

ACHARYA NAGARJUNA UNIVERSITY

CENTRE FOR DISTANCE EDUCATION

NAGARJUNA NAGAR,

GUNTUR

ANDHRA PRADESH



PROGRAM PROJECT

REPORT

05. MASTER OF SCIENCE (MICROBIOLOGY)

Master of Science (Microbiology)

PROGRAMME CODE: 5

MISSION :

M.Sc. Microbiology is a multidisciplinary branch of biological sciences. Microbiology is study of microbes like bacteria, viruses, fungi, algae and finds its use and applications in the various fields such as food and dairy industry, pharmaceuticals, fermentation, recombinant biopharmaceuticals, microbial based bioremediation, microbial waste management, water treatment plants, and agriculture.

OBJECTIVES :

The objectives of this course are as follows:

To develop and promote the culture of research among students

To give students practical exposure and hands-on experience

To train students for higher learning through discussions, debates and presentations

To enable students to be aware of current research work going on in different areas of biology

To help place the students at various laboratories, institutions, hospitals and pharma companies for summer training programs in order to enable them to gain experience

RELEVANCE :

The M.Sc. (Microbiology) programme offered through Open and Distance Learning mode is purely relevant and aligned with the goals and mission of CDE, ANU. This programme is structured in order to equip the learners with core competence in research and analytical aspects of scientific evolution there by new areas will be unfolded. This programme is helpful for enhancing the employability skills with the global perspective and conforming to the vision and mission of ANU.

NATURE OF PERSPECTIVE TARGET GROUP OF LEARNERS :

Aim of open and distance education is to enhance the academic competence in those who were deprived of higher education for various socio-economic reasons. This programme is designed for candidates which is helpful in their career advancement, updating the knowledge, upgrading their qualification for school teachers, diagnostics field, microbiologists, Food and beverage companies, Waste management companies, Pharmaceutical companies, Agri chemical companies, Food standard agencies, Warer companies, Environmental consultants etc.

SKILLS AND COMPETENCE OF THE PROGRAMME :

In consideration of the huge gap in education and industry and also in skill development now it is imperative on the part of every university to reach out every nooc and corner of the country where the institutions with significant infrastructure are not availble in order to elevate the status of the marginalised sections of the society especcially living in rural areas of the country. The only solution appears to be "open and distance education" and Acharya Nagarjuna University takes initiative by reaching out those unreached by ICT enabled blended mode of distance learning programmes. M.Sc. (Microbiology) programme is an innovative programme. The learning outcomes of this programme are as follows:

- Professional development of teachers.
- Incorporating generic transferrable skills and competencies
- To develop critical learning, anylitical skills and research skills.

INSTRUCTIONAL DESIGN: Course structure and detailed syllabi

ACHARYA NAGARJUNA UNIVERSITY : CENTRE FOR DISTANCE EDUCATION
Master of Science (Microbiology) - Program code: 05
Program Structure

| Program code | Program | Internal assessment | External exams | Max. Marks | credits |
|-------------------|--|---------------------|----------------|------------|---------|
| SEMISTER 1 | | | | | |
| 101MB24 | Virology | 30 | 70 | 100 | 4 |
| 102MB24 | Microbial Biochemistry and Analytical Techniques | 30 | 70 | 100 | 4 |
| 103MB24 | Bacteriology | 30 | 70 | 100 | 4 |
| 104MB24 | Biology of Eukaryotic Microbes | 30 | 70 | 100 | 4 |
| 105MB24 | Practical-I | 30 | 70 | 100 | 4 |
| 106MB 24 | Practical-II | 30 | 70 | 100 | 4 |
| SEMISTER 2 | | | | | |
| 201MB24 | Microbial physiology and metabolism | 30 | 70 | 100 | 4 |
| 202FMB24 | Microbial genetics and molecular biology | 30 | 70 | 100 | 4 |
| 203MB24 | Immunology | 30 | 70 | 100 | 4 |
| 204MB24 | Agricultural microbiology | 30 | 70 | 100 | 4 |
| 205MB24 | Practical-I | 30 | 70 | 100 | 4 |
| 206MB24 | Practical-II | 30 | 70 | 100 | 4 |
| SEMISTER 3 | | | | | |
| 301MB24 | Medical Microbiology | 30 | 70 | 100 | 4 |
| 302MB24 | Recombinant DNA technology | 30 | 70 | 100 | 4 |
| 303MB24 | Cellular Microbiology and Bioinformatics | 30 | 70 | 100 | 4 |
| 304MB24 | Fermentation Technology | 30 | 70 | 100 | 4 |
| 305MB24 | Practical-I | 30 | 70 | 100 | 4 |
| 306MB24 | Practical-II | 30 | 70 | 100 | 4 |
| SEMISTER 4 | | | | | |
| 401MB24 | Environmental Microbiology | 30 | 70 | 100 | 4 |
| 402MB24 | Food Microbiology | 30 | 70 | 100 | 4 |
| 403MB24 | Industrial Microbiology | 30 | 70 | 100 | 4 |
| 404MB24 | Biofertilizer technology | 30 | 70 | 100 | 4 |
| 405MB24 | Practical-I | 30 | 70 | 100 | 4 |
| 406MB24 | Practical-II | 30 | 70 | 100 | 4 |

SEMESTER-I
MASTER OF SCIENCE (MICROBIOLOGY)
101MB24 - VIROLOGY

UNIT-I

Brief outline of discovery of viruses; properties of viruses. Morphology of viruses- Structure, Capsid architecture; envelopes and peplomers. Chemistry of viruses- viral proteins, genome – structure and types. Study of sub-viral agents – Brief account of diseases caused by viroids – PSTV, Cadangcadang; Prions- Scrape, Cruetzfeldjakob; Satellite viruses, Satellite RNA's.

UNIT-II

General methods of cultivation of viruses-in embryonated eggs, experimental animals and cell cultures, monolayer cultures, cell lines. General methods of purification of viruses. Serological methods for detection of viruses- haemagglutination & HAI, immunofluorescence, ELISA, PCR and RIA. Infectivity assay – plaque method.

UNIT-III

Taxonomy of plant viruses, Symptoms of diseases caused by plant viruses (morphological, Physiological and histological), Ultra structure and life cycles of TMV and CaMV, Transmission of plant viruses – mechanical and biological (vector and nonvector), Basic control measures of plant diseases- vector and chemical control.

UNIT-IV

Taxonomy of human viruses. Ultra structure and brief account on life cycles of RNA viruses- Polio, Influenza and HIV. Ultra structure and brief account on life cycles of DNA viruses- Vaccina, Adenovirus, SV40.

UNIT-V

Ultra structure and life cycles of bacteriophages- M13, Mu, T4 & lambda. General account of viruses of Cyanobacteria, algae and fungi. Viral vaccines- Types, preparation and production of vaccines. New generation vaccines- genetic recombinant vaccines. General account on interferons and antiviral drugs.

REFERENCE BOOKS

1. Dimmock Nj, Primrose Sb (1994). Introduction to Modern Virology IV Edition, Blackwell Scientific publications. Oxford.
2. Morag, C And Timbury M (1994). Medical Virology, Churchill Livingstone, CONRAT HF, KIMBALL PC and LEVY JA (1994). Virology-III Ed. Englewood cliff, New Jersey.
3. Mathews, Re (1992). Functional of plant Virology, Academic Press, San Diego. TOPLEY and WILLIAMS (1995). Text book on Principles of Bacteriology, virology and immunology, Edward Arnold, London.
4. William Hayes (1985), The genetics of bacteria and Their viruses, black Well Scientific publishers, London.
5. David Ga Walkey (1985). Applied Plant Virology. William Heinemann Ltd, London.

SEMESTER-I
MASTER OF SCIENCE (MICROBIOLOGY)
102MB24 - MICROBIAL BIOCHEMISTRY AND ANALYTICAL TECHNIQUES

UNIT-I

Properties of Biomolecules: Carbohydrates – Structure and physicochemical properties of mono and oligosaccharides. Structures and biological importance of structural and storage polysaccharides. Lipids– Physicochemical properties of fatty acids, Triacylglycerols, Glycolipids, Phospholipids, Lipid aggregations (micelles, monolayers, bilayers, liposomes). Nucleic Acids: Structure of DNA and RNA. Renaturation and denaturation of DNA, cot values of DNA.

UNIT-II

Amino acids: classification, amino acid properties, essential amino acids, Biological significance. Proteins: peptide bond and types of peptides, peptides of non-protein origin, three dimensional structure of proteins (Primary, Secondary, Tertiary, Quaternary). Chaperones, denaturation and renaturation of proteins.

UNIT-III

Enzymes – Nature and outline classification of enzymes, binding energy, activation energy, rates of reactions, MM equation, factors influencing the enzyme action, mechanism of enzyme action, enzyme inhibitors, allosteric enzymes, isoenzymes, ribozymes, abzymes. Protein purification and characterization methods, methods of lipid separation and analysis.

UNIT-IV

Spectroscopy – Principles and applications of UV-Vis, NMR, ESR and Mass spectroscopy. Centrifugation: Instrumentation for centrifugation, principles and applications of differential and density gradient centrifugation.

UNIT-V

Chromatography – Principles and applications of adsorption, ion exchange, gel filtration, affinity and ion exchange chromatography.

Electrophoresis – Principles and applications of Polyacrylamide, Agar, Pulsed, and Immuno electrophoresis.

SUGGESTED BOOKS:

1. Nelson and Cox 2000. Lehninger Principles of Biochemistry.
2. Moat, A. Gand J.N. Foster. 1999. Microbial Physiology.
3. Wilson, K and J. Walker 1995. Practical Biochemistry. Principles and Techniques. 4thed.
4. Upadhyay, A., Upadhyay, K and Nirmalendru Nath. 2003. Biophysical Chemistry – Principles and Techniques.
5. David Freifeilder and W. Freeman 1982. Physical Biochemistry – Applications to Biochemistry and Molecular Biology. 2nded.
6. Caldwell, D.R. 1995. Microbial Physiology and Metabolism.

SEMESTER-I
MASTER OF SCIENCE (MICROBIOLOGY)
103MB24 - BACTERIOLOGY

UNIT-I

Outline classification of microorganisms – Different types of kingdom systems (Haeckel's three kingdom concept, Whittaker's five kingdom concept); three domain concept of Carl Woese. Principles of bacterial taxonomy and classification of bacteria – Numerical taxonomy, Identification characters – morphological, staining, physiological, biochemical and genetical (mol% G+C, Nucleic acid hybridization, 16S rRNA sequencing) characters. Bacterial classification as per the latest edition of Bergey's Manual of Systematic Bacteriology. Ultrastructure of typical bacterial cell – Surface appendages, Cell envelope and Cytoplasmic components. Sporulation in bacteria.

UNIT-II

Sterilization methods to control bacterial growth – Physical (Heat, Filtration, Radiation) and Chemical methods. General methods of isolation of bacteria from soil (Plating methods, Serial dilution technique, MPN technique, Contact slide technique, Winogradsky column) and water (Multiple tube fermentation test, Membrane filter technique); anaerobic culture methods. Maintenance and Preservation of bacterial cultures – Sub-culturing, Oil over laying, Lyophilization, Cryo- preservation. Techniques for staining bacteria – Negative, Simple and Differential staining methods.

UNIT-III

Bacterial Nutrition – Nutritional classification of bacteria, Essential macronutrients, micronutrients and growth factors. Bacterial Growth – Growth characteristics of bacteria on solid medium, Kinetics of growth, Typical bacterial growth curve, Diauxic growth curve, Batch culturing, Continuous culturing – chemostat and turbidostat, synchronous culturing. Factors affecting the bacterial growth; Methods for measurement of bacterial growth. Bacterial Homeostasis.

UNIT-IV

Classification, General characters, Reproduction and significance of Archaeobacteria. Classification, General characters, Reproduction and significance of Cyanobacteria. Classification, General characters, Reproduction and significance of Actinomycetes.

UNIT-V

Taxonomy and characteristic features of the following bacterial genera-*Agrobacterium*, *Bacillus*, *Clostridium*, *Escherichia*, *Mycoplasma*, *Nitrosomonas*, *Pseudomonas*, *Rhizobium*, *Rickettsia*, *Spirochaete*, *Staphylococcus*, *Streptococcus*.

REFERENCE BOOKS

1. Brock, T.D. and Madigan, M.T. – Biology of Microorganisms (1999)
2. Prescott, L.M., Harley, J.P. Klein, D.A. – Microbiology (2008)
3. Stanier, R.Y., Ingraham, J.L., Wheelis, M.L., Painter, P.R. – The Microbial World (1988)
4. Pelczar, M.J., Chan, E.C.S., Kreign, N.R. – Microbiology (2006)
5. Black, J.G. - Microbiology – Principles and Explorations (1999)
6. Atlas, R.M. – Principles of Microbiology (1996)
7. Salle AJ. Fundamental principles of Bacteriology (2001)
8. Birge-Modern Microbiology
9. Schlegel HG. General Microbiology (2008)
10. Sneath, P.H.A., Mair, N.S., Elizabeth, M. – Bergey's Manual of Systematic Bacteriology
11. Dubey RC and Maheswari DK. - A Text Book of Microbiology (2010)
12. Alcamo E. - Fundamentals of Microbiology (2001)

SEMESTER-I
MASTER OF SCIENCE (MICROBIOLOGY)
104MB24 - BIOLOGY OF EUKARYOTIC MICROBES

UNIT-I

Ultra structure of eukaryotic cell; Organelles of eukaryotic cell – Ultrastructure of Cell wall, Cell membrane, Nucleus, Chloroplast, Mitochondria, Endoplasmic reticulum, Ribosome, Golgi apparatus, Lysosomes.

UNIT-II

Phases of cell cycle, role of check points in monitoring and regulation of cell cycle, Kinenins. Cell division – different stages of mitosis and meiosis.

Cytoskeleton – definition, types and structure of cytoskeletal filaments, role of cytoskeleton in cell division.

UNIT-III

Algae – Distribution, General account, Thallus organization, nutrition, reproduction and classification of algae. Economic importance of algae – Algae as primary producers and commercial products. Algae as SCP. Algal blooms and toxins.

UNIT-IV

Fungi – General characters, Nutrition (parasitic, saprophytic & symbiotic), Reproduction, Parasexuality. Ainsworth's system of classification.

Importance of fungi in Agriculture and Industry. Importance of yeasts. Edible and poisonous mushrooms. Mycotoxins.

UNIT-V

Protozoa – General account, morphology, nutrition and locomotion. Brief account of – *Entamoeba*, *Trypanosoma*, *Leishmania*, *Trichomonas*, *Giardia*, *Balantidium* and *Pneumocystis*.

REFERENCE BOOKS:

- 1) Introductory Phycology - HD Kumar
- 2) Biology of Algae – Round
- 3) The Fungi - Alexopolus
- 4) Prescott *et al*- Microbiology
- 5) Barner R.D – Invertebrates Zoology

SEMESTER-2
MASTER OF SCIENCE (MICROBIOLOGY)
201MB24 - MICROBIAL PHYSIOLOGY AND METABOLISM

UNIT-I

Concept of thermodynamic principles, entropy, enthalpy, concept of free energy. Oxidation – reduction potential, ATP structure, free energy change in oxidation/reductions, different types of phosphorylations, solute uptake – passive and active transport, Phosphotransferase system, Iron uptake, group translocation; Regulation of bacterial metabolism.

UNIT-II

Photosynthesis – Oxygenic (cyanobacteria) and anoxygenic (Rhodospirillaceae, Chromatiaceae, Chlorobiaceae, Chloroflexaceae); Photosynthetic pigments, Bacteriorhodopsin, Photochemistry of photosystems; Photosynthetic Carbon Reduction (Calvin Cycle, RTCA, Hydroxy propionate pathway, reductive acetyl COA pathway).

UNIT-III

Chemolithotrophy: - Hydrogen (H₂), Carbon monoxide (Co), ammonia (NH₃), nitrite(NO₂⁻), sulphur (S⁰) and Iron (Fe²⁺) Oxidizing Bacteria; bioluminescence. Respiration – EMP, ED, HMP, Methyl glyoxylate. HMP pathways, TCA cycle, ETC in bacteria and mitochondria, ETC inhibitors. Anaplerotic sequences.

UNIT-IV

Anaerobic respiration (SO₄²⁻ and NO₃⁻). Fermentations – Mixed acid, propionate and Butyrate-Butanol fermentations. Syntrophy, anaerobic food chain, gluconeogenesis. Methanogenesis and its biological importance.

UNIT-V

Biosynthesis of amino acid. Catabolism of amino acids (deamination, decarboxylation and transamination). Protein degradation – exo and endo proteases. Fatty acid synthesis (saturated and unsaturated), Fatty acid degradation (saturated and unsaturated). Bacterial cell wall synthesis (+ve and –ve). Polyamine biosynthesis, Biochemistry of 'N₂' fixation.

SUGGESTED BOOKS:

- 1) Reddy and Reddy (2005). Microbial physiology.
- 2) Freeman, W.H.(2001). Biochemistry, by Stryer, 5th edition
- 3) Nelson and Cox.2000; Lehninger principles of Biochemistry
- 4) Moat, A.G and J.W. Foster (1999). Microbial physiology
- 5) Caldwell, D.R.1995. Microbial Physiology and Metabolism
- 6) David White.1995. The Physiology and Biochemistry of Prokaryotes
- 7) Gottschalk, G. Bacterial Metabolism
- 8) Hans G. Schlegel. General Microbiology
- 9) Lansing M. Prescott et al. 2005. Microbiology

SEMESTER-2
MASTER OF SCIENCE (MICROBIOLOGY)
202MB24 - MICROBIAL GENETICS AND MOLECULAR BIOLOGY

UNIT-I

Experimental evidences for establishing the nucleic acids as genetic material. Gene concept – classical concept, Modern concept (cistron, muton, recon, exon & intron); Different theories of gene concept. Plasmids – Definition, characteristics of plasmids, types of plasmids, properties of F plasmids, R plasmids, col plasmids, Ti plasmids and other plasmids; Replication of plasmids; Isolation of plasmids; Significance of plasmids. Mutations – spontaneous mutations versus induced mutations; somatic & germinal mutations; Types of mutations – morphological, conditional, nutritional, forward, backward, suppressor, point and frame shift mutations; Radiation induced mutations – ionizing and non-ionizing radiation. Chemical mutagens – Base analogues, nitrous acid, acridines, alkylating and hydroxylating agents. Screening and isolation of mutants.

UNIT-II

Genetic recombination in Bacteria – Transformation, Conjugation, Transduction (Generalized and Specialized); Gene mapping in bacteria; Gene transfer techniques – Electroporation, Microinjection, Biolistics and chemical methods. Applications of bacterial genetic recombination. Phage Genetics – Lytic phage – Genome organization of phage T4, genetic recombination; gene mapping and gene expression in T4 life cycle. Lysogenic phage – λ -phage genome organization; gene mapping; genetics of lysogenic life cycle; recombination.

UNIT-III

Replication of DNA – Semi-conservative replication, enzymology of replication, continuous and discontinuous DNA synthesis. Unidirectional replication, bi-directional replication, rolling circle replication.

DNA damage and repair - Types of DNA damage- deamination, alkylation, pyrimidine dimers; Repair mechanisms – Photoreactivation, base excision repair, nucleotide excision repair, post replication and recombination repair, methyl-directed mismatch repair and SOS repair.

Gene expression – Central dogma of gene action; Transcription – structural components of RNA polymerases, initiation, elongation and termination of transcription; post transcriptional processing and RNA splicing in eukaryotes; Translation – components involved (mRNA, ribosomes, amino acyl-tRNAs), initiation, elongation and termination of translation; Post translational modifications of polypeptide.

UNIT-IV

Regulation of Gene expression in bacteria – Operon concept, Inducible and repressible operons, Positive and negative regulations, Inducer molecules, Repressor molecules, Co-Repressor molecules. Induction and catabolite repression of lac operon in *E. coli*. Repression and attenuation of trp operon in *E. coli*. Positive and negative controls in ara operon in *E. coli*. Genetics of nitrogen fixation – nif genes, regulation of nif genes (local control and global control mechanisms); nod genes and their regulation.

UNIT - V

Transposable elements in bacteria - IS elements, Composite transposons, Tn3 transposons. Transposable elements in eukaryotes - Ac and Ds elements in maize, Ty elements in yeast, transposons in *Drosophila*, Human retrotransposons. Mechanisms of transposition – Conservative and replicative modes. Genome rearrangements – mating type switching in yeast; diversity in Ig molecules. Regulation of genome activity during sporulation by special σ subunits.

REFERENCE BOOKS

- 1) Gene VII – Benjamin lewin (2000)
- 2) Principles of genetics – Gardener, E.J., Simmons, M.J., Snustad,D.P. (1991)
- 3) Genetics – Peter J Russell (1998)
- 4) Microbial Genetics – David Freifelder (1990)
- 5) Molecular Biology – David Freifelder (2001)
- 6) Molecular genetics of bacteria – Dale JW
- 7) Principles of genetics – Tamarin RH (1999)
- 8) An introduction to Genetic analysis - Suzuki,D.T et al.
- 9) Molecular Cell Biology - Darnell, J., Lodish, H. Baltimore, D. (1986)
- 10) Cell and Molecular Biology - Karp,G. (1986)
- 11) Molecular Genetics of Bacteria - Dale,J.W.
- 12) Principles of Genetics - Snustad, D.P., Simmons, M.J., Jenkins, J.B. (1997).

SEMESTER-2
MASTER OF SCIENCE (MICROBIOLOGY)
203MB24 - IMMUNOLOGY

UNIT - I

History of immunology. Structure, composition and functions of cells and organs involved in immune system- B-cells, T-cells, phagocytes, auxilliary cells, soluble mediators. Lymphokines and Cytokines, functions of important Interleukins; Lymphoid organs- primary (Thymus and bone marrow), secondary (spleen and lymph node); Types of immunity - Innate and acquired immunity; Humoral and cell mediated immunity; primary and secondary immune response.

UNIT - II

Antigens- nature and properties; haptens and toxoids. Immunoglobulins- structure, heterogenicity, types, sub-types; antibody production- hybridoma technique, catalytic enzymes. Complement system- structure, components, pathways and biological sequences of complement activation. Antigen- antibody reactions- agglutination, precipitation, complement fixation, Immuno fluorescence microscopy, ELISA, RIA.

UNIT – III

Hypersensitivity reactions- antibody mediated- Anaphylaxis; antibody dependent cell toxicity; immune complex mediated reactions; cell mediated hypersensitivity reactions. Brief account on the respective diseases.

UNIT – IV

Structure and functions of MHC. Transplantation immunology- concept, tissue typing methods, role of HLA, survival of allograft, graft versus host reaction. Autoimmunity- general account of autoimmune diseases; mechanism and therapy of Rheumatoid arthritis. Tumor immunology- Tumor diagnosis by onco fetal antigens, effector mechanisms in tumor immunology.

UNIT –V

Immune response to infectious diseases: viral infections, bacterial infections, protozoan diseases. Vaccines – Designing vaccines for active immunization, whole organism vaccines, purified macromolecules as vaccines, recombinant vector vaccines, DNA vaccines, Synthetic peptide vaccines and multivalent subunit vaccines..

REFERENCE BOOKS:

- 1) Roitt, i.m. (1998). Essentials of Immunology. ELBS, Blackwell Scientific Publishers, London.
- 2) Kuby's Immunology. IV Edition. Freeman and Company, New York.
- 3) Klaus d elgert (1996) immunology- Understanding of immune system. Wiley- Liss. ny.
- 4) Topleyand Williams (1995). Text book on Principles of Bacteriology, Virology and immunology, Edward Arnold, London.

SEMESTER-2

MASTER OF SCIENCE (MICROBIOLOGY) 204MB24 - AGRICULTURAL MICROBIOLOGY

UNIT-I

Rhizosphere – Microbial flora of rhizosphere soil, rhizosphere effect; root exudates; soil fungistasis. Techniques - soil plate, contact slide method, Fluorescence microscopy. Plant growth promoting rhizobacteria, Siderophores. Phyllosphere microflora and their significance.

UNIT-II

Biofertilizers - Mycorrhiza – Ecto mycorrhizas and Arbuscular mycorrhiza, *Azotobacter* and *Azospirillum*. N - fixing cyanobacteria; Legume-Rhizobium association – Nitrogenase, Rhizobia complex, cross-inoculation groups; Development, structure and functions of legume root nodules. Phosphate solubilizing microorganisms and their use.

UNIT-III

Concept of disease in plants; Symptoms caused by plant pathogenic fungi, bacteria and viruses. Symptomology, etiology, epidemiology and control of following plant diseases: Late blight of potato, powdery mildew of cucurbits, black stem rust of wheat, grain smut of sorghum, tikka disease of groundnut, blast disease of rice, angular leaf spot of cotton and tobacco mosaic disease.

UNIT-IV

General principles of plant disease control – Plant quarantine, seed treatment, cultural practices, chemical control, development of disease resistance varieties; Biological control of plant diseases. Biopesticides – *Bacillus thuringiensis*, NPV and CPV.

UNIT – V

Biostatistics - Basic principles; Measures of Central tendency – Mean, Median, Mode; Standard deviation and Standard Error; Simple hypothesis tests – Students 't'- test , 'F'- test and Chi-square test. Analysis of variance – one-way ANOVA and two-way ANOVA, Correlation and Linear Regression. Experimental designs – Randomized Block Design (RBD) and Completely Randomized Design (CRD).

REFERENCE BOOKS:

- 1) Subbarao, N.S. 2000. Soil Microbiology 4thEdn.
- 2) Subbarao, N.S. 1995 Biofertilizers in Agriculture and Forestry
- 3) Tilak, K.V.B.R. 1991. Bacterial biofertilizers, ICAR publications
- 4) Atlas, R.M. and Bartha, R. 1998. Microbial ecology: Fundamentals and Applications, Addison Wesley Longman Publications
- 5) Lynch and Poole, 1983 Microbial ecology, ELBS Publications
- 6) Singh, R.S. 1990 Plant diseases 6thEdn. Oxford & IBH publications
- 7) Rangaswami, G. and Mahadevan, A. 1999. Diseases of crop plants in India. Prentice Hall of India publications, New Delhi
- 8) Rangaswami, G. and Bagyaraja, D.J. 2001. Agricultural Microbiology, 2ndEdn., Prentice Hall of India, New Delhi.
- 9) Mehrotra, R.S. 1980. Plant Pathology, Tata
- 10) Schaum's Outline Statistics by Murray.R, Spiegel, Larry.J. Stephens, 4th edition, McGraw Hill Companies.
- 11) Zar, J. - Bio-statistical Analysis, Prentice Hall of India.
- 12) An introduction to Bio-Statistics by N.Gurumani. 2009 – MJP Publications.
- 13) Daniel, 2006, Biostatistics, Eighth Edition. John Wisley and sons.

SEMESTER-3
MASTER OF SCIENCE (MICROBIOLOGY)
301MB24 - MEDICAL MICROBIOLOGY

UNIT-I

Important developments in Medical Microbiology. Normal microbial flora of human body. Nosocomial infections and their control. Epidemiology – Types of epidemics, disease reservoirs, methods of transmission and control of epidemics.

UNIT-II

Detailed study of the pathogen, pathogenesis, symptoms, epidemiology, diagnosis and control of the diseases caused by the following bacteria: *Staphylococcus aureus*, *Streptococcus pneumoniae*, *Neisseria meningitidis*, *Corynebacterium diphtheriae*, *Clostridium tetani*, *Salmonella typhi*, *Vibrio cholerae*, *Treponema pallidum* and *Mycobacterium tuberculosis*.

UNIT - III

Detailed study of the pathogen, pathogenesis, symptoms, epidemiology, diagnosis and control of the following fungal infections. Dermatomyces – tineas; Systemic mycoses – Histoplasmosis and Cryptococcosis; Opportunistic mycoses – Candidiasis and Aspergillosis.

UNIT-IV

Detailed study of the following viral diseases – Poliomyelitis, Influenza, Rabies, Hepatitis, AIDS. Brief note on oncogenic viruses.

UNIT-V

Chemotherapy: Properties of chemotherapeutic drugs, chemical nature, clinical use and mode of action of the following drugs. Antibacterial drugs: Sulpha drugs, Penicillins, Cephalosporins, Streptomycin, Tetracyclines, Chloramphenicol, Rifamycin, Polymyxin. Antifungal drugs: Imidazoles, Flucytosine, Nystatin, Amphotericin-B. Antiviral drugs: Amantadine, Azidothymidine, Acyclovir.

REFERENCE BOOKS:

- 1) Ananthanarayana, R. and Panicker, C.K.J. 2000. Text book of Microbiology, Oriental Longman publications
- 2) Jawetz *et al.* 1998. Medical Microbiology 21st Edn. Prentice Hall International Inc.
- 3) White, D.O. and Fenner, F. 1994 Medical Virology, Academic Press, London
- 4) Bailey and Scott 1998 Diagnostic Microbiology (10th Edn.) Published by Mosby.
- 5) Madigan *et al.* 1997. Brock's Biology of Microorganisms 8th Edn. Prentice Hall International Inc.
- 6) Prescott *et al.* 2005. Microbiology 3rd edition.

SEMESTER-3
MASTER OF SCIENCE (MICROBIOLOGY)
302MB24 - RECOMBINANT DNA TECHNOLOGY

UNIT-I

Introduction and importance of recombinant DNA technology. Tools in DNA technology: Enzymes: restriction endonucleases, DNA and RNA polymerases, DNA ligases, S1 nuclease, polynucleotide kinase, alkaline phosphatases, Oligonucleotides – linkers, adaptors and homopolymer tails. Characteristics of different types of Vectors – plasmids (pBR322, phagemids, cosmids), Yeast artificial chromosomes, Ti plasmid derivatives, caulimoviruses, constructs of SV40.

UNIT-II

DNA sequencing: Chemical and enzymatic methods. Automated sequencing. Genome sequencing and physical mapping of genomes.

Molecular diagnostics: Preparation of DNA and RNA probes and their application, nucleic acid hybridization, factors influencing hybridization and Microarrays.

UNIT - III

PCR - Principles, factors affecting PCR, different types of PCR and their applications. Site-directed mutagenesis– Definition, types – PCR based site-directed mutagenesis, Random mutagenesis and its applications. Blotting techniques: Southern, Northern and Western blotting techniques.

UNIT-IV

Cloning strategies: Generation of DNA fragments, and construction of cloned gene into the vector. Methods of transformation of rDNA into host. Screening and identification of recombinants (antibiotic, nucleic acid and protein based methods). Construction of DNA libraries - genomic and cDNA libraries. Strategies for over expression of cloned genes in prokaryotic expression systems - *E. coli* expression, Yeast expression systems. Strategies for over expression of cloned genes in Eukaryotic expression systems- Baculovirus and mammalian expression systems.

UNIT-V

Production of human growth hormone and insulin using recombinant microorganisms.

Development of transgenic plants with desired traits – herbicidal, pest and stress resistance and for various economically important plant products – Transgenic plants as bioreactors. Problems associated with expression of foreign DNA in plant cells. Development of transgenic animals with desired traits – construction of expression vectors, transfer of cloned genes, production and use of transgenic animals – mice, cow, sheep, & goat. Problems associated with expression of foreign DNA in animal cells.

REFERENCE BOOKS

- 1) Old and primrose. 1994. Principles of Gene Manipulation: An introduction to genetic engineering. 5th ed. Blackwell Scientific publ.
- 2) Glick and Pasternak 1994, Molecular Biotechnology, panama publ.
- 3) Watson et al 1992 Recombinant DNA. Freeman & co
- 4) Walker and Rapley 2002. Molecular biology and Biotechnology 4th ed. Panima publ
- 5) Ratledge & Kristinsen 2001 Basic Biotechnology, University press
- 6) Higgins and Hames (eds) Protein expression : A practical approach., Oxford University press
- 7) Hunt & Liveey (eds) 2000 Functional Genomics, Oxford University press
- 8) Krenzer & Massey – Recombinant DNA and Biotechnology : A guide for teachers
2nd ed. ASM press.
- 9) Brown, t.a. (2001). *Gene cloning and DNA Analysis*. 4th Edition. Blackwell Publishers
- 10) Gene biotechnology – S.N. Jogdand.
- 11) Principles of Gene Manipulation - An Introduction to Genetic Engineering - R. W. Old and S. B. Primrose.

SEMESTER-3
MASTER OF SCIENCE (MICROBIOLOGY)
303MB24 - CELLULAR MICROBIOLOGY AND BIOINFORMATICS

UNIT-I

Bacterial adhesion to Host Cells: Basic principles of microbial adhesion – pre adhesion events, molecular mechanisms of adhesion, bacterial adhesins. Consequences of bacterial adhesion.

Bacterial Invasion – Routes of invasion (phagocytosis, induced endocytosis, active invasion).

Intracellular niches for pathogens (intralysosomes, isolated vacuoles, cytosol). Mechanisms of bacterial invasion (Zipper mechanism and trigger mechanism); Consequences of invasion.

Intracellular motility and intercellular spread of pathogenic bacteria.

UNIT-II

Types of Secretion systems in Animal and plant-interacting bacteria. Bacterial toxins – Toxins acting on cell surface (super antigens, toxins cleaving cell surface molecules, pore forming toxins). Soluble toxins with an Intracellular target (toxins acting on protein synthesis and G-Proteins; cAMP generating toxin). Toxins directly delivered by bacteria into eukaryotic cell cytoplasm (EPEC Tir; *P.aeruginosa* exoenzyme S; *C.botulinum* exoenzyme 3). Biological effects of toxin action (cell death, nerve transmission, interactions with cytokines, signal transduction).

UNIT-III

Basic characteristics of cell signalling systems. Extracellular first messengers in signalling. Intracellular second messengers (cAMP, IP3, DAG, Calcium ions) in signalling. Eukaryotic cell-to-cell signalling – GPC receptor, RTK receptor, endocrine hormone signaling, cytokine signaling.

UNIT-IV

Prokaryotic cell-to-cell signalling (quorum sensing and bacterial pheromones, signals controlling conjugation in *Enterococcus faecalis*, signals controlling sporulation in *Myxococcus xanthus*).

Intracellular signalling mechanisms in prokaryotes.

Apoptosis – triggering of apoptosis, effector molecules of apoptosis, induction of apoptosis by microbes, activation of host cell receptors that signal apoptosis.

UNIT-V

Bioinformatics – introduction, scope and applications. Data bases – CBI Genebank, PDB, OMIM, EMBL. Literature Data Bases- Pub Med, Agricola, Med line. Types of Biological data bases; Sequence databases, Structural databases, Protein secondary structure prediction. Tools for sequence alignment – BLAST, FASTA. Visualization of protein structures using Rasmol or SPDB Viewer. Proteomics: Basics of proteomics; proteome analysis – two dimensional separation of total cellular proteins, isolation and sequence analysis of individual protein spots by mass spectroscopy. Applications of proteomics.

REFERENCE BOOKS:

- 1) Cellular Microbiology – Henderson et. al. (1999).
- 2) Cellular Microbiology – Cossart et. al. (2000).
- 3) Genomes – T.A. Brown (2002).
- 4) Principles of Genetics – Snustad et. al. (1997).
- 5) Genes VII – Lewin (2000).
- 6) Bioinformatics: Methods and Applications (Genomics, Proteomics and Drug Discovery) - S.C. Rastogi et al., Kindle Edition.
- 7) Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins - Edited by Andreas D. Baxevanis and B.F. Francis Ouellette (1998, ISBN-13: 978-0471383918)
- 8) Biological sequence analysis - Durbin, Eddy, Krogh, Mithison.
- 9) Introduction of Bioinformatics - T.A. Attwood - D.J. parry – smith (2001).
- 10) Bioinformatics a Practical Approach - K. Mani & N. Vijayaraj, Aparna Publications, Coimbatore.
- 11) Proteomics – Pennington, S.R. and Dunn M.J. (2002)

SEMESTER-3

MASTER OF SCIENCE (MICROBIOLOGY) 304MB24 - FERMENTATION TECHNOLOGY

UNIT-I

Introduction to fermentation processes: The range of fermentation processes, chronological development of fermentation industry, component parts of fermentation process. Primary and secondary metabolites. Screening of commercially valuable microorganisms: Primary and secondary screening procedures.

UNIT-II

Strain improvement of industrially important microorganisms: Conventional and modern genetic engineering approaches. Preservation of commercially useful microbial cultures: Storage at reduced temperatures, storage in dehydrated form. Design of culture media for industrial fermentations: Sources of energy, carbon and nitrogen, minerals, growth factors, buffers, addition of precursors and metabolic growth regulators, oxygen requirements, antifoams.

UNIT-3

Fermentors: Basic functions, body construction, aeration and agitation systems, maintenance of aseptic conditions, valves and steam traps, types of fermentors. Fermentation processes: Batch, fed-batch, semi-continuous and continuous fermentation systems, dual and multiple fermentations.

UNIT-IV

Recovery and purification of fermentation products (Downstream process): Separation of microbial cells from liquid fraction (filtration, centrifugation, and flocculation), cell disruption, solvent extraction, chromatography, membrane processes, drying of the product.

Solid-state fermentations: Characteristics, microbial growth, production of enzymes and other metabolites, processes: Criteria used for scale-up, physical, chemical and process factors.

UNIT -V

Microbial production of commercially important metabolites. Treatment of industrial effluents: Physical, chemical and biological (aerobic and anaerobic) treatments, disposal of effluents. Economics of the fermentation process.

REFERENCES BOOKS:

- 1) Biotechnology- A text book of Industrial Microbiology. W.Crueger and A.Cruegar, 2000.
- 2) Manual of Industrial Microbiology and Biotechnology, Biochemistry and Technology. Joshi and Pandey (Eds.), 2 vols. 1999.
- 3) Principles of fermentation technology. P.F.Stanbury, A.Whitaker and S.J.Hall, 1997.
- 4) Molecular Biotechnology. B.R.Glick and J.J.Paternak, 1996.
- 5) Concepts in Biotechnology. D.Balasubramanian, C.F.A.Bryce, K.Dharmalingam, J.Green, Kunthala Jayaraman, 1996.
- 6) Microbial Biotechnology. A.N.Glazer and H.Nikaido, 1995.
- 7) Comprehensive Biotechnology-The principles, applications and regulations of Biotechnology in Industry, agriculture and Medicine. Murray Moo-Young (Editor-in-Chief), 1989.
- 8) A Revolution in Biotechnology. J.L. Marx (Ed.), 1989.
- 9) Biotechnology- A comprehensive treatise in 8 vols. H.J.Rehm and G.Reed (Eds.), 1985.
- 10) Microbial Technology. H.J.Peppler and D.Perlman 1980.

SEMESTER-4
MASTER OF SCIENCE (MICROBIOLOGY)
401MB24 - ENVIRONMENTAL MICROBIOLOGY

UNIT-I

Aerial environment; kinds of micropropagules in air; adaptations of airspora to aerial environs. Seasonal and diurnal periodicities of airspora; importance of aerobiological studies. Methods of detecting the micropropagules in extramural and intramural environs- air sampling techniques. General account on aeroallergens and allergic reactions.

UNIT-II

Aquatic environment, microorganisms in water bodies- phytoplankton populations and importance. Sampling of water samples, detection and enumeration of microorganisms in water, coliform test for water quality. Treatment of waters for drinking purpose. BOD determination. Sewage water treatment.

UNIT-3

Soil environment: components of soil, diversity and abundance of dominant soil microorganisms, methods of isolation and estimation of soil microflora. Soil organic matter- nature, synthesis and decomposition. Beneficial and antagonistic interaction among soil microorganisms.

UNIT-IV

Transformation of carbon, sulphur, phosphorus and iron (nature of microorganisms, mechanism and importance) in soil. Organisms, mechanisms and ecological significance of transformations of nitrogenous compounds in soil – Dinitrogen fixation, ammonification, nitrification and denitrification.

UNIT-V

Bioremediation of polluted soils: Microbial degradation of xenobiotics – recalcitrance of pesticides in soil, microbial degradation of pesticides. Microbial degradation of petroleum products (hydrocarbons) in oil spills. Bioleaching of minerals- factors affecting leaching, microbial leaching processes of copper, uranium and gold. Bioenergy – role of microorganisms in production of biogas, hydrogen and bioethanol.

REFERENCE BOOKS:

- | | |
|--------------------------|---|
| 1) RAPHL MITCHELL | - Environmental Microbiology (1978) |
| 2) LYNCH & POOLE | - Microbial Ecology : A conceptual approach (1979) |
| 3) PAUL & CLARK | - Soil Microbiology & Biochemistry (1989) |
| 4) GREGORY | - The Microbiology of atmosphere (1973) |
| 5) RHEINHEIMER | - Aquatic Microbiology (1974) |
| 6) TILAK | - Aerobiology (1997) |
| 7) SUBBA RAO | - Soil Microorganisms and Plant Growth (1995) |
| 8) SUBBA RAO | - Soil Microbiology (1999) |
| 9) SUBBA RAO | - Biofertilizers in Agriculture and Forestry (1995) |
| 10) ATLAS & BARTHA | - Microbial Ecology (1997) |
| 11) MAIER, PEPER & GERBA | - Environmental Microbiology (2000) |
| 12) COYNE | - Soil Microbiology (2000) |
| 13) RATLEDGE C | - Biochemistry of Microbial degradation |

SEMESTER-4
MASTER OF SCIENCE (MICROBIOLOGY)
401MB24 - FOOD MICROBIOLOGY

UNIT-I

Introduction to Food Microbiology. Microorganisms associated with foods and sources of microbial contamination of foods. Factors affecting microbial activity in foods – intrinsic factors (Nutrient content, pH, Redox potential, Water activity) and extrinsic factors (Relative humidity, Temperature, Gaseous atmosphere). Methods for microbial examination of foods – enumeration methods, alternative methods and rapid methods.

UNIT-II

Food spoilage – causes of food spoilage, microbial spoilage of vegetables, fruits, cereals & cereal products, fresh and processed meats, poultry & eggs, fish & shellfish, beverages (beer and wine) and canned foods.

Food preservation methods – low temperature, high temperature, drying, radiation and chemical preservation (salting, benzoic acid, sorbic acid, sulphur dioxide, sulphates, nitrites, nitrates, acetic acid, antibiotics).

UNIT-III

Dairy microbiology – Microorganisms in milk (normal flora & biochemical types of bacteria), sources of contamination of milk, causes of milk spoilage, enumeration of microorganisms in milk samples, fermented milk products (natural butter milk, cultured butter milk, acidophilus milk, bulgarian butter milk, kumiss, kefir, yoghurt), types and production of Cheddar cheese.

UNIT-IV

Fermented foods – Fermented vegetables (Sauerkraut); Alcoholic beverages (beer, wine); Non-alcoholic beverages (tea, coffee); Fermented meat products; Bread making.

Introduction to Probiotics.

GM foods and biosafety.

UNIT-V

Food poisoning and food-borne infections – botulism, gastroenteritis of *Staphylococcus* and *Clostridium perfringens*, Salmonellosis, Shigellosis, Listeriosis, Vibriosis, Yersiniosis, paralytic shellfish poisoning. Preventive measures – Good manufacturing practices, health hazard critical control point analysis. Food control Agencies and Acts. International commission on the microbiological specifications for foods.

REFERENCE BOOKS

- 1) Food Microbiology - **Frazier WC and Westhoff Dc (2003)**
- 2) Food Microbiology - **Adams, MR and Moss, MO (2015)**
- 3) Modern Food Microbiology - **James M. Jay (1996)**
- 4) Basic Food Microbiology - **George J. Banwart (1989)**
- 5) Food Processing and preservation - **Sivasankar, B (2002)**
- 6) Essentials of food Microbiology - **John Garbutt (1997)**
- 7) Outlines of Dairy Technology - **Sukumar De (1997)**
- 8) Dairy Microbiology - **Robinson RK (1990)**

SEMESTER-4
MASTER OF SCIENCE (MICROBIOLOGY)
403MB24 - : INDUSTRIAL MICROBIOLOGY

UNIT-I

Introduction to Industrial Microbiology: Definition, scope, microorganisms, properties and industrial products. Production of antibiotics by fermentation: Microbial groups producing antibiotics. Production, biosynthesis and regulation, strain development, production medium, fermentation, recovery of Penicillin, semi-synthetic penicillins, Tetracyclines and Streptomycin: Production of organic feed stocks by fermentation: Ethanol, Acetone/butanol fermentation.

UNIT-II

Fermentative production of Enzymes: Microbial enzymes for industrial use. Amylases: Microbial groups producing α -amylases, β -amylases, glucoamylases, pullulanases, strain development, medium formulation, Process conditions and recovery. Proteases: Microbial production of Alkaline, Neutral and Acid Proteases, Production methods. Industrial production of vitamins by microorganisms: vitamin B12 and Riboflavin-Structure, biosynthesis and production process. Production of Nucleosides and Nucleotides by fermentation: Structure, biosynthesis and production process.

UNIT-III

Production of Organic acids by fermentation: Microbial strains producing Organic acids. Microbial strains, biosynthesis and production process of Citric acid and Acetic acid. Production of Amino acids by fermentation: Microbial strains employed in Amino acid Production. Production strains, biosynthesis and production process of L-Glutamic acid and L-Lysine: Microbial polysaccharides: Nature, mechanism of synthesis, bacterial polysaccharides, fungal polysaccharides and yeast polysaccharides.

UNIT-IV

Microbial Transformations: Types of bioconversion reactions, procedures for biotransformation, application of Bioconversions, transformation of steroids and sterols, transformation of non-steroid compounds, transformation of antibiotics.

Industrial waste management: Types of waste (Solid, liquid, air, toxic, medical, radioactive) and their management. Bioremediation of various types of industrial waste. Concept of xenobiotics and their management.

UNIT-V

Immobilization of cells and enzymes: Matrices for immobilization, Methods of immobilization, Immobilized cell fermentations versus conventional fermentations, applications of immobilized cells and enzymes.

Intellectual Property Rights: Copy right patent, Trademark, Trade secrets, Utility model, procedure for patent filing, Geographical indication, Industrial design rights.

Bio safety - Concept of Biosafety regulation in development and handling of recombinant microbial products

REFERENCE BOOKS

- 1) Biotechnology-A text book of Industrial Microbiology. W. Crueger and A.Cruegar, 2000.
- 2) Manual of Industrial Microbiology and Biotechnology. A.L.Demain and J.W.Davies (Eds), 1999.
- 3) Biotechnology:Food fermentation-Microbiology, Biochemistry and Technolgy. Joshi and Pandey (Eds.), 2 vols.1999.
- 4) Molecular Biotechnology. B.R. Glick and J.J.Paternak, 1996.
- 5) Concepts in Biotechnology. D.Balasubramanian, C.F.A.Bryce,
- 6) K.Dharmalingam, J.Green, Kunthala Jayaraman, 1996.
- 7) Microbial Biotechnology. A.N.Glazer and H.Nikaido, 1995.
- 8) Comprehensive Biotechnology-The principles, applications and regulations of Biotechnology in Industry, agriculture and Medicine. Murray Moo-Young (Editor-in-Chief), 1989.
- 9) A Revolution in Biotechnology. J.L.Marx (Ed.), 1989.
- 10) Biotechnology-A comprehensive treatise in 8 vols. H.J.Rehm and G.Reed (Eds.), 1985.
- 11) Microbial Technology. H.J.Peppler

SEMESTER-4
MASTER OF SCIENCE (MICROBIOLOGY)
404MB24 - BIOFERTILIZER TECHNOLOGY

UNIT-I

Introduction: importance & scope of biofertilizers in agriculture & organic farming.

History of biofertilizer production; classification of biofertilizers, Factors influencing efficacy of biofertilizers. Advantage of biofertilizers over chemical fertilizers. Types of biofertilizers, qualitative screening of phosphate solubilization, ammonia and IAA production; mechanism of action of phosphate solubilization, ammonia and IAA production. Benefits of biofertilizers. Buying and storage methods of biofertilizers. Cautions and limitations of biofertilizers. Carrier material: Different types of carrier materials, properties of carrier, sterilization methods of carrier, advantages and disadvantages of carrier material.

UNIT-II

Rhizobium – Morphology, molecular identification, collection and preservation of root nodules, isolation technology of different strains, screening of N₂ fixation. Bioprocessing (carrier based and liquid inoculants), Field application methods.

Case study: Inoculation and fertilization methods of *Rhizobium* inoculants for Soy bean in Japan.

Azospirillum - Morphology, molecular identification, collection and isolation technology of endophytic bacteria, associate bacteria from rice fields. Screening of ammonia production. Bioprocessing (mass inoculum and liquid inoculants), Field application methods.

Case study: Inoculation and fertilization methods of *Azospirillum* inoculants for corn in Indonesia.

UNIT-III

Mycorrhiza - Morphology, collection, identification and isolation technology of Vesicular- arbuscular mycorrhiza from roots and spores. Bioprocessing (Trap culture and peat culture), preservation, field application methods.

Phosphate solubilizers - Morphology, collection, identification and isolation of inorganic phosphate and organic phosphate solubilizers from soil. Bioprocessing (carrier based and liquid inoculants), preservation, field application methods.

Case study: Improvement of soil condition with phosphate solubilizers on fifty years long term experiments in rice in Korea.

UNIT-IV

Vermicompost - Importance of vermicompost, economic importance of earthworms in maintenance of soil structure. Useful species of earthworms (Local species of earthworms. Exotic species of earthworms). Limit factors (gases, diet, humidity, temperature, PH, light, and climatic factors). Physico-chemical parameters of vermicompost. Different Methods of vermicomposting (Small- and large-scale Bed method, Pit method Small Scale Earthworm farming for home gardens). Nutritional composition of vermicompost for plants, comparison with other fertilizers.

UNIT-V

General concept of Quality control: Microbial function and shelf life of recommended biofertilizers, Properties of microbial products and Quality management.

Quality control procedures- mother culture test, broth culture test, peat culture.

Quality control of laboratory; preparation room, growth room and storage room.

Inoculation on media, count of colony forming units. Quality text for certifications and prospects.

REFERENCE BOOKS:

- 1) The Complete Technology Book on Biofertilizer and Organic Farming (2nd Revised Edition) – 2012 by NIIR Board
- 2) Microbes as Bio-fertilizers and their Production 2015-By S.G.Borkar
- 3) Hand Book Of Microbial biofertilizer 2006 - edited by M.K. Roy

Duration of the Programme:

Minimum: Two Academic Years from the year of joining of the course (Four Semesters).

Maximum: Five Academic Years from year of joining of the course for securing First Class or Second Class.

INSTRUCTIONAL DESIGN :

Instructional delivery mechanism: University has its own faculty for M.Sc. Microbiology department and all the faculty members will act as resource persons. Our University has blended mode delivery mechanism i.e., ICT and Conventional modes.

Media of delivery mechanisms:

- **Printing:** The study material delivery media include Printing of books which are issued to the students who are enrolled for the programme.

- **Online:** On line PDF format content is also given access to the students who wish to study through online mode.

- **Interactive sessions, and Discussion boards:** In distance Education, face to face contact between the learners and their tutors is relatively less and therefore interactive sessions are conducted. The purpose of such interactive session is to answer some of the questions and clarify doubts that may not be possible in other means of communication. This programme provides an opportunity to meet other fellow students. The Counsellors at the study centres are expected to provide guidance to the students. The interactive sessions are conducted during week ends and vacations to enable the working students to attend.

- **Student support services:** Student support services include Internet enabled student support services like e-mails, SMS and even an app is planned. Student feed back mechanism is created and feed back is designed. Student Learning Management System (LMS) is customized to every student. For every student customized examination management system (EMS) is also created facilitating self evaluation, demo tests, model question papers and periodical Internal Assessments.

- **Credit System:** University has adopted Choice Based Credit System (CBSE) under semester mode from 2013. The same has been approved by relevant Statutory boards in Distance mode also.

- **Admission procedure:** In M.Sc. (Microbiology) programme candidates can take admission directly. For this purpose, CDE, ANU will advertise for admissions. Then candidates should apply in prescribed format of the CDE after publication of the advertisement.

- **Eligibility Criteria:** The eligibility for admission into this course is candidates who have passed with Microbiology or Botany as one of the subjects are eligible for admission. In addition to the above, the candidates who have passed B.Sc. with Zoology / Bio-Chemistry / Agriculture / aquaculture / Pharmacy / Medical Lab Technology / Biotechnology / Veterinary Science as one of the subjects are also eligible for admission.

- **Fee Structure:** The total course fee is Rs. 30,400/-.

- **Policy of programme delivery:** Our University has blended mode delivery mechanism i.e., ICT and Conventional modes. In conventional mode printed material is given and also online mode of delivery with learning management system is adopted.

- **Activity planner:** There is an yearly academic plan and as per plan interactive sessions, assignments, examinations etc are conducted to the candidates.
- **Evaluation System:** Periodical progress of learning is evaluated by web based feed back mechanism in the Learning Management System. Evaluation of learner progress is conducted as follows:
 - (i) The examination has two components i.e., continuous evaluation by way of assignments (30 %) and term end University Examination (70 %).
 - (ii) Each student has to complete and submit assignment in each of the theory paper before appearing to the term end examination. The term end examination shall be of 3 hours duration.
 - (iii) Minimum qualifying marks in each paper is 40 % individually in internal and term end examination. The candidates who get 60 % and above will be declared as passin First Division, 50 % to below 60 % as Second Division and 40 % to below 50 % as Third Division.
 - (iv) The Centre for Distance Education, Acharya Nagarjuna University will conduct the examinations, evaluations and issue certificates to the successful candidates.
 - (v) All the term end examinations will be conducted at the examination centres fixed by the CDE.
 - (vi) Qualitatively the examinations conducted for the students of the Distance Education are on par with the examinations conducted for the regular University students.

LIBRARY SUPPORT AND LIBRARY RESOURCES :

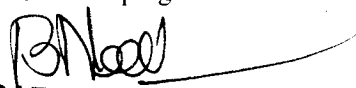
The M.Sc. (Microbiology) program is based on the theory and practical papers. Laboratory support is available to students. Further, entire University Library is accessible to all the students of distance education. Additionally every department in the University has a well equipped library which is accessible to all the students. CDE also provides a compendium of web resources to every student to support learning.

COST ESTIMATE :

The Programme fee for I year is Rs.14,300/-, and II year is Rs. 16,100/-. The university will pay the remuneration to Editors and lesson writers as per university norms. DTP charges, Printing of books and Examination fees will be paid by the ANUCDE as per prescribed norms. This institution is providing high quality programmes at low cost.

QUALITY ASSURANCE :

Quality assurance comprises the policies, procedures and mechanisms which that specified quality specifications and standards are maintained. These include continuous revision and monitoring activities to evaluate aspects such as suitability, efficiency, applicability and efficacy of all activities with a view to ensure continuous quality improvement and enhancement. The programme is designed with a focus on the proposed learning outcomes aimed at making the learner industry ready also for career advancement, enterprenureal development, and as wealth creators. There is a continuous evaluation of learning and of competence internally and also by ICT enabled feed back mechanism and Centre for Internal Quality Assurance (CIQA). The University ensures maintaining quality in education provided through open and diatance learning mode. As per the need of the information society and professional requirement, the University ensures to change the mechanism from time to time along with enhancement of standard in course curriculum and instructional design. Therefor, the outcomes of the programme can meet the challenges in the changing society.


DIRECTOR
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 Acharya Nagarjuna University
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