development of inoculums for industrial fermentations; Types of fermentation: Batch, continuous, dual or multiple, surface, submerged, aerobic and anaerobic.

UNIT II

Fermenter – Design and types. Instrumentation and control - aeration and agitation. Recovery and purification of fermentation products. Enzyme and cell immobilization, production of recombinant proteins having therapeutic and diagnostic applications: Vaccines, Insulin, Interferon, Somatotropin, Single cell protein.

UNIT III

Biology of industrial micro organisms. *Streptomyces*, Yeasts (*Saccharomyes*, *Hansenela*) *Spirulina* and *Penicillium*. Mushroom cultivation. Biosensors and Biochips. Biofuels from microbial sources.

UNIT IV

Production of primary metabolites: Alcohols (Ethanol and Butanol); Beverages (Beer and Wine); Aminoacids (Glutamic acid and Lysine); Organic acids (Citric acid and acetic acid).

UNIT V

Production of secondary metabolites: Antibiotics (Penicillin and Streptomycin); Vitamins (Riboflavin and Cyanocobalamin); Steroids; Production of enzymes (Protease, amylase and lipase); Biopolymers (Xanthan gum and PHB); Biopreservatives (Nisin).

*****

ELECTIVE-4-THEORY: BIOSTATISTICS AND BIOINFORMATICS

UNIT I

Nature and scope of statistical methods and their limitations compilation, classification, tabulation and applications in life sciences. Graphical representation – measure of average, dispersion - stem and leaf plots; box and whisker plots, coplots. Introduction to probability theory and distributions (concepts without derivation) binomial, poission and normal (only definition and problems).

UNIT II

Correlation and regression – concepts of sampling and sampling distribution – tests of significance based on t-test, chi-square and F-test for means, proportions, variations and correlation efficient, theory of attributes and tests of independence of contingency tables.

UNIT III

Sampling methods- simple, random, stratified, systemic and cluster sampling procedures. Sampling and non-sampling errors. Principles of scientific experiments- analysis of variance- one way and two way classification.

UNIT IV

Overview of bioinformatics- database types. Genomics and human genome project. Computational tools for sequence analysis and similarity searching.

UNIT V

Pair wise and multiple sequence alignment. Macromolecular structure function relationships. DNA micro array**.** Next generation sequencing. Systems medicine.

*****

THIRD SEMESTER

CORE 7-THEORY: MICROBIAL GENETICS

UNIT I

Historical perspectives of microbial genetics. Nucleic acid as genetic information carriers: experimental evidence. DNA – types, structure and properties topology, super helicity, linking number.

UNIT II

Organization of genes and chromosomes: Definition of gene. Operon – Positive regulation. Structure of chromatin and chromosomes -unique and repetitive DNA, heterochromatin, euchromatin, transposons.

UNIT III

Plasmids as extrachromosomal genetic elements; types and properties. Structure and replication of different plasmids: Col E1, F1 and Ti plasmids. Plasmid amplification and curing; Gene transfer mechanisms: Transformation, conjugation and transduction.

UNIT IV

Mutation and Mutagenesis – mechanisms, biochemical basis, mutagens. Molecular basis of spontaneous and induced mutations. Reversion and suppression. Environmental Mutagenesis and toxicity testing; Carcinogenecity - chemical carcinogenesis and their testing. Isolation of Mutants.

UNIT V

Molecular recombination - Mechanism, control and models. Transposition; regulatory sequences and transacting factors. Genetic mapping in E. coli and Yeast. Genetics of Lambda, M13, Mu, T_4 and OX174Genetic systems of yeast and *Neurospora*.

*****

CORE 8- THEORY: GENETIC ENGINEERING

UNIT I

Principles and methods in genetic engineering: Host cell restriction - restriction modification. Restriction enzymes - types and applications, restriction mapping; Enzymes used in genetic engineering - Nucleases, Ribonucleases, DNA ligases, Tag DNA Polymerases, Methylases, Topoisomerases, Gyrases and Reverse Transcriptases.

UNIT II

Vectors - Plasmid vectors: pSC101, pBR322, pUC series and Ti plasmids based vectors - Bacteriophage vectors: Lambda phage based vectors, phagemids, cosmids, and M13 based vectors - Viral vectors: Vaccinia, Retroviral, SV40 and Baculoviral system; Bacterial and yeast artificial chromosomes. Expression vectors.

UNIT III

Cloning techniques - Genomic DNA and cDNA library Construction - Screening methods. Cloning in *E. coli, Bacillus, Pseudomonas, Streptomyces* and yeast. Expression systems. Gene fusion and Reporter genes. Gene targeting. Methods of gene transfer - transformation, transfection; electroporation, microinjection and biolistics.

UNIT IV

Analysis of Recombinant DNA. Polymerase chain reaction. Principles and techniques of nucleic acid hybridization and cot curves - Southern, Northern, Western and South-Western blotting techniques. Dot and Slot blotting.

UNIT V

DNA and protein sequencing. Protein engineering. Protoplast fusion. Hybridoma Technology. DNA finger printing - RFLP, RPAD and AFLP techniques. Applications of genetic engineering in agriculture, health and industry including gene therapy.

*****

CORE 9 – THEORY: MOLECULAR BIOLOGY

UNIT I

Composition, structure and function of biomolecules (carbonhydrates, lipids, proteins and nucleic acids). Conformation of proteins (Ramachandran plot, secondary, tertiary and quaternary structure; domains; motif and folds). Conformation of nucleic acids (A-, B-, Z-, DNA), t-RNA, micro-RNA. Stability of protein and nucleic acid structures. Molecular approaches to diagnosis and strain identification.

UNIT II

DNA replication, repair and recombination - unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extra-chromosomal replications. DNA damage and repair mechanisms.

UNIT III

RNA synthesis and processing: Transcription factors and machinery - formation of initiation complex, transcription activators and repressors, RNA polymerases, capping, elongation and termination. RNA processing - RNA editing, splicing, polyadenylation, RNA transport.

UNIT IV

Protein synthesis - formation of initiation complex, elongation and termination – machineries and their regulation. Genetic code. Aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, translational proof-reading, translation inhibitors. Post-translational modification of proteins.

UNIT V

Control of gene expression at transcription and translation level - Regulation of phages, viruses, prokaryotic and eukaryotic gene expression - Role of chromatin in regulating gene expression and gene silencing.

*****

CORE 7, 8 AND 9- PRACTICAL: MICROBIAL GENETICS, MOLECULAR BIOLOGY AND GENETIC ENGINEERING

UNIT I

Isolation of genomic DNA from bacteria and demonstration in agarose gel electrophoresis. Isolation of plasmid DNA by alkali lysis method. Estimation of DNA by diphenyl amine method. Determination of Tm value of DNA. Quantitation of nucleic acids by UV Spectrophotometer.

UNIT II

Isolation of RNA from yeast. Estimation of RNA by orcinol method. Induced mutagenesis - Isolation of antibiotic resistant auxotrophic mutants.

UNIT III

Estimation of proteins by Lowery *et al* method. SDS-PAGE. 2D-Gel electrophoresis. Isoelectric focussing. Separation of amino acids by TLC and paper chromatography.

UNIT IV

Separation of proteins using Gel filtration and Ion exchange chromatography. Immobilization of enzymes and whole cells. Western blotting. Protoplast and spheroplast isolation. Induction of beta-galactosidase activity in E. coli using IPTG.

UNIT V

Preparation of competent cells. Transformation and Blue-White selection for transformants. DNA amplification by PCR. Separation of PCR amplified product on PAGE and determination of product size. Restriction mapping / Restriction analysis.

*****

ELECTIVE-5 THEORY : SOIL AND AGRICULTURAL MICROBIOLOGY

UNIT I

Characteristics and classification of soils; Soil Microorganisms; Interactions between microorganisms - Mutalism, commensalism, ammensalism, synergism, parasitism, predation, competition. Interaction of microbes with plants - rhizosphere, phyllosphere and mycorrhizae.

UNIT II

Symbiotic and Asymbiotic Nitrogen fixation – mechanism and genetics of Nitrogen Fixation. Biogeochemical cycles - carbon, nitrogen, phosphorus, sulfur. Biofertilizers - *Rhizobium*, *Azotobacter*, *Azospirillum*, VAM, Phosphobacteria, *Azolla* Cyanobacteria. Biopesticides. Interrelationships between microorganisms, plants and soil - Enzymes of microbial origin and their role in release of available plant nutrients.

UNIT III

Plant pathogens and classification of plant diseases. Host-pathogen recognition and specificity. Principles of plant infection and defense mechanisms - entry of pathogen in to host, colonization of host; role of enzymes, toxins and growth regulatory substances. Defense mechanisms in plants - Structural and biochemical - Molecular aspects of host defense reactions - Lipoxygenase and other enzymes in the expression of disease resistance.

UNIT IV

Symptoms, Etiology, Epidemiology and management of the following plant diseases: Mosaic disease of tobacco; Bunchy top of banana; Leaf roll of potato; Bacterial blight of paddy; Angular leaf spot of cotton, Late blight of potato; Damping off of tobacco, Downy mildew of bajra; Powdery mildew of cucurbits; Head smut of sorghum; Leaf rust of coffee; Blight of maize/sorghum; Leaf spot of paddy, Grassy shoot of sugar cane; Root knot of mulberry.

UNIT V

Plant disease management – exclusion, evasion, eradication, crop rotation. Sanitation - physical, chemical and biological control. Plant disease forecasting. Biotechnological approaches to disease management.

*****

EXTRA DISCIPLINARY (ELECTIVE-6) –THEORY: ENVIRONMENTAL BIOTECHNOLOGY

UNIT I

Biofilm – occurrence causes and effects - control measures. Biofilm reactor-soluble microbial products and inert biomass – principle and applications.

UNIT II

Bioreactors - principles and designing. Reactor types – batch, continuous-flow, stirred-tank reactor, plug-flow reactors. Effluent recycle - reactors with recycle of settled cells - alternate rate models - Reactors in series.

UNIT III

Denitrification – physiology, types and microbes involved - sludge denitrification. Waste water treatment systems - anaerobic and aerobic- Special factors for the design of anaerobic sludge digesters. Drinking-water treatment: principles - anaerobic treatment by methanogenesis.

UNIT IV

Detoxification of Hazardous chemicals - factors causing molecular recalcitrance. Synthetic organic chemicals - Energy metabolism versus co-metabolism - Electron donor versus electron acceptor - Biodegradation of environmental contaminants.

UNIT V

Bioremediation: Strategies for bioremediation - Pollution monitoring, control and remediation (petroleum industry, paper industry, chemical industry etc.). Biomass from the wastes.

*****

FOURTH SEMESTER

CORE 10-THEORY - FOOD, DAIRY AND ENVIRONMENTAL MICROBIOLOGY

UNIT I

Food Microbiology: Occurrence of microorganisms in food - Factors influencing microbial growth - extrinsic and intrinsic. Principles and methods of food preservation - high Temperature, low Temperature, drying, irradiation and chemical preservatives. Food borne diseases - Bacteria, Fungi, Viruses, Algae and Protozoa. Spoilage of fruits, vegetables, meat, poultry, fish and sea foods.

UNIT II

Dairy Microbiology: Microflora of milk - sources of contamination. Spoilage and preservation of milk and milk products. Fermented foods - Sauerkraut, Pickles, Buttermilk, Yogurt and Cheese. Probiotics and Prebiotics. Milk borne diseases. Food sanitation - food control agencies and their regulations.

UNIT III

Microbiology of air: Occurrence - number and kinds of microbes in air. Distribution and sources of air borne organisms - aerosol and droplet nuclei. Assessment of air quality -Air Sanitation - Airborne diseases. Microbiology of water: Aquatic habitats - their microflora and fauna - lake, ponds, river, estuary and sea. Biology and ecology of reservoirs and influence of environmental factors on the aquatic biota.

UNIT IV

Environmental Microbiology: Waste treatment - Wastes - types and characterization. Treatment of solid wastes - composting, vermiform composting, silage, pyrolysis and saccharifications. Treatment of liquid wastes - primary, secondary (anaerobic and aerobic) - trickling, activated sludge, oxidation pond, and oxidation ditch-tertiary - disinfection.

UNIT V

Degradation of Xenobiotic compounds: Simple aromatics, chlorinated polyaromatic petroleum products, pesticides and surfactants. Biodeterioration of materials - paper, leather, wood, textiles and paint. Metal corrosion - Bioaccumulation of heavy metals. Biofouling and Bioleaching.

*****

CORE 10- PRACTICAL: SOIL, AGRICULTURAL, FOOD AND ENVIRONMENTAL MICROBIOLOGY

UNIT I

Isolation and enumeration of soil microorganisms (fungi, bacteria and actinomycetes). Isolation of phosphate solubilizer from soil. Isolation of Nitrogen fixers - *Rhizobium* from root nodule and - *Azotobacter* from rhizosphere. Screening of antagonistic bacteria in soil by agar overlay method. Isolation of Cyanobacteria and Photosynthetic bacteria from soil/water.

UNIT II

Estimation of foliar infection by Stoyer's method. Cultivation of oyster mushroom. Study of the following diseases: Tobacco mosaic; Bacterial blight of paddy; Downy mildew of bajra; Powdery mildow of cucurbits; Head smut of sorghum, Leaf rust of coffee; Leaf spot of mulberry, Red rot of sugarcane, Root knot of mulberry.

UNIT III

Detection of number of bacteria in milk by breed count. Determination of quality of milk sample - methylene blue reduction test and Resorzurin method. Detection of number of bacteria in milk - standard plant count. Isolation of yeast and molds from spoiled nuts, fruits, and vegetables. Bacteriological examination of specific foods – curd, raw meat, fish, Ice cream.

UNIT IV

Extracellular enzyme activities - phosphatase. Quantification of microorganisms in air-solid and liquid impingement techniques.

UNIT V

Physical, chemical and microbial assessment of water and potability test for water. Physical and chemical - colour, pH, alkalinity, acidity, COD, BOD, anions and cations. Microbiological - MPN index - presumptive, completed and confirmatory tests.

*****

ELECTIVE 7 – THEORY: RESEARCH METHODOLOGY

UNIT I

Research Methodology - Meaning and objectives and types of research. Research approaches - research Process. Defining the research problem - research design. Sampling – types and design. Data collection - methods - processing and analysis of data. Testing of Hypothesis. Fundamentals of Bioethics.

UNIT II

Writing the Research Report (Thesis and publications): Components of research report - Title, Authors, Addresses, Abstract, Keywords, Introduction, Materials and Methods, Results, Discussion, Summary, Acknowledgements and Bibliography.

UNIT III

Molecular biology methods: In vitro mutagenesis and detection techniques. Gene knock out in bacterial and eukaryotic organisms. Methods for analysis of gene expression - RNA and protein level - micro array based techniques. Isolation, separation and analysis of protein, carbohydrate and lipid molecules.

UNIT IV

Histochemical and immunotechniques: Flowcytometry and immunofluorescence microscopy. Detection of molecules in living cells - FISH and GISH. Biophysical methods: Analysis of biomolecules - UV/visible, fluorescence, circular dichroism, NMR and ESR spectroscopy. Structure determination - X-ray diffraction, mass spectrometry and surface plasma resonance methods.

UNIT V

Radiolabeling techniques: Radioisotopes used in biology – properties, detection and measurement. Molecular imaging of radioactive material and safety guidelines. Miscroscopic techniques: Microscopy of living cells, scanning and transmission microscopes, different fixation and staining techniques for EM, freeze-etch and freeze-fracture methods for EM - Image processing methods in microscopy.

CORE 11 - PROJECT AND VIVA VOCE

OBJECTIVE OF THE COURSE

To impart advanced practical knowledge in conducting a research project.

To plan and design statistically, retrieve relevant literature, organize and conduct, process the data, photograph relevant observations, evaluate by statistical programmes. Present the project in any regional/national conference/seminar during the Second year of the course and submit for final semester Examinations. The work has to be conducted in department under the guidance of the project supervisor. Interdisciplinary collaborations from external departments / institutions can be organized only for essential areas of the project. The method of valuation of project report submitted by the candidate is outlined as follows:

Internal	(2 out of 3 presentations)	-	20 Marks
Viva		-	20 Marks
Project Report		-	60 Marks

*****

TEXT BOOKS

1. Davis, B.D., Delbecco, R., Eisen, H.N. and Ginsburg, H.S. (1990) Microbiology, 5th Edn. Harper & Row, New York.
2. Arora, D.R. (2003) *Text Book of Microbiology*, 2nd Edn. CBS Publishers & Distributors, New Delhi.
3. Dubey, R.C. and Maheswari, D.K. (2003) *A Text Book of Microbiology*, 1st Edn. S. Chand & Co. Ltd., New Delhi.
4. Boyd, R.F. (1998) General Microbiology. Times Mirror, Mosby College Publishing ,St Louis.
5. Prescott, L.M., Harley, J.P. and Klein, D.A. (1999) Microbiology. McGraw Hill, New Delhi.
6. Roitt, I.M. (1998) Essential Immunology. Blackwell Scientific Publications, Oxford.
7. Weir, D.M. and Steward J. (1993) Immunology, 7th Edn. ELBS, London.
8. Abbas, A.K., Lichtman, A.H. and Pober, J.S. (1994) Cellular and Molecular Immunology, 2nd Edn. WB Saunders, USA.
9. Humphrey, J.H. and White, R.G. (1995) Immunology for Students of Medicine, 5th Edn. ELBS, London.
10. Jagadish Chander (1996) A Text Book of Medical Mycology. Interprint, New Delhi.
11. Greenwood, D., Slack, R.B. and Peutherer, J.F.(2002) Medical Microbiology, 16th Edn. Churchill Livingstone, London.
12. Extremophiles by Johri B.N. 2000. Springer V erlag New York
13. Microbial Diversity by Colwd, D. 1999, Academic Press.

14. Microbial Life in Extreme Environments , Edited by D.J. Kushner, Academic Press.
15. Microbiology of Extreme Environments. Edited by Clive Edward. Open University Press.Milton Keynes.
16. Microbiology of Extreme Environments and its potential for Biotechnology. Edited by M.S.Da Costa, J.C.Duarate, R.A.D. Williams. Elsiever Applied Science, London.
17. Extreme Environment. Mechanism of Microbial adaptation. Edited by Milton R.Heinrich. Academic press.
18. Thermophiles, general, molecular and applied microbiology, edited by Thomas D. brock. Wiley Interscience publication.
19. Microbiology: dyanamics and diversity by perry.
20. Microbial ecology Fundamentals and applications by Ronald M. Atlas and Rchard Bartha 2nd and 4th edition by The Benjamin Cummins Pub. Co. inc.
21. Brocks Biology of Microorganisms. 8th edition.
22. Advances in applied microbiology vol 10 edited by wayne w. umbereit and d. Pearlman academic press.
23. Finegold, S.M. (2000) Diagnostic Microbiology, 10th Edn. C.V. Mosby Company, St. Louis.
24. Parija, S.C. (1996) *Text Book of Medical Parasitology*. Orient Longman, Chennai.
25. Chatterjee (1986) *Medical Parasitology*. Tata McGraw Hill, Calcutta.
26. Easwari Nayar (1974) *Hand Book on Medical Entomology*. Kalpana Printing House, Delhi.
27. Arora. D.R. and Arora, B. (2002) *Medical Parasitology*, 1st Edn. CBS Publishers & Distributors, New Delhi.
28. Ananthanarayanan, R. and Jayaram Panicker C.K. (2004) *Text book of Microbiology*. Orient Longman, Hyderabad.
29. Gerhardt, P., Murray, R.G., Wood, W.A. and Kreig, N.R. (Eds) (1994) *Methods for General and Molecular Bacteriology.* ASM Press, Washington, DC.
30. Collee, J.C., Duguid, J.P., Fraser, A.C. and Marimon, B.P. (1996) *Mackie and McCartney Practical Medical Microbiology,* 14th Edn. Churchill Livingstone, London.
31. Dubey, R.C. and Maheshwari, D.K. (2002) *Practical Microbiology,* 1st Edn. S. Chand & Co. Ltd., New Delhi.
32. Morag, C. and Timbury, M.C. (1994) *Medical Virology,* 10th Edn. Churchill Livingston, London.
33. Dimmock, N.J. and Pimbrose, S.B. (1994) *Introduction to Modern Virology*, 4th Edn. Blackwell Scientific Publications, Oxford.
34. Conrat, H.F., Kimball, P.C. and Levy, J.A. (1994) *Virology*, 3rd Edn, Prentice Hall, New Jersey.

35. Snedecar, G.W. and Cochram, W.G.(1967) *Statistical Methods*. Oxford Press,London.

36. Daniel, W.W. (1995) *Biostatistics* : *A foundation for analysis in health sciences*,6th Edn. John Wiley & Sons, New York.

37. Cotton, T. (1974) *Statistics in Medicine*. Little Brown, Boston.

38. Arunagirinathan, N. and Rajendran, P.(2006) *Allergy*, 1st Edn. Rahul Publication,Arcot,Vellore.

39. Kannan, I. (2007) *Immunology.* MJP Publishers, Chennai.

40. Daniel, J.C. (1996) *Environmental Aspects of Microbiology.* Bright Sum Publication, Chennai.

41. Meena Kumari, S. (2006) *Microbial Physiology.* MJP Publishers, Chennai.

42. Arunagirinathan, N. and Aswini, L. (2006) *Biotechniques*, 1st Edn. Rahul Publication,Arcot,Vellore.

43. Cappuccimo, J. and Sherman, N. (2002) *Microbiology: A Laboratory Manual*, 6th Edn. Pearson Education Publication, New Delhi.

44. Vijaya Ramesh, K (2007) *Food Microbioloy.* MJP Publishers., Chennai.

45. Prescott, L.M., Harley, J.P. and Klein, D.A. (1999) Microbiology. McGraw Hill, New Delhi

46. Ketchum, P.A. (1984) Microbiology: Concepts and Applications. John Wiley and Sons, New York.

47. Madigan, M.T., Martinko, J.M. and Parker, J. (1999). Brock's Biology of Micro organisms, 9th Edn. Prentice Hall, New Jersey.

48. Salle, A.J. (1992) Fundamental Principles of Bacteriology, 7th Edn. Tata McGraw Hill, New Delhi.

49. Mandelstam, J., McQuillen, K. and Dawes, L. (1992) Biochemistry of Bacterial Growth, 3rd Edn. Blackwell Scientific Publications, Oxford.

50. Moat, A.G. and Foster, J.W. (1995) Microbial Physiology, 3rd Edn. John Wiley and Sons, New York.

51. Roitt, I.M.(1988) Essential Immunology. Blackwell Scientific Publications,Oxford.

52. Jawetz, E., Melnic, J.L. and Adelberg, E.A. (2000) Review of Medical Microbiology ,19th Edn. Lange Medical Publications, U.S.A.

53. Ananthanarayan, R. and Jeyaram Paniker, C.K. (1994) Text Book of Microbiology,6th Edn. Orient Longman, Chennai.

54. Jeyaram Paniker, C.K. (2006) Text Book of Parasitology. Jay Pee Brothers, New Delhi.

55. Alexender, M. (1977) Introduction to Soil Microbilogy. John Wiley and Sons, New York.

56. Stanbury, P.F., Whitaker, A. and Hall, S.J. (1995) Principles of Fermentation Technology, 2nd Edn. Pergamon Press, Oxford.

57. Frazier, W.C. and Westhoff, D.C. (1988) Food Microbiology, 4th Edn. McGraw Hill, New York.

58. Old, R. and Primrose, S.B. (1995) Principles of Gene Manipulation: An Introduction to Genetic Engineering, 5th Edn. Blackwell Scientific Publications, Oxford.

59. Freifelder, D. (1995) Molecular Biology. Narosa Publishing House, New Delhi.

60. Timbury, M.C. (1986) Medical Virology, 9th Edn. Churchill Livingstone, London.

61. Jagadish Chander (1996) A Text Book of Medical Mycology. Interprint, New Delhi.

62. Arora, D.R. (2003) Text Book of Microbiology, 2nd Edn. CBS Publishers & Distributors, New Delhi.

63. Arora, D.R. and Arora, B.(2002) Medical Parasitology, 1st Edn. CBS Publishers & Distributors, New Delhi.

64. Dubey, R.C. and Maheswari, D.K. (2003) A Text Book of Microbiology, 1st Edn. S. Chand & Co. Ltd., New Delhi.

65. Dubey, R.C. and Maheswari, D.K. (2002) Practical Microbiology, 1st Edn. S. Chand & Co. Ltd., New Delhi

66. Sathyanarayana, U. (2002) Essentials of Biochemistry 1st Edn. Books and Allied (P) Ltd., Kolkata.

67. Deb, A.C., (1999) Concepts of Biochemistry, 1st Edn. Books and Allied (P) Ltd., Kolkata.

68. Rose,A.H. (1976) Chemical Microbiology: An Introduction to Microbial Physiology, 3rd Edn.Plenum, New York.

69. Gottschalk, G. (1986) Bacterial Mrtabolosm, 2nd Edn. Springer-Verlag, New York.

70. Davis, B.D., Delbecco, R., Eisen, H.N. and Ginsburg, H.S. (1990) Microbiology, 5th Edn. Harper & Row, New York.

71. Alexopolus, C.J. and Mims, C.W. (1979) Introductory Mycology, 3 rd Edn .John Wiley and Sons, New York.

72. Schmidt, G.D. and Roberts, L.S. (1981) Foundations of Parasitology, 2nd Edn, Mosby, St. Louis.

73. Tizard, R.I. (1983) Immunology: An Introduction. Saunders College Publishing, Philadelphia.

74. Kuby, J. (1994) Immunology, 2nd Edn. H.W.Freeman and Company, New York.

75. Elgert, K.D. (1996) Immunology:Understanding the Immune System. Wiley – Liss, New York.

76. Cambell, R. (1983) Microbial Ecology, 2nd Edn. Blackwell Scientific Publications, London.

77. Atlas, R.M. and Bartha, R. (1992) Microbial Ecology: Fundamentals and Applications, 2nd Edn. The Benjamin / Cummings Publishing Co.,Redwood City,CA.

78. Mitchell, R. (1974) Introduction to Environmental Microbiology. Prentice – Hall. Inc. New Jersey.

79. Subba Rao, N.S. (1995) Soil Microorganisms and Plant Growth. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

80. Paul, E.A. and Clark, F.E. (1989) Soil Microbiology and Biochemistry. Academic Press, London.

81. Subbha Rao, N.S. (1995) Biofertilizers in Agriculture and Forestry, 3rd Edn. Oxford & IBH Pub. Co. Pvt. Ltd., New Delhi.

82. Banwart, G.J. (1989) Basic Food Microbiology. CBS Publishers and Distributors, New Delhi.

83. Casida, J.E. (1968) Industrial Microbiology. Wiley Eastern, New Delhi.

84. Adams, M.R. and Moss, M.O. (1995) Food Microbiology. Royal Society of Chemistry, Cambridge.

85. Winnacker, E.L. (1987) From Genes to Clones: Introduction to Gene Technology. VCH, Weinheim.

86. Brown, T.A. (1995) Gene Cloning. Chapman and Hall, London.

87. Maloy, S.R., Cronan, J.E., Jr. and David Freifelder. (1994) Microbial Genetics, 2nd Edn. Jones and Bartlett, Boston.

88. Chatterjee (1986) Medical Parasitology. Tata McGraw Hill, Calcutta.

89. Grierson, D. and Covery, S. (1989) Plant Molecular Biology, 2nd Edn. Blackie, London.

90. Luria, S.E., Darnel, J.E., Jr., Baltimore, D. and Campbell, A. (1978) General Virology, 3rd Edn. John Wiley & Sons, New York.

91. Fenner, F. and White, D.O. (1970) Animal Virology. Academic Press,New York.

92. Glick B.K. and Pasternak, J.J. (1999) Molecular Biotechnology. Principles and Applications of Recombinant DNA. ASM Press, Washington, DC.

93. Stryer, L. (1995) Biochemistry. W.H. Freeman & Co., New York.

94. Ingraham, J.L. and Ingraham, C.A. (2000) Introduction to Microbiology, 2nd Edn. Books / Cole Thomson Learning, UK.

95. Lee, J.D. (2001) Inorganic Chemistry. Blackwell Science,Oxford.

96. Sony, P.L. (2000) A Text Book of Inorganic Chemistry. S.Chand & Sons, New Delhi.

97. Greenwood, N.N. and Earnshaw, A. (1989) Chemistry of the Elements.Mac Millan Publication New York.

98. Cotton, F.A and Wilkinson, G. (1989) Inorganic Chemistry. John Wiley and Sons, NewYork.

99. Schelegel, H.G. (1993) General Microbiology,7th Edn. Cambridge University Press, Cambridge.

100. Lehninger, A.L., Nelson, D.L. and Cox, M.M. (1993) Principles of Biochemistry, 2nd Edn. CBS Publishers, New Delhi.

101. Pelczar, M.J., Jr., Chan, E.C.S and Kreig, N.R. (1993) Microbiology. McGraw Hill, New York.

102. Negi, A.S. and Anand, S.C. (1997) A Text Book of Physical Chemistry, 5th Edn. New Delhi.

103. Gerald Karp,(2002) Cell and Molecular Biology : Concepts and Experiments,3rd Edn John Wiley, New York.

104. Arora, M.P., Gurdarshan and Sandhu, S. (2004) Genetics, 5th Edn. New Age International Publishers, New Delhi.

105. Raven & Johnson (1990) Biology, 4th Edn. Wm. C. Brown Publishers, London.

106. Salisbury, F.B. and Ross, C.W. (1991) Plant Physiology. Wassworth Publication. Co. Belmont.

107. Daniel, W.W. (2005) Biostatistics; A foundation for analysis in the health sciences, 7th Edn. Jhon Wiley & sons Inc, New York.

108. Garumani, N. (2004) An introduction to Biostatistics. JP publishers, Chennai.

109. Wilson, K. and Walker, J. (2002) Practical Biochemistry: Principles & Techniques, 5th Edn. Cambridge University Press, Cambridge.

110. Sundar Rao, P.S.S. and Richard, J. (2006) Introduction to Biostatistics & Research methods. Prentice-Hall of India (P) Ltd, New Delhi.

111. Rittman, B.E. and McCarty P.L. (2001) Environmental Biotechnology: Principles and application. McGraw-Hill, New York.

112. Anderson, J.B., Durston, H. and Poole, M. (1970) Thesis and Assignment Writing, Wiley Eastern Private Limited, New Delhi.

113. Day, R.A. (1988) How to write and publish a scientific paper, 3rd edition, Oryx Press, Phoenix, Anzona.

114. Jayaraman, J. (2000) Laboratory Manual of Biochemistry. Wiley Eastern Limited, New Delhi 110 002.

115. Sharma, K.R. (2002) Research methodology. National Publishing House, Jaipur and New Delhi.

116. Webster, J.G. (2004) Bioinstrumentation, John Wiley & Sons (Asia) Pvt. Ltd., Singapore.

117. Agrios, G.N. (1978) Plant Pathology, 2nd Edn., Academic Press, New York.

118. Butler, E.J. (1918) Fungi and Disease in plants. Thacker Spink and Co., Calcutta.

119. Gregory, P.H. and Monteth (1962). Airborne Microbes. Cambridge University Press, Cambridge, UK.

120. Watson, J.D., Gilman, M., Witkowshi, J. and Zoller, M. (1992) Recombinant DNA, 2nd Edn. Scientific American Books, New York, USA.

121. Board, R.G. (1983) A modern introduction to food microbiology. Blackwell Scientific Publications, Oxford.

122. Hobbs, B.C. and Roberts, D. (1993) Food Poisoning and Food Hygiene. Edward Arnold: London.

123. Jay, J.M. (1987) Modern food microbiology. CBS Publisher and Distributors, New Delhi.

124. Weir, D.M. and Steward J. (1993) Immunology, 7th Edn. ELBS, London.

125. Humphrey, J.H. and White, R.G. (1995) Immunology for Students of Medicine, 5th Edn. ELBS, London.

126. Parija, S.C. (1996) Text Book of Medical Parasitology. Orient Longman, Chennai.

127. Morag, C. and Timbury, M.C. (1994) Medical Virology, 10th Edn. Churchill Livingston, London.

128. Daniel, W.W. (1995) Biostatistics : A foundation for analysis in health sciences,6th Edn. John Wiley & Sons, New York.

129. Cotton, T. (1974) Statistics in Medicine. Little Brown, Boston.

130. Arunagirinathan, N. and Rajendran, P.(2006) Allergy, 1st Edn. Rahul Publication,Arcot,Vellore.

131. Kannan, I. (2007) Immunology. MJP Publishers, Chennai.

132. Daniel, J.C. (1996) Environmental Aspects of Microbiology. Bright Sum Publication, Chennai.

133. Meena Kumari, S. (2006) Microbial Physiology. MJP Publishers, Chennai.

134. Arunagirinathan, N. and Aswini, L. (2006) Biotechniques, 1st Edn. Rahul Publication,Arcot,Vellore.

135. Cappuccino, J. and Sherman, N. (2002) Microbiology: A Laboratory Manual, 6th Edn. Pearson Education Publication, New Delhi.

136. Vijaya Ramesh, K (2007) Food Microbioloy. MJP Publishers., Chennai.

137. Jayapal, V. (2007) Fundamentals of Medical Immunology. Jay Pee Brothers Medical Publications, New Delhi.

138. George Pinchuk (2002) Immunology (Schaum's Outlines). McGraw Hill , New York.

139. Palanivelu, P (2004) Analytical Biochemistry & Separation Techniques – A Laboratory Manual for B.Sc & M.Sc Students, 3rd Edn. Twenty-first Century Publication, Palkalai Nagar, Madurai.

140. Nicholl, D.S.T. (1994) An Introduction to Genetic Engineering. Cambridge Press, London, UK.

141. Sundararaj, T. (2002) Microbiology Laboratory Manual, Ist Edn.Mrs.Aswathy Sundararaj Publication, Chennai .

142. Robinson, R.K. (1990) Dairy Microbiology. Elsevier Applied Sciences, London.

143. Gautham, N. (2006) Bioinformatics. Narosa Publishing Company, New Delhi.

144. Lesk, A.M. (2002) Introduction to Bioinformatics, Ist Edn. Oxford University press, Oxford, UK.

145. Westhead, D.R., Parish, J.H. and Twyman, R.M.(2003) Instant Notes Series – Bioinformatics, Ist Edn. Viva Books Private Limited, New Delhi, India.

146. Attwood, T.K. and Parry-Smith, D.J.(1999) Introduction to Bioinformatics. Addision Wesley Longman Limited, England.

147. Ignacimuthu, S. (2005) Basic Bioinformatics, Ist Edn. Narosa Publishing House, New Delhi, India.

REFERENCE BOOKS

1. Wolfgang, Joklik and Smith, D.T. (1990) *Zinsser Microbiology*, 16th Edn. Appleton Century Crafts, New York.

2. Cowan and Steel (1995) *Manual for Identification of Medical Bacteria*, 4th Edn. Cambridge University Press, London.

3. Ingraham, J.L. and Ingraham, C.A. (2000) *Introduction to Microbiology* 2nd Edn. Books/Cole Thomson Learning, UK.

4. Weir, D.M. (1995) *Experimental Techniques in Immunology*. Blackwell Scientific Publications, Oxford.

5. Topley and Wilson (1995) *Principles of Bacteriology Virology and Immunity*. 9th Edn. Vol I, Edward Arnold, London.

6. Jawetz, E., Melnick, J.L. and Adelberg, E.A. (1998) *Review of Medical Microbiology*, 19th Edn. Lange Medical Publications, U.S.A..

7. Murray, P.R., Baron, E.J., Jorgensen, J.H., Pfaller, M.A. and Yoke, R.H. (2003) *Manual of Clinical Microbiology*, 8th Edn. Vol 1&2, ASM Press, Washington, D.C.

8. Balows, A., Hausler. W.J., Ohashi.M. and Turano.A. (Eds) (1988) *Laboratory Diagnosis of Infectious Diseases: Principles and Practice,* Vol 1 Springer-Verlag, New York.

9. Holt, J.S., Krieg, N.R., Sneath, P.H.A. and Williams, S.S.T. (1994) *Bergey's Manual of Determinative Bacteriology,* 9th Edn. Williams & Wilkins, Baltimore.

10. Jayapal, V. (2007) *Fundamentals of Medical Immunology.* Jay Pee Brothers Medical Publications, New Delhi.

11. George Pinchuk (2002) *Immunology* (Schaum's Outlines). McGraw Hill , New York.

12. Finegold, S.M. (2000) Diagnostic Microbiology, 10th Edn. C.V. Mosby Company, St. Louis

13. Holt, J.S., Krieg, N.R., Sneath, P.H.A. and Williams, S.S.T. (1994) Bergey's Manual of Determinative Bacteriology, 9th Edn. Williams & Wilkins, Baltimore.

14. Rheinheimer, G. (1980) *Aquatic Microbilogy*, 2nd Edn. John Wiley & Sons, New York.

15. Peppler, H.J. and Pearl Man, D. (1979) Fermentation Technology, Vol 1 & 2, Academic Press, London.

16. Bert Desowitz (1980) Ova and Parasites. Harper and Row Publishers, New York.

17. Hayes, W. (1968) The Genetics of Bacteria and their Viruses. Blackwell Scientific Publications, London.

18. Lennette, E.H. (1974) Diagnostic Procedures for Viral and Rikettsial Diseases. American Public Health Association, New York.
19. Hoeprich, P.D. (1977) Infectious Diseases, 2nd Edn. Harper & Row Publishers, New York.
20. Hall, D.V. and Rao, K.K. Photosynthesis. Arnold, London.
21. Postgate, J. (1987) Nitrogen Fixation,2nd Edn. Cassel, London.
22. Zar, J.H. (2006) Biostatistical analysis, 4th Edn. Pearson education Inc. New Jersey.
23. Scragg, A. (1999) Environmental Biotechnology. Pearson Education Ltd., England.
24. Marshall, K.C. (1985) Advances in Microbial Ecology, Vol.8, Plenum Press, U.K.
25. Fletcher, M. and Gray, T.R.G. (1987). Ecology of Microbial communities. Cambridge University Press, Cambridge, UK.
26. Forster, C.F. (1985). Biotechnology and Wastewater Treatment. Cambridge University Press, Cambridge,UK.
27. Gray, N.F. (1989). Biology of Waste Water Treatment. Oxford University Press, Oxford,UK.
28. Metcalf and Eddy (1985) Waste Water Engineering: Treatment, Disposal and Reuse, 2nd Edn. McGraw Hill, International Book Company, Auckland.
29. Rheinheimer (1977) Microbial ecology of brackish water environment. Ecological studies, Vol. 25, Springer - Verlag Berlin - Heidelberg. N.Y.
30. Watson, J.D., Hopkins, N.H., Roberts, J.W., Steitz, J.A. and Weiner, A.M. (1987) Molecular biology of the gene, 4th Edn. The Benjamin/cummings Publishing Company Inc. NY.
31. Baumberg, S., Hunter, I.S. and Rhodes, P.M. (ed). (1989) Microbial Products - New approaches. Cambridge University Press, Cambridge, UK.
32. Demain, A.L. and Solomon, N.A. (1986) Manual of Industrial Microbiology and Biotechnology. American Society for Microbiology, Washington.
33. Reed, G. (1982) Industrial Microbiology. Mac Millan Publishers Ltd., Wisconsin.
34. Boyd, R.F. (1998) General Microbiology. Times Mirror, Mosby College Publishing, St Louis.
35. Abbas, A.K., Lichtman, A.H. and Pober, J.S. (1994) Cellular and Molecular Immunology, 2nd Edn. WB Saunders, USA.
36. Gerhardt, P., Murray, R.G., Wood, W.A. and Kreig, N.R. (Eds) (1994) Methods for General and Molecular Bacteriology. ASM Press, Washington, DC.
37. Snedecar, G.W. and Cochram, W.G. (1967) Statistical Methods. Oxford Press,London.
38. Wolfgang, Joklik and Smith, D.T. (1990) Zinsser Microbiology, 16th Edn. Appleton Century Crafts, New York.
39. Cowan and Steel (1995) Manual for Identification of Medical Bacteria, 4th Edn. Cambridge University Press, London.

40. Weir, D.M. (1995) Experimental Techniques in Immunology. Blackwell Scientific Publications, Oxford.

41. Topley and Wilson (1995) Principles of Bacteriology Virology and Immunity. 9th Edn. Vol I, Edward Arnold, London.

42. Murray, P.R., Baron, E.J., Jorgensen, J.H., Pfaller, M.A. and Yoke, R.H. (2003) Manual of Clinical Microbiology, 8th Edn. Vol 1&2, ASM Press, Washington, D.C.

43. Balows, A., Hausler. W.J., Ohashi.M. and Turano.A. (Eds) (1988) Laboratory Diagnosis of Infectious Diseases: Principles and Practice, Vol 1 Springer-Verlag, New York.

44. Murray, R.K., Granner, D.K.and Rodwell, V.W. (2006) Harper's Illustrated Biochemistry, 27th Edn. Mc Graw Hill, Singapore.

45. Strachan, T. and Read, A. P. (1996) Human Molecular Genetics, Bios Scientific Publishers, U.K.

46. Lodish, H., Baltimore, O., Berk, A., Zipursky, S.L.,Matsudaira ,P.and Darnell, J. (1995). Molecular Cell Biology, Scientific American Books, New York USA.

47. Innis, M.A (1995) PCR Strategies. Academic Press, London, UK.

48. Clover, D.M. (1987) DNA cloning series, Vol. I to IV, IRL Press, Oxford.

49. Benjamin Lewin (1997) Genes VII. Oxford University Press, London,UK.

50. Baker, K.H. and Herson, O.S. (1994) Bioremediation. Mc Graw Hill, Inc.New York.

51. Amold, L., Demain, A.L. and Davies, J.E. (1999) Manual of Industrial Microbiology and Biotechnology, 2nd Edn. ASM Press, Washington DC.

52. Maniatis, T., Fritsh, E.F. and Sambrook, J. (1998) Molecular cloning A Laboratory Manual, Vol I to III, Coldspring Harbour Lab., New York, USA.

53. Krane, D.E. and Raymer,M.L. (2003) Fundamental Concepts of Bioinformatics, Benjamin Cummings, New York, USA.

54. Baldi, P. and Brunak, S. (2003) Bioinformatics. Affillated East – West Press, New Delhi, India.

55. Srinivas, V.S. (2005) Bioinformatics: A Modern Approach. Prentice Hall of India Private Limited, New Delhi, India.

56. Mount, D.W. (2001) Bioinformatics Sequence and Genome Analysis, Ist Edn. Cold Spring Harbor Laboratory Press, New Delhi, USA.

57. Doelle, H.W. (1975) Bacterial Metablism, 2nd Edn. Academic Press, London.

58. Collee, J.C., Duguid, J.P., Fraser, A.C. and Marimon, B.P. (1996) Mackie and McCartney Practical Medical Microbiology, 14th Edn. Churchill Livingstone, London.

59. Greenwood, D., Slack, R.B. and Peutherer, J.F. (2002) Medical Microbiology, 16th Edn. Churchill Livingstone, London.

60. Lynch, J.M. and Poole, N.J. (1979) Microbial Ecology: A. Conceptual Approach. Blackwell Scientific Publications, London.

61. Glover, D.M. (1984) Gene Cloning: The Mechanism of DNA Manipulation. Chapman and Hall, London.

62. Levanthal, R. and Cheadle, R.S. (1979) Medical Parasitology. S.A. Davies Co., Philadelphia.

63. Walter Beck, J. and Davies, J.E. (1976) Medical Parasitology, 2nd Edn. C.V. Mosby Company, St. Louis.

64. Bridge, E.A. (1994) Bacterial and Bacteriophage Genetics, 3rd Edn. Springer–Verlag,New York.

65. Jacob, W.P. (1979). Plant Hormones and Plant Development. Cambridge University Press, Cambridge.

66. Baker, K.F. and Cook, R.J. (1974) Biological Control of Plant Pathogens. W.H. Freeman and Co., New York.

67. Imhoff, K. and Fair, G.M. (1956) Sewage Treatment. John Wiley and Sons Inc., New York.

68. Dan, R.R. and Jellis, G.J. (1988) Genetics and plant pathogenesis, Blackwell Scientific Publication, Oxford.

69. Ward, O.P. (1989) Fermentation Biotechnology: Principles, Processes and Products. Prentice Hall Engle Wood Cliffs, New Jersey.

70. Dimmock, N.J. and Pimbrose, S.B. (1994) Introduction to Modern Virology, 4th Edn. Blackwell Scientific Publications, Oxford.