

B.Sc., MICROBIOLOGY

Syllabus

Program Code: UMB

2019- Onwards



MANNAR THIRUMALAI NAICKER COLLEGE

(AUTONOMOUS)

Re-accredited with “A” Grade by NAAC

PASUMALAI, MADURAI – 625 004

Eligibility for Admission

Candidates should have passed the Higher Secondary Examination conducted by the board of Higher Secondary Education, Government of Tamil Nadu or equivalent examination conducted by other states of India with Science as one of the subjects in Higher Secondary Education.

Duration of the Course

The students shall undergo the prescribed B.Sc (Microbiology) course of study for a period of three academic years (six semesters).

Subject of Study

Part I: Tamil

Part II: English

Part III:

1. Core Subjects
2. Allied Subjects
3. Electives

Part IV:

1. Non Major Electives
2. Skill Based Subjects
3. Environmental Studies
4. Value Education

PartV: Extension activities

The scheme of Examination

The components for continuous internal assessment are:

| | | |
|-----------------------------|----|----------------------------|
| Two tests and their average | -- | 15 marks |
| Seminar /Group discussion | -- | 05 marks |
| Assignment | -- | 05 marks |
| Total | -- | ----- 25 marks ----- |

Pattern of the question paper (Summative Examinations)

Note: Duration – 1 hour 30 minutes

(For Part I, Part II, Part III, NME & Skilled Paper in Part IV)

The question paper may have 3 parts.

Duration of the Summative Examinations is 3 hours

Part –A

Ten questions (answer all) 10 x 01 = 10 Marks
(Two questions from each unit)

Part –B

Five questions (either or choice) 05 x 07 = 35 Marks
(One question from each unit)

Part –C

Answer any three out of five 03 x 10 = 30 Marks
(One question from each unit) -----

Total 75 Marks

Question paper pattern

(For part IV – Environmental Studies and Value Education only)

Part –A

Five questions (either-or choice) 5 x 06 = 30 marks

Part –B

Answer any three out of five 3 x 15 = 45 marks

Total 75 marks

Note: No unit shall be omitted; not more than two question from each unit

Pattern of the Question paper (Internal)

Part –A

Six questions (answer all) 6 x 01 = 06 Marks

Part –B

Two questions (either or choice) 2 x 07 = 14 Marks

Part –C

Answer any one out of two 1 x 10 = 10 Marks

Total 30 Marks

**Pattern of the Question paper for Environmental Studies & Value Education only)
(Internal)**

Part –A

Four questions (either or choice) $4 \times 05 =$ 20 Marks

Part –B

One question (either or choice) $1 \times 10 =$ 10 Marks

Total

30 Marks

Minimum Marks for a Pass

40% of the aggregate (Internal + Summative Examinations).

No separate pass minimum for the Internal Examinations.

27 marks out of 75 is the pass minimum for the Summative Examinations.

MANNAR THIRUMALAI NAICKER COLLEGE (AUTONOMOUS)

B.Sc (Microbiology)

**Table: 1: Course pattern
(Those who joined during 2019 and after)**

| Study Component | I Sem | II Sem | III Sem | IV Sem | V Sem | VI Sem | Total Hours | Total Credit | No. of course | Total marks |
|---|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|---------------------|----------------------|--------------------|
| Part – I Tamil | 6(3) | 6(3) | 6(3) | 6(3) | | | 24 | 12 | 4 | 400 |
| Part –II English | 6(3) | 6(3) | 6(3) | 6(3) | | | 24 | 12 | 4 | 400 |
| Part –III | | | | | | | | | | |
| Core subjects | 5(5) | 5(5) | 5(5) | 5(5) | 5(5) 5(5) | 6(6) 6(6) | 88 | 77 | 19 | 1900 |
| Core Practical | 3(2) | 3(2) | 3(2) | 3(2) | 3(2) 3(2) | 4(3) | | | | |
| Core elective | | | | | 5(5) | 5(5) | | | | |
| In-plant training | | | | | 7(5) | | | | | |
| Project | | | | | | 7(5) | | | | |
| Allied Subject-I | 4(4) | 4(4) | | | | | 12 | 9 | 3 | 300 |
| Allied practical- I | 2(0) | 2(1) | | | | | | | | |
| Allied Subject-II | | | 4(4) | 4(4) | | | 12 | 9 | 3 | 300 |
| Allied practical – II | | | 2(0) | 2(1) | | | | | | |
| Part-IV | | | | | | | | | | |
| Skill Based Subjects | 2(2) | 2(2) | 2(2) | 2(2) | 2(2) | 2(2) | 12 | 12 | 6 | 600 |
| Environmental studies / Value Education | 2(2) | 2(2) | | | | | 04 | 4 | 2 | 200 |
| Non Major Elective | | | 2(2) | 2(2) | | | 04 | 4 | 2 | 200 |
| Part V | | | | | | | | | | |
| Extension Activities | | | | 0(1) | | | 00 | 1 | 1 | 100 |
| Total | 30 (21) | 30 (22) | 30 (21) | 30 (23) | 30 (26) | 30 (27) | 180 | 140 | 44 | 4400 |

| SEMESTER – I | | | | | | | |
|--------------|---|----------------|--------------|-----------|---------------|------------|------------|
| Subject code | Subjects | No. of Courses | Hours / week | Credits | Maximum Marks | | |
| | | | | | Int. | Ext | Total |
| 18UTAG11 | Part –I Tamil தற்கால கவிகையும் உரைநடையும் | 1 | 6 | 3 | 25 | 75 | 100 |
| 18UENG11 | Part –II English Subject English-I: Exploring Language Through Literature-I | 1 | 6 | 3 | 25 | 75 | 100 |
| 19UMBC11 | Part –III Core Subject Fundamentals of Microbiology | 1 | 5 | 4 | 25 | 75 | 100 |
| 19UMBCP1 | Fundamentals of Microbiology – Practical | 1 | 3 | 2 | 40 | 60 | 100 |
| 19UMBA11 | Part –III Allied Subject Biochemistry | 1 | 4 | 4 | 25 | 75 | 100 |
| 19UMBAP1 | Biochemistry and Cell Biology - Practical | -- | 2 | 0 | -- | -- | -- |
| 19UMBS11 | Part –IV Skill Subject Bio Instrumentation | 1 | 2 | 2 | 25 | 75 | 100 |
| 18UEVG11 | Part –IV Mandatory Subject Environmental Studies | 1 | 2 | 2 | 25 | 75 | 100 |
| | Total | 7 | 30 | 20 | 190 | 510 | 700 |

SEMESTER – II

| Subject code | Subjects | No. of Courses | Hours / week | Credits | Maximum Marks | | |
|--------------|---|----------------|--------------|-----------|---------------|------------|------------|
| | | | | | Int. | Ext | Total |
| 18UTAG21 | Part –I Tamil பக்தி இலக்கியமும் நாடகமும் | 1 | 6 | 3 | 25 | 75 | 100 |
| 18UENG21 | Part –II English Subject English-II: Exploring Language Through Literature-II | 1 | 6 | 3 | 25 | 75 | 100 |
| 19UMBC21 | Part –III Core Subject Microbial Physiology | 1 | 5 | 5 | 25 | 75 | 100 |
| 19UMBCP2 | Microbial Physiology - Practical | 1 | 3 | 2 | 40 | 60 | 100 |
| 19UMBA21 | Part –III Allied Subject Cell Biology | 1 | 4 | 4 | 25 | 75 | 100 |
| 19UMBAP1 | Biochemistry and Cell Biology - Practical | 1 | 2 | 1 | 40 | 60 | 100 |
| 19UMBS21 | Part –IV Skill based Subject Mushroom cultivation | 1 | 2 | 2 | 25 | 75 | 100 |
| 18UVLG21 | Part –IV Mandatory Subject Value Education | 1 | 2 | 2 | 25 | 75 | 100 |
| | Total | 8 | 30 | 22 | 230 | 570 | 800 |

| SEMESTER – III | | | | | | | |
|----------------|---|----------------|--------------|-----------|---------------|------------|------------|
| Subject code | Subjects | No. of Courses | Hours / week | Credits | Maximum Marks | | |
| | | | | | Int. | Ext | Total |
| 18UTAG31 | Part –I Tamil பக்தி இலக்கியமும் சிறுகதையும் | 1 | 6 | 3 | 25 | 75 | 100 |
| 18UENG31 | Part –II English Subject Exploring Language Through Literature –III | 1 | 6 | 3 | 25 | 75 | 100 |
| 19UMBC31 | Part –III Core Subject Microbial Genetics | 1 | 5 | 5 | 25 | 75 | 100 |
| 19UMBPC3 | Microbial Genetics– Practical | 1 | 3 | 2 | 40 | 60 | 100 |
| 19UMBA31 | Part –III Allied Subject Molecular Biology | 1 | 4 | 4 | 25 | 75 | 100 |
| 19UMBAP2 | Molecular Biology & Immunology - Practical | -- | 2 | 0 | -- | -- | -- |
| 19UMBS31 | Part –IV Skill Subject Vermitechnology | 1 | 2 | 2 | 25 | 75 | 100 |
| 19UMBN31 | Part –IV Non Major Elective Microbes in human welfare | 1 | 2 | 2 | 25 | 75 | 100 |
| | Total | 7 | 30 | 21 | 190 | 510 | 700 |

| SEMESTER – IV | | | | | | | |
|----------------------------|--|----------------|--------------|-----------|---------------|------------|------------|
| Subject code | Subjects | No. of Courses | Hours / week | Credits | Maximum Marks | | |
| | | | | | Int. | Ext | Total |
| 18UTAG41 | Part –I Tamil பழந்தமிழ் இலக்கியமும் புதினமும் | 1 | 6 | 3 | 25 | 75 | 100 |
| 18UENG41 | Part –II English Subject Exploring Language Through Literature –IV | 1 | 6 | 3 | 25 | 75 | 100 |
| 19UMBC41 | Part –III Core Subject Agriculture and Environmental Microbiology | 1 | 5 | 5 | 25 | 75 | 100 |
| 19UMBCP4 | Agriculture and Environmental Microbiology– Practical | 1 | 3 | 2 | 40 | 60 | 100 |
| 19UMBA41 | Part –III Allied Subject Immunology | 1 | 4 | 4 | 25 | 75 | 100 |
| 19UMBAP2 | Molecular Biology and Immunology - Practical | 1 | 2 | 1 | 40 | 60 | 100 |
| 19UMBS41 | Part –IV Skill Subject Bioinoculants technology | 1 | 2 | 2 | 25 | 75 | 100 |
| 19UMBN41 | Part –IV Non Major Elective Elemental concepts of Microbiology | 1 | 2 | 2 | 25 | 75 | 100 |
| 18UEAG40 to 18UEAG49 | Part – V Extension activities | 1 | 0 | 1 | 100 | -- | 100 |
| | Total | 9 | 30 | 23 | 330 | 570 | 900 |

| Course Code | Title of the Course | Hours | Credits | Maximum Marks | | |
|-----------------------|---|-----------|-----------|---------------|------------|------------|
| | | | | Int | Ext | Total |
| FIFTH SEMESTER | | | | | | |
| Part - III | Core Subjects | | | | | |
| 19UMBC51 | Basic Biotechnology | 5 | 5 | 25 | 75 | 100 |
| 19UMBC52 | Industrial Microbiology | 5 | 5 | 25 | 75 | 100 |
| Part -III | Core Practicals | | | | | |
| 19UMBCP5 | Biotechnology –Practical | 3 | 2 | 40 | 60 | 100 |
| 19UMBCP6 | Industrial Microbiology -Practical | 3 | 2 | 40 | 60 | 100 |
| Part III | Core Elective | | | | | |
| 19UMBE51 | Fundamentals of Algae and Fungi | 5 | 5 | 25 | 75 | 100 |
| 19UMBE52 | Fundamentals of Botany and Zoology | | | | | |
| 19UMBE53 | Plant and Animal Biotechnology | | | | | |
| 19UMBIP1 | In-Plant Training | 7 | 6 | 40 | 60 | 100 |
| Part IV | Skill Based Subject | | | | | |
| 19UMBS51 | Computer applications in biology | 2 | 2 | 25 | 75 | 100 |
| | Total | 30 | 27 | 220 | 480 | 700 |
| SIXTH SEMESTER | | | | | | |
| Part - III | Core Subjects | | | | | |
| 19UMBC61 | Medical Microbiology | 6 | 6 | 25 | 75 | 100 |
| 19UMBC62 | Virology | 6 | 6 | 25 | 75 | 100 |
| Part-III | Core Practicals | | | | | |
| 19UMBCP7 | Medical Microbiology and Virology - Practical | 4 | 3 | 40 | 60 | 100 |
| Part III | Core Elective | | | | | |
| 19UMBE61 | Biosafety and intellectual property rights | 5 | 5 | 25 | 75 | 100 |
| 19UMBE62 | Biostatistics | | | | | |
| 19UMBE63 | Diagnostic Microbiology | | | | | |
| Part-III | Project | | | | | |
| 19UMBPR1 | Project | 7 | 5 | 40 | 60 | 100 |
| Part IV | Skill Based Subject | | | | | |
| 19UMBS61 | Entrepreneurial Microbiology | 2 | 2 | 25 | 75 | 100 |
| | Total | 30 | 27 | 180 | 420 | 600 |

FIRST SEMESTER



MANNAR THIRUMALAI NAICKER COLLEGE (Autonomous)
DEPARTMENT OF MICROBIOLOGY
(For those who joined in 2019-2020 and after)

| | | | |
|---------------------|------------------------------|-----------------|---------------|
| Class | : B.Sc (Microbiology) | Part III | : Core |
| Semester | : I | Hours | : 05 |
| Subject Code | : 19UMBC11 | Credits | :04 |

FUNDAMENTALS OF MICROBIOLOGY

Course outcomes

On successful completion of the course, the learners should be able to

- CO1:** understand the fundamentals of microbial world.
- CO2:** acquire knowledge on historical perspective of microbiology.
- CO3:** explain the bacterial cellstructure and organization.
- CO4:** classify the types of media.
- CO5:** describe about the sterilization and pure culture techniques.

UNIT – I

Microbiology – Definition, History and scope of microbiology. Contributions of Leeuwenhoek, Louis Pasteur, Robert Koch, Edward Jenner, Paul Ehrlich and Alexander Fleming. Binomial nomenclature of Microbes. Classification of bacteria according to Bergey's manual of determinative bacteriology.

UNIT –II

Structure and Organization of bacterial Cell, Gram - positive and Gram - negative bacterial cell wall. Types of staining – Simple, Differential (Gram's, AFB), Special – Capsular staining (negative) and Spore staining.

UNIT-III

Culture media- definition - Types of media: Liquid, semisolid and solid with example, Natural, Synthetic, Semi synthetic, Complex, Selective, Differential, Indicator, Enriched, Enrichment, transport and anaerobic media.

UNIT IV

Pure culture – Definition. Methods of isolation of pure culture - Streak plate, pour plate and spread plate methods. Preservation methods of microbial cultures – aerobic and anaerobic methods.

UNIT V

Sterilization– Definition & Principles. Methods of Sterilization - Physical methods – Dry heat - Moist heat. Radiation – ionizing and non-ionizing. Filtration - Membrane - HEPA. Chemical Sterilization - Chemical agents - mode of action. Disinfectant – Definition, ideal characteristics of disinfectant and quality control.

Text Book:

1. Pelzer J, Chen E.C.S, Krieg N.R, 1986, Microbiology, McGraw Hill Company.

Reference books:

1. Willey J.M, Sherwood L.M and Woolverton C.J, 2017, Prescott's Microbiology. Tenth edition, McGraw Hill International edition.
2. Brock T.D, Smith D.W and Madigan N.T, 1987, Biology of Microorganisms edn, Eniglcwood Cliffs, NJ Prentice Hall K.
3. Dubey R.C and Maheswari D.K, 2012, A text of Microbiology (Revised edition). S.Chand and Company Ltd., New Delhi.
4. GeetaSumbali and Mehrotra R.S, 2009, Principles of Microbiology. First edition, Tata McGraw Hill P.Ltd., New Delhi.



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| | | | |
|----------------------|-----------------------------|-----------------|---------------|
| Class | :B.Sc (Microbiology) | Part III | : Core |
| Semester | : I | Hours | : 03 |
| Subject Code: | 19UMBCP1 | Credits | :02 |

FUNDAMENTALS OF MICROBIOLOGY- PRACTICAL

Course outcomes

On successful completion of the course, the learners should be able to

- CO1:**Demonstrate the basic skill in aseptic techniques
CO2:Perform various staining techniques to identify microbes.
CO3:Develop skill in cultivating microorganisms using different cultivation techniques.
CO4:Determine bacterial motility using hanging drop method
CO5:Enumerate bacteria from the environmental samples.

01. Laboratory safety measures and sterilization techniques -Demonstration
02. Preparation of media: nutrient broth, nutrient agar.
03. Pure culture techniques: streak plate, spread plate and pour plate.
04. Cultivation of microorganisms using Agar slant, agar deep and agar plate.
05. Bacterial motility determination – Hanging drop method.
06. Serial dilution technique.
07. Enumeration of bacteria - Total plate count from environmental samples
08. Staining methods: simple, negative and Gram staining
09. Spore staining.
10. Fungal slide culture technique.

Text Book:

1. Dubey R.C and Maheswari D.K, 2004, Practical Microbiology, First edition, S. Chand and Company Ltd, New Delhi.

Reference Books:

1. James G Cappuccino and Natalie Sherman, 2004, Microbiology: A Laboratory Manual, sixth edition, published by Pearson Education.
2. Aneja K.R, 2005, Experiments in Microbiology, Plant pathology and Biotechnology, Fourth edition, New Age International Publishers, Chennai.
3. Reddy S.M, Ram Reddy S, Microbiology: A Laboratory Manual, BSC Publishers and Distributors, Hyderabad.



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| | | | |
|---------------------|-----------------------------|----------------|-----------------|
| Class | :B.Sc (Microbiology) | PartIII | : Allied |
| Semester | : I | Hours | : 04 |
| Subject Code | :19UMBA11 | Credits | :04 |

BIOCHEMISTRY

Course outcomes

On successful completion of the course, the learners should be able to

CO1: Explore the scope and importance of biochemistry.

CO2: Demonstrate the fundamental biochemical functions of biomolecules.

CO3: Classify carbohydrates, amino acids, proteins and lipids

CO4: Illustrate nucleic acids.

CO5: Describe the importance of macromolecules.

UNIT I

History of Biochemistry, Scope and importance of Biochemistry. Biomolecules – Atoms, molecules, organic and inorganic compounds. Chemical bonds – Ionic bond, Covalent bond and Hydrogen bond. Water – pH, buffer system.

UNIT II

Carbohydrates – Definition, classification and importance. Monosaccharides – occurrence, structure, properties, linear form, Haworth projection and functions. Oligosaccharides and polysaccharides – structure, properties and functions.

UNIT III

Amino acids – Structure, classification and properties. Proteins- Structure (Primary, secondary, tertiary and Quaternary structure), classifications and functions. Enzymes - classification.

UNIT IV

Lipids- Structure and classification. Simple, compound and derived lipids. Physical and chemical properties of lipids. Fatty acids – saturated and unsaturated fatty acids.

UNIT V

Nucleic acids- Nucleoside, Nucleotide, Polynucleotide. DNA – Structure, types and functions. RNA – structure, types (mRNA, tRNA, rRNA) and functions. Vitamins - types and functions.

Text Book:

1. Jain J.L, Sunjay Jain, Nitin Jain, 2016, Fundamentals of Biochemistry, S.Chand& Company.

Reference Books:

1. Conn E.E, Stumpf P.K, 1987, Outlines of Biochemistry, John Wiley.
2. Voet D, Voet J.G & Pratt C.W, 2007, Fundamentals of Biochemistry, John Wiley
3. Nelson D.L and Cox M.M, 2004, Lehninger Principles of Biochemistry, Macmillan.
4. Satyanarayana U and Chakrapani U, 2017, Biochemistry, Fifth edition, Books and Allied (P) Ltd. Kolkata.



MANNAR THIRUMALAI NAICKER COLLEGE (Autonomous)
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Class :B.Sc (Microbiology)
Semester : I& II
Subject Code:19UMBAP1

Part III : Allied
Hours : 02
Credits: --

BIOCHEMISTRY AND CELL BIOLOGY-PRACTICAL

Course outcomes

On successful completion of the course, the learners should be able to

CO1: Determine the qualitative analysis of important biomolecules.

CO2: Estimate the amount of biomolecule in the given sample.

CO3: Prepare the buffer solution.

CO4: Describe mitotic stages.

CO5: Understand the different stages of meiosis.

1. Measurement of pH using pH meter.
2. Buffer preparation.
3. Qualitative analysis of Carbohydrates - Starch, Glucose and Sucrose.
4. Estimation of Carbohydrates by anthrone method.
5. Qualitative analysis of Proteins.
6. Estimation of Protein sample by Lowry's method.
7. Separation of aminoacids by Circular Paper chromatography.
8. Observation of Prokaryotic and Eukaryotic cell – Microslides.
9. Observation of mitotic stages in onion root tip.
10. Observation of meiotic stages in testes of Grasshopper.

Text Manuals:

1. Palanivel P, 2000, Laboratory manual for Analytical Biochemistry & Separation Techniques.
2. Chaitanya K.V, Cell and Molecular Biology – A Lab manual, PHI publishers.

Reference Books:

1. Wilson K. Walker J & Walker JM, 2005, Principles and techniques of Practical Biochemistry.
2. Jayaraman J, Laboratory manual in Biochemistry, Wiley Eastern Limited.



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(For those who joined in 2019-2020 and after)

| | | | |
|----------------------|-----------------------------|----------------|----------------|
| Class | :B.Sc (Microbiology) | Part IV | : Skill |
| Semester | : I | Hours | : 02 |
| Subject Code: | 19UMBS11 | Credits | :02 |

BIO INSTRUMENTATION

Course outcomes

On successful completion of the course, the learners should be able to

CO1: Explain the basic tools and usage of instruments in the laboratory.

CO2: Acquire knowledge of working principle of instruments used for microbiology.

CO3: Depict about Separation techniques.

CO4: Illustrate centrifuge.

CO5: Classify chromatography.

UNIT – I

Microscope - principle and working mechanism of simple, compound light microscopy, Bright and Dark field, Phase contrast, Fluorescence, SEM and TEM.

Unit II

Principle, components and applications - pH meter, Colorimeter, UV-Visible spectrophotometer.

Unit – III

Principle and applications of Autoclave, Hot air oven, Incubator, Laminar air flow chamber / Bio safety cabinets.

Unit - IV

Centrifuge – basic principles, components and applications (Laboratory and Analytical).

Unit -V

Chromatography – principles, classification and applications - Paper Chromatography (Descending, Ascending and Circular), Thin layer, Column and HPLC.

Text Book:

1. Wilson K and Walker J, 2010, Principles and Techniques of Biochemistry and Molecular Biology, 7th Ed., Cambridge University Press.

Reference Books:

1. Karp G, 2010, Cell and Molecular Biology: Concepts and Experiments, 6th Ed., John Wiley & Sons. Inc.
2. De Robertis and De Robertis, Cell and Molecular Biology, 8th ed., Wolters Kluwer Pvt. Ltd. (India)
3. Nigam and Ayyagari, Lab Manual in Biochemistry, Immunology and Biotechnology, Tata McGraw Hill.

SECOND SEMESTER



MANNAR THIRUMALAI NAICKER COLLEGE (Autonomous)
DEPARTMENT OF MICROBIOLOGY
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Class :B.Sc (Microbiology)
Semester : II
Subject Code: 19UMBC21

Part III : Core
Hours : 05
Credits : 05

MICROBIAL PHYSIOLOGY

Course outcomes

On successful completion of the course, the learners should be able to

- CO1:** Differentiate the nutritional requirements of microorganisms
- CO2:** Understand the physiological principles underlying microbial life.
- CO3:** Obtain knowledge about respiratory and cellular metabolism of microbes.
- CO4:** Describe carbohydrate and lipid biosynthesis.
- CO5:** Explain the biosynthesis of purines and pyrimidines.

UNIT I

Nutrition requirements of microorganisms–Autotrophs, Heterotrophs, Chemotrophs, Copiotrophs and Oligotrophs. Transport of nutrients by active and passive ways.

UNIT II

Different phases of growth – Growth curve – Generation time. Factors influencing microbial growth – Temperature, pH, Pressure, Salt concentration and Nutrients. Synchronous growth, Continuous growth and Diauxic growth.

UNIT III

Respiratory metabolism – Glycolysis, Krebs' cycle and Oxidative Phosphorylation. Fermentation – Lactic acid, Propionic acid and Mixed acid fermentation.

UNIT IV

Chemoautotrophy – Hydrogen Oxidation, Sulfur and Iron Oxidation, Ammonium and Nitrite Oxidation. Photoautotrophy – Absorption of Light Energy, Oxygenic Photosynthesis and Anoxygenic Photosynthesis.

UNIT V

Carbohydrate biosynthesis – Gluconeogenesis, Glyoxalate Cycle, Peptidoglycan biosynthesis. Lipid biosynthesis – Fatty acid biosynthesis. Biosynthesis of Nucleotides (Pyrimidines and Purines).

Text Book:

1. Ronald M. Atlas, 1997, Principles of Microbiology, Second edition, WCB / McGraw-Hill.

Reference Books:

1. Albert G. Moat & John W. Foster, 2007, Microbial Physiology, A John Wiley and sons, INC publications, New York.
2. Caldwell D.R, 1995, Microbial Physiology and Metabolism, Brown Publishers.
3. Dubey R.C & Maheshwari D.K, 2009, A text book of microbiology, Chand & Company Ltd. New Delhi.



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| | | | |
|----------------------|-----------------------------|-----------------|---------------|
| Class | :B.Sc (Microbiology) | Part III | : Core |
| Semester | : II | Hours | : 03 |
| Subject Code: | 19UMBPC2 | Credits | : 02 |

MICROBIAL PHYSIOLOGY – PRACTICAL

Course outcomes

On successful completion of the course, the learners should be able to

CO1:Measure the growth of microorganisms.

CO2:Explore the environmental influences on the microbial growth.

CO3:Demonstrate the effect of pH and osmotic pressure on the microbial growth.

CO4:Replicate the yeast fermentation technique.

CO5:Identify the bio-chemical activities of microbes.

1. Growth curve and determination of generation time in *E. coli*.
2. Effect of pH on the microbial growth.
3. Effect of Osmotic pressure on the microbial growth.
4. Measurement of Cell number using Haemocytometer.
5. Yeast Fermentation technique
6. Bio Chemical activities of microorganisms
 - a. Hydrolysis of Starch
 - b. Hydrolysis of Gelatin
 - c. Carbohydrate fermentation
 - d. Indole production test
 - e. Methyl red test
 - f. Voges-proskauer test
 - g. Citrate utilization test
 - h. Hydrogen sulfide production test
 - i. Catalase test
7. Field Visit -Microbial industries/farms / research laboratories.

Text Manual:

1. James G Cappuccino and Natalie Sherman, 2004, Microbiology: A Laboratory Manual, sixth edition, published by Pearson Education.

Reference Books:

1. Kannan N, 1996, Laboratory manual in General Microbiology, First edition, Palani Paramount publications, Palani.
2. Aneja K.R, 2005, Experiments in Microbiology, Plant pathology and Biotechnology, Fourth edition, New Age International Publishers, Chennai.
3. Rajan S and Selvi Christy, 2011, Experimental procedures in life sciences, Anjana book house, publishers and distributors, Chennai.



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Class :B.Sc (Microbiology)
Semester : II
Subject Code:19UMBA21

PartIII : Allied
Hours : 04
Credits :04

CELL BIOLOGY

Course outcomes

On successful completion of the course, the learners should be able to

CO1:Acquire knowledge on history of cell biology.

CO2:Discriminate the structures and purpose of basic components of prokaryotic and eukaryotic cells.

CO3:Illustrate the cellular components underlying mitosis and meiosis.

CO4: Compare mitosis with meiosis.

CO5:Apply their knowledge of cell biology to selected examples in cell function.

UNIT – I

History of cell Biology.Cell- cell theory, Types- Epithelial, endothelial and nerve cells.Overview of prokaryotic and eukaryotic cells - shapes, size and cell volume.Ultra structure and functions of plant, animal and bacterial cell.

Unit II

Cell components, Plasma membrane- chemical composition, Fluid mosaic model and functions. Cell wall- chemical composition, structure and functions.Cytoplasmic and extra cytoplasmic structure –pili and flagella.Ribosomes – structure, types and functions.

Unit – III

Endoplasmic reticulum - Morphology, ultrastructure, types (Smooth and rough endoplasmic reticulum), chemical composition and functions.Golgi apparatus – occurrence, structure, morphology, chemical composition and functions. Lysosomes – origin, structure and functions.

Unit - IV

Mitochondria - Distribution, localization, ultrastructure and functions. Plastids – chloroplasts, chromoplasts, amyloplast and vacuoles. Nucleus – ultrastructure, composition and functions, nuclear membrane and nucleoplasm. Chromosomes – heterochromatin and euchromatin, polytene chromosomes (salivary gland) and lampbrush chromosomes.

Unit -V

Cell division and cell cycle – Mitosis -Mitotic stages and significance; Meiosis - stages, types (homotypic and heterotypic) and significance- Comparison of Mitosis and Meiosis.

Text Book:

1. De Robertis and De Robertis, 2011, Cell and Molecular Biology, 8th ed., B.I. Publications Pvt. Ltd. (India).

Reference Books:

1. Karp G,2010,Cell and Molecular Biology: Concepts and Experiments, 6th Ed, John Wiley & Sons.Inc.
2. Verma P.S and Agarwal V.K, 1995,Cell Biology, Genetics and Molecular biology, S.Chand & Co.
3. Power C.B, 2009, Essentials of Cytology, Himalaya publishing house, Bombay.



MANNAR THIRUMALAI NAICKER COLLEGE (Autonomous)
DEPARTMENT OF MICROBIOLOGY
(For those who joined in 2019-2020 and after)

| | | | |
|----------------------|-----------------------------|-----------------|-----------------|
| Class | :B.Sc (Microbiology) | Part III | : Allied |
| Semester | : I& II | Hours | : 02 |
| Subject Code: | 19UMBAP1 | Credits | :01 |

BIOCHEMISTRY AND CELL BIOLOGY -PRACTICAL

Course outcomes

On successful completion of the course, the learners should be able to

CO1: Determine the qualitative analysis of important biomolecules.

CO2: Estimate the amount of biomolecule in the given sample.

CO3: Prepare the buffer solution.

CO4: Describe mitotic stages.

CO5: Understand the different stages of meiosis.

1. Measurement of pH using pH meter.
2. Buffer preparation
3. Qualitative analysis of Carbohydrates- Starch, Glucose and Sucrose
4. Estimation of Carbohydrates by anthrone method.
5. Qualitative analysis of Proteins.
6. Estimation of Protein sample by Lowry's method.
7. Separation of aminoacids by Circular Paper chromatography.
8. Observation of Prokaryotic and Eukaryotic cell- Microslides
9. Observation of mitotic stages in onion root tip
10. Observation of meiotic stages in testes of Grasshopper.

Text Manuals:

1. Palanivel P, 2000, Laboratory manual for Analytical Biochemistry & Separation Techniques.
2. ChaitanyaK.V, Cell and Molecular Biology – A Lab manual, PHI publishers.

Reference Books:

1. Wilson K. Walker J & Walker JM, 2005, Principles and techniques of Practical Biochemistry.
2. Jayaraman J, Laboratory manual in Biochemistry, Wiley Eastern Limited.



MANNAR THIRUMALAI NAICKER COLLEGE (Autonomous)
DEPARTMENT OF MICROBIOLOGY
(For those who joined in 2019-2020 and after)

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|---------------------|-----------------------------|-----------------|----------------|
| Class | :B.Sc (Microbiology) | Part III | : Skill |
| Semester | : II | Hours | : 02 |
| Subject Code | :19UMBS21 | Credits | : 02 |

MUSHROOM CULTIVATION

Course outcomes

On successful completion of the course, the learners should be able to

CO1: Acquire knowledge about the importance of mushrooms.

CO2: Understand the cultivation techniques of different types of mushrooms.

CO3: Obtain knowledge about the management of diseases in mushrooms.

CO4: Describe about the post harvesting techniques in mushroom cultivation.

CO5: Prepare mushroom recipes

UNIT I

Introduction and importance of mushrooms. History of mushroom cultivation. Present status of mushroom industry in India.

UNIT II

Biology of mushroom. Cultivable edible mushroom. Nutritional and medicinal properties of mushroom (Protein, Carbohydrates, Vitamins, Minerals and Fiber content). Poisonous and Medicinal mushrooms.

UNIT III

Mushroom farm structure – Design and layout. Spawn principles and techniques of spawn production. Principles and techniques of Compost and Composting.

UNIT IV

Cultivation techniques - White button mushroom – Oyster mushroom – Milky mushroom. Management of fungal, viral and bacterial diseases in mushroom.

UNIT V

Post harvesting techniques – Freezing - Dry freezing – Drying – Canning. Preparation of mushroom recipes – Pickles – Soup.

Text Book:

1. Tripathi D.P, 2005, Mushroom cultivation, Oxford and IBH publishing Co. Pvt. Ltd, New Delhi.

Reference Books:

1. Nita Bahl, 2002, Hand book of mushroom, fourth edition, Vijay Primlani for Oxford and IBH publishing Co.Pvt.Ltd, New Delhi.
2. Marimuthu T, Krishnamoorthy AS, Sivaprakasam K and Jayarajan R, 1991, Oyster mushrooms, Department of Plant pathology, Tamil Nadu Agricultural University, Coimbatore.
3. Handbook of mushroom cultivation, 1999, TNAU publications.

THIRD SEMESTER



MANNAR THIRUMALAI NAICKER COLLEGE (Autonomous)
DEPARTMENT OF MICROBIOLOGY
(For those who joined in 2019-2020 and after)

| | | | |
|---------------------|------------------------------|-----------------|---------------|
| Class | : B.Sc (Microbiology) | Part III | : Core |
| Semester | : III | Hours | : 05 |
| Subject Code | :19UMBC31 | Credits | : 05 |

MICROBIAL GENETICS

Course outcomes

On successful completion of the course, the learners should be able to

CO1: Describe genetics of microbes, gene transfer, transposition, bacterial gene expression,

plasmids, mutation, DNA damage and DNA repair (K₁ & K₂).

CO2: Identify gene transfer mechanism, regulation of bacterial gene expression and recombination (K₃).

CO3: Classify transposition, plasmid and mutation mechanisms (K₄).

CO4: Justify direct repair, excision repair, mismatch repair, recombination repair and SOS

repair with their mechanisms (K₅).

CO5: Illustrate the experiments on genetic material of famous scientist (K₆).

UNIT – I

DNA: Genetic material – experiment of Griffith, Avery, MacLeod and McCarty, Hershey and Chase; RNA: Genetic material – Gierer and Schramm experiments.

UNIT –II

Gene transfer mechanism in bacteria - Transformation, Conjugation and Transduction (Generalized and Specialized); Transposition: Transposable elements in prokaryotes – insertion sequences – composite & non-composite transposons – replicative & non-replicative transposition.

UNIT-III

Regulation of bacterial gene expression – lac operon – trp operon – attenuation – two component regulatory system; homologous recombination – Holiday model; Plasmid – size and copy number – conjugation & compatibility – classification - amplification.

UNIT IV

Mutation: spontaneous and induced mutations, Point mutation and chromosomal mutations, base pair changes, frame shift mutation and mismatch; DNA damage: lesions, dimerization, AP sites, oxidative damage, alkylation and genotoxic effects.

UNIT V

DNA repair: Direct repair – photoreactivation and dealkylation, excision repair – base excision and nucleotide excision, mismatch repair, recombination repair and SOS repair.

Text Book:

1. David R Hyde. 2010, Genetics and Molecular biology. Special Indian edition, Tata McGraw Hill P.Ltd, New Delhi.

Reference Books:

1. Maloy S.R, Cronan Jr. J.E, Freifelder D. 1994, Microbial genetics, Jones and Barlett publishers.
2. Lodish H, Baltimore Daerk A, Zipsury S.L, Marsudaisa P, Darnel J. 1995, Molecular cell biology.
3. Brown T.A. 1998, Molecular Biology Lab; Gene Analysis, Academic Press, London.
4. Krebs J.E, Goldstein E.S, Kilpatrick S.T. 2011, Lewin's Genes X, Jones and Bartlett publishers.



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|---------------------|------------------------------|----------------|---------------|
| Class | : B.Sc (Microbiology) | Part IV | : Core |
| Semester | : III | Hours | : 3 |
| Subject Code | : 19UMBCP3 | Credits | : 2 |

MICROBIAL GENETICS - PRACTICAL

Course outcomes

On successful completion of the course, the learners should be able to

- CO1:**Enumerate streptomycin resistant mutant, auxotrophic mutant, Lac⁻ and Lac⁺ colonies (K₁).
- CO2:**Illustrate the streptomycin resistant mutant, auxotrophic mutant, Lac⁻ and Lac⁺ colonies (K₂).
- CO3:**Identify the *E.coli* strains for UV sensitivity (K₃).
- CO4:**Analyze replica plating (K₄).
- CO5:** Interpret bacterial conjugation (K₅).

1. Isolation of streptomycin resistant mutant by gradient plate method.
2. Isolation of auxotrophic mutants by replica plating.
3. UV sensitivity of *E.coli*.
4. Calculation of percentage killing of *E.coli* after UV irradiation.
5. Phenotypic checking of the given auxotroph.
6. Competent cell preparation.
7. Isolation of Lac⁻ and Lac⁺ colonies
8. Uninterrupted bacterial conjugation.
9. Isolation of phage.
10. Demonstration of bacterial transformation.

Reference Books:

1. Malov S.R. 1990, Experimental Techniques in Bacterial Genetics, Jones and Bartlett Publishers, Boston.
2. Ausubel F.M, Roger B, Robert E.Kingston, David A. Moore, Seidman J.G, John A. Smith and Kelvin S. 1992, Short Protocols in Molecular Biology, Third Edition, John Wiley & Sons Inc, New York.
3. Kannan N. 2003, Hand Book of Laboratory Culture Medias, Reagents, Stains and Buffers, Panima Publishing Co, New Delhi.



MANNAR THIRUMALAI NAICKER COLLEGE (Autonomous)
DEPARTMENT OF MICROBIOLOGY
(For those who joined in 2019-2020 and after)

Class : B.Sc (Microbiology)
Semester : III
Subject Code :19UMBA31

Part III : Allied
Hours : 4
Credits : 4

MOLECULAR BIOLOGY

Course outcomes

On successful completion of the course, the learners should be able to

CO1:Recognize DNA, RNA and genetic code(K₁).

CO2:Describe the structure of DNA and RNA, Chargaff's principles, DNA supercoiling Wobble hypothesis, Meselson and Stahl experiment, rolling circular model of replication, genetic code and molecular techniques (K₂).

CO3:Demonstrate the structure of DNA and RNA, DNA replication, transcription, translation and molecular techniques (K₃).

CO4:Compare DNA with RNA, prokaryotic and eukaryotic DNA replication, prokaryotic transcription with eukaryotic transcription and prokaryotic translation with eukaryotic translation(K₄).

CO5: Conclude post transcription and post translation modification(K₅).

UNIT – I

Structure of DNA: Single stranded and double stranded (Watson and Crick model) - Chargaff's principles – DNA supercoiling. RNA: structure – characteristics – codon & anti-codon recognition and Wobble hypothesis.

UNIT –II

DNA replication – semiconservative – Meselson and Stahl experiment – prokaryotic and eukaryotic DNA replication – initiation, elongation and termination. Rolling circular model of replication.

UNIT-III

Transcription: Prokaryotic transcription – RNA polymerase – initiation, elongation and termination. Eukaryotic transcription – initiation, elongation and termination. Post transcriptional modifications.

UNIT IV

Translation: Prokaryotic translation – initiation, elongation and termination. Eukaryotic translation– initiation, elongation and termination. Post translational modification.

UNIT V

Genetic code; Codon - Anti-codon. Molecular techniques; DNA finger printing - DNA Microarray - Gene Mapping and Protein Micro array.

Text Book:

1. Frifelder D. 2000, Molecular Biology, Second edition, Narosa Publishing House, New Delhi.
2. Verma P.S and Agarwal V.K. 2016, Cell Biology (Cytology, Biomolecules, Molecular Biology), Paperback, S. Chand and Company Ltd.

Reference Books:

1. Lodish H, Baltimore DaerkA, Zipsury S.L, Marsudaisa P, Darnel J. 1995, Molecular cell biology.
2. De Roberties E.D.P and E.M.F. De Roberties. 2011, Cell and Molecular Biology, Eighth edition, Lippincott Williams & Wilkins, Philadelphia.
3. Gardner, Simon and Snustad, Principles of genetics, 8th Edition. John Wiley & sons. Inc. New York.



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| | | | |
|---------------------|------------------------------|----------------|-----------------|
| Class | : B.Sc (Microbiology) | Part IV | : Allied |
| Semester | : III & IV | Hours | : 2 |
| Subject Code | : 19UMBAP2 | Credits | : -- |

MOLECULAR BIOLOGY AND IMMUNOLOGY - PRACTICAL

Course outcomes

On successful completion of the course, the learners should be able to

- CO1:** Describe the isolation techniques in DNA & RNA(K₁).
- CO2:** Determine blood grouping and Rh typing(K₃).
- CO3:** Illustrate bacterial transduction (K₄).
- CO4:** Deduct total count and differential count in blood cells(K₅).
- CO5:** Prepare double immunodiffusion and radial immunodiffusion test(K₆).

1. Gel Electrophoresis
2. Isolation of chromosomal DNA from bacteria
3. Estimation of DNA by spectrophotometric method.
4. Isolation of plasmid DNA from bacteria.
5. Isolation of RNA from plant cells.
6. Blood grouping and Rh typing.
7. Examination of blood cells – Total count.
8. Examination of blood cells – Differential count.
9. Agglutination reaction
10. Ouchterlony double immunodiffusion test.
11. Single radial immunodiffusion.
12. Dot blot.

Reference Books:

1. Ausubel F.M, Roger B, Robert E. Kingston, David A. Moore, Seidman J.G, John A. Smith and Kelvin S. 1992. Short Protocols in Molecular Biology, Third Edition, John Wiley & Sons Inc., New York.
2. Rajamanickam C. 2001, Experimental protocols in basic molecular biology, Osho Scientific Publications, Madurai.
3. Annadurai B. 2008, Immunology and Immunotechnology, First edition, S.Chand & Company Ltd, New Delhi.
4. Kannan N. 1996, Laboratory Manual in General Microbiology, First edition, Palani Paramount Publications, Palani.



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Class : B.Sc (Microbiology)
Semester : III
Subject Code : 19UMBS31

Part IV : Skill
Hours : 2
Credits : 2

VERMITECHNOLOGY

Course outcomes

On successful completion of the course, the learners should be able to

- CO1:**Elaborate vermiculture and its concept, vermiculture, vermicast, vermiwash, factors affecting vermicomposting, earthworm pests, parasites and pathogens(K₂).
- CO2:**Identify the role of earthworms in soil fertility and its application in agriculture and various fields(K₃).
- CO3:**Classify earthworm and vermicomposting methods (K₄).
- CO4:**Justify the problems in vermiculture and its remedies (K₅).
- CO5:** Design harvesting of vermicompost(K₆).

UNIT – I

Definition and concepts of vermiculture. Earthworm classification – morphology and anatomy.

UNIT –II

Types of vermicomposting – role of earthworms in soil fertility – vermiculture – vermicast – vermitechology and its applications.

UNIT-III

Vermicomposting materials, vermicomposting methods (small scale and large scale) and Factors affecting vermicomposting (pH, moisture and temperature).

UNIT IV

Harvesting of vermicompost – quality, properties and advantages over chemical fertilizers. Vermiwash and its application.

UNIT V

Earthworm pests, parasites and pathogens. Problems in vermiculture and remedial solution. Application of vermicomposting in agriculture. Uses of earthworms in food and medicine.

Text Book:

1. Gupta P.K. 2008, Vermicomposting for sustainable agriculture, Second edition, Agrobios.

Reference Books:

1. Ismail S.A. 1997, Vermitechnology: The biology of Earthworm. Orient Longman.
2. Ranganathan L.S. 2006, Vermicomposting technology - from soil health to human health.
3. Edwards C.A, and Bother, B. 1996, Biology of Earthworms, Chapman Hall Publ. Co, London.
4. Talashikar S.C. 2008, Earthworms in Agriculture, Agrobios.



MANNAR THIRUMALAI NAICKER COLLEGE (Autonomous)
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| | | | |
|---------------------|------------------|----------------|--------------|
| Class | : UG | Part IV | : NME |
| Semester | : III | Hours | : 2 |
| Subject Code | :19UMBN31 | Credits | : 2 |

MICROBES IN HUMAN WELFARE

Course outcomes

On successful completion of the course, the learners should be able to

CO1:Outline the contributions of Louis Pasteur, Robert Koch and Edward Jenner (K₂).

CO2:Discover the role of microbes in household products, industrial products,sewage treatment, agriculture and in biogas production (K₃).

CO3:Infer the microbial activity in household products, industrial products,sewage treatment, agriculture and in biogas production (K₄).

CO4:Evaluate the microbial benefits in household products, industrial products and in agriculture (K₅).

CO5: Formulate the biogas productionand the microbial activity in sewage treatment(K₆).

UNIT – I

Microbiology: Definition and history – contributions of Louis Pasteur, Robert Koch and Edward Jenner.

UNIT –II

Role of microbes in household products: *Saccharomyces*, *Lactobacillus*, *Agaricus*and *Spirulina*.

UNIT-III

Role of microbes in industrial products – fermented beverages – antibiotics(Penicillin production)-chemicals and enzymes(Insulin production).

UNIT IV

Role of microbes in Agriculture: Biocontrol agent – *Bacillus thuringiensis*and biofertilizer–*Azospirillum*.

UNIT V

Role of microbes in sewage treatment: primary treatment, secondary treatment–aerobic and anaerobic(trickling filter,activated sludge and oxidation pond)treatment.Role of microbes in biogas production.

Text Book:

Dubey R.C and Maheswari D.K. 2005, A Text book of Microbiology, S.Chand & Company Ltd, New Delhi.

Reference Books:

1. Frazies W.C and Westhoff D.C. 1988, Food microbiology, Fourth edition, McGraw Hill.
2. Subba Rao N.S. 1995, Soil Microorganisms and plant growth, Oxford and IBH publishing Co. Pvt. Ltd.
3. Hugo W.B, Russell A.D. Pharmaceutical Microbiology, Fourth edition, Blackwell scientific publications / Oxford.
4. Powar C.B and Daginawala H.F. 2005, General Microbiology, Volume I & II, Eighth edition, Himalaya Publishing House, Mumbai.

FOURTH SEMESTER



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| | | | |
|---------------------|------------------------------|----------------|---------------|
| Class | : B.Sc (Microbiology) | Part IV | : Core |
| Semester | : IV | Hours | : 5 |
| Subject Code | : 19UMBC41 | Credits | : 5 |

AGRICULTURE AND ENVIRONMENTAL MICROBIOLOGY

Course outcomes

On successful completion of the course, the learners should be able to

- CO1:** Relate the importance of soil microorganisms and soil fertility and rhizosphere microorganisms and its importance (K₁).
- CO2:** Discuss the phyllosphere microorganisms, plant-microbe and microbe-microbe interactions in soil, biogeochemical cycles, nitrogen fixers, plant diseases, microbial pesticides and microbiology of air, water and sewage (K₂).
- CO3:** Identify the soil, rhizosphere and phyllosphere microorganisms, nitrogen fixers, bacterial, fungal and viral diseases in plants (K₃).
- CO4:** Analyze the microbes in air, water and sewage (K₄).
- CO5:** Design sewage treatment (K₅).

UNIT – I

Distribution and importance of soil microorganisms in soil fertility – factors affecting the activities of soil microorganisms; Rhizosphere microorganisms and its importance; Phyllosphere microorganisms; plant-microbe and microbe-microbe interactions in soil.

UNIT –II

Biogeochemical cycles- carbon, nitrogen, phosphorus and sulphur Cycle; Nitrogen fixers – root nodule formation – nitrogenase, hydrogenase – biochemistry of nitrogen fixation.

UNIT-III

Plant diseases (mode of entry of pathogens, symptoms, disease cycle and control measures) Bacterial disease – angular leaf spot of Cotton, Fungal disease - blast disease of paddy and Viral disease- bunchy top of banana. Microbial pesticides- types and applications- *Pseudomonas fluorescens* and NPV.

UNIT IV

Microbiology of air – microbes in aerosol – assessment of quality of air- air sanitation – air borne diseases and their control measures. Microbiology of water: potability of water, indicator organisms, microbial assessment of water quality, water purification, water borne diseases and their control measures. Pollutants - bioremediation.

UNIT V

Microbiology of sewage – chemical and biochemical characteristics of sewage – BOD and COD – sewage treatment- physical, chemical and biological – aerobic and anaerobic (trickling filter, activated sludge and oxidation pond) treatment- disposal of wastes.

Text Books:

1. SubbaRao N.S. 2000, Soil Microorganisms and Plant Growth, Third Edition, Oxford & IBH Publishing Co. Pvt. Ltd, New Delhi.
2. AtlasR.A&BarthaR.2000, Microbial Ecology, Fundamentals and Application, Benjamin Cummings, New York.

Reference Books:

1. Rangaswami G and Bagyaraj D.J. 2002, Agricultural Microbiology, Second edition, PHI Learning (P) Ltd., New Delhi.
2. Sharma, P.D. 2001, Plant Pathology, First edition. Rastogi Publications.
3. Mitchell R. 1974, Introduction to Environmental Microbiology, Prentice Hall Inc., Englewood Cliffs.



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DEPARTMENT OF MICROBIOLOGY
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Class : B.Sc (Microbiology)
Semester : IV
Subject Code : 19UMBCP4

Part IV : Core
Hours : 3
Credits : 2

AGRICULTURE AND ENVIRONMENTAL MICROBIOLOGY- PRACTICAL

Course outcomes

On successful completion of the course, the learners should be able to

CO1:Enumerate bacteria from soil, water, air, leguminous plant and diseased plants (K₁).

CO2:Demonstrate water analysis (K₂).

CO3: Identify the isolation techniques of *Azotobacter*, rhizobium and Phosphobacteria (K₃).

CO4:Deduct microbes from air and water (K₄).

CO5: Prepare biofertilizer(K₅).

1. Isolation of microorganisms from soil (Bacteria, Actinomycetes and Fungi).
2. Isolation of free-living nitrogen fixers – *Azotobacter*
3. Isolation of *Rhizobium* from Legume nodule.
4. Isolation of Phosphobacteria from soil.
5. Isolation of microbes from crops infected with bacterial diseases.
6. Water analysis by MPN technique.
7. Microbial assessments of air quality – open plate method.
8. Isolation and counting of coliforms from water.
9. Demonstration on different biofertilizers types, formulation and application methods.
10. Visit to biofertilizers and biopesticides unit to understand about the Unit operation procedures.

Reference Books:

1. Dubey R.C and Maheswari D.K. 2002, Practical Microbiology, S.Chand Ltd
2. Christon J. Hurst, Ronald L. Crawford, Manual of environmental microbiology, Second edition, ASM Press.
3. Aneja K.R. 2003, Experiments in Microbiology, Plant Pathology and Biotechnology. New Age International.
4. Cappuccino J.G, Sherman S. 2002, Microbiology. A Laboratory Manual Benjamin Cummings Publishing Company.



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(For those who joined in 2019-2020 and after)

Class : B.Sc (Microbiology)
Semester : IV
Subject Code : 19UMBA41

Part IV : Allied
Hours : 4
Credits : 4

IMMUNOLOGY

Course outcomes

On successful completion of the course, the learners should be able to

CO1: Describe the history of immunology, types of immunity, immune cells, immune organs, antigen, antibody, monoclonal antibodies, MHC, Complement system,

hypersensitivity reactions and autoimmune diseases (K₁).

CO2: Classify the types of immunity, antigen and antibody, classical and alternative pathways of complement system and antibody mediated and cell mediated hypersensitivity reactions (K₂).

CO3: Identify immune cells, immune organs, antigen, antibody, antigen – antibody interactions hypersensitivity reactions and autoimmune diseases (K₃).

CO4: Categorize the properties of immune cells, immune organs, antigen and antibody (K₄).

CO5: Evaluate the role of immunoglobulins in immunity (K₅).

UNIT – I

History of immunology; Immune organs – bone marrow, thymus, lymph node, spleen, GALT and MALT. Structure, function and properties of immune cells – T cell, B cell, NK cell, macrophage, neutrophil, eosinophil, basophil, mast cell and dendritic cell;

UNIT –II

Types of immunity – innate and acquired immunity – humoral and cell mediated immunity. Immune tolerance.

UNIT-III

Antigens: properties (epitope, adjuvants) – chemical nature – types – immunogen – hapten and determinants of antigenicity. Antibodies: immunoglobulins – structure – types and properties. Monoclonal antibodies – hybridoma technology.

UNIT IV

Antigen-antibody interaction – agglutination, precipitation, RIA, ELISA and Immunoelectrophoresis. MHC – antigen processing and presentation. Complement system – classical and alternative pathways.

UNIT V

Hypersensitivity reactions – antibody mediated (Type I, II & III) and cell mediated (Type IV). Transplantation immunology, Autoimmune diseases – types and mechanisms.

Text Book:

1. Janis Kuby. 1993, Immunology, Second edition, W.H. Frummen and company, New York.

Reference Books:

1. Roitt, I.M. 1991, Essentials of Immunology, Seventh edition, Blackwell Scientific Publications.
2. Kannan I. 2007, Immunology, First edition, MJ Publishers, Chennai.
3. Ian R. Tizard. 1995, Immunology: An Introduction, Fourth edition, Saunders College Publishing.
4. Chakravarthy, A.K. (1996) – Immunology, Tata McGraw Hill Publishing Co. Ltd., New Delhi.



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(For those who joined in 2019-2020 and after)

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|---------------------|------------------------------|----------------|-----------------|
| Class | : B.Sc (Microbiology) | Part IV | : Allied |
| Semester | : III & IV | Hours | : 2 |
| Subject Code | : 19UMBAP2 | Credits | : 1 |

MOLECULAR BIOLOGY AND IMMUNOLOGY - PRACTICAL

Course outcomes

On successful completion of the course, the learners should be able to

- CO1:** Describe the isolation techniques in DNA & RNA (K₁).
- CO2:** Determine blood grouping and Rh typing (K₃).
- CO3:** Illustrate bacterial transduction (K₄).
- CO4:** Deduct total count and differential count in blood cells (K₅).
- CO5:** Prepare double immunodiffusion and radial immunodiffusion test (K₆).

1. Gel Electrophoresis
2. Isolation of chromosomal DNA from bacteria
3. Estimation of DNA by spectrophotometric method.
4. Isolation of plasmid DNA from bacteria.
5. Isolation of RNA from plant cells.
6. Blood grouping and Rh typing.
7. Examination of blood cells – Total count.
8. Examination of blood cells – Differential count.
9. Agglutination reaction
10. Ouchterlony double immunodiffusion test.
11. Single radial immunodiffusion.
12. Dot blot.

Reference Books:

1. Ausubel F.M, Roger B, Robert E. Kingston, David A. Moore, Seidman J.G, John A. Smith and Kelvin S. 1992. Short Protocols in Molecular Biology, Third Edition, John Wiley & Sons Inc., New York.
2. Rajamanickam C. 2001, Experimental protocols in basic molecular biology, Osho Scientific Publications, Madurai.
3. Annadurai B. 2008, Immunology and Immunotechnology, First edition, S.Chand & Company Ltd, New Delhi.
4. Kannan N. 1996, Laboratory Manual in General Microbiology, First edition, Palani Paramount Publications, Palani.



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|---------------------|------------------------------|----------------|----------------|
| Class | : B.Sc (Microbiology) | Part IV | : Skill |
| Semester | : IV | Hours | : 2 |
| Subject Code | : 19UMBS41 | Credits | : 2 |

BIOINOCULANTS TECHNOLOGY

Course outcomes

On successful completion of the course, the learners should be able to

CO1: Describe about the importance of bioinoculants, biofertilizers, biomanures and biopesticides (K₁).

CO2: Identify symbiotic N₂ fixers, non-symbiotic N₂ fixers, Phosphate solubilizing microbes and biocontrol agents of bacteria and fungi (K₃).

CO3: Distinguish symbiotic and non-symbiotic nitrogen fixers (K₄).

CO4: Assess the quality control of bioinoculants (K₅).

CO5: Prepare inoculums for biofertilizers, biomanures and biopesticides (K₆).

UNIT – I

Bioinoculants – definition – various types – biofertilizers, biomanures and biopesticides - and their importance in sustainable agriculture. Symbiotic N₂ fixers – *Rhizobium* – isolation, characterization, inoculums production and field application.

UNIT –II

Non-Symbiotic N₂ fixers – *Azospirillum* – Associated N₂ fixer – *Azotobacter* – isolation, characterization, mass inoculum production and field application.

UNIT-III

Symbiotic N₂ fixers – *Cyanobacteria*, *Rhizobium*, *Azolla* – isolation, characterization, mass multiplication and field application.

UNIT IV

Phosphate solubilizing microbes – isolation, characterization, mass inoculum production and field application. Phosphate solubilization mechanism, Vesicular arbuscular mycorrhizae (VAM)

UNIT V

Biocontrol agents – bacteria and fungi – *Bacillus thuringiensis* & *Trichoderma viridae*. Mass production of biopesticides. Quality controlling in bioinoculants.

Text Book:

1. SubbaRao N.S. 1988, Biofertilizers in Agriculture and forestry, Oxford and IBH Publishing Co, Ltd., New Delhi.

Reference Books:

1. Mahendra K. Rai. 2005, Hand book of Microbial biofertilizers, The Haworth Press, Inc. New York.
2. SubbaRao N.S. 1995, Soil microorganisms and plant growth, Oxford and IBH publishing Co. Pvt. Ltd, New Delhi.
3. Kannaiyan S. 2003, Bioethnology of Biofertilizers, CHIPS, Texas.



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| | | | |
|---------------------|-------------------|----------------|--------------|
| Class | : UG | Part IV | : NME |
| Semester | : IV | Hours | : 2 |
| Subject Code | : 19UMBN41 | Credits | : 2 |

ELEMENTAL CONCEPTS OF MICROBIOLOGY

Course outcomes

On successful completion of the course, the learners should be able to

CO1: Label the parts of microscope, autoclave, laminar air flow chamber, incubator, bacterial

cell, DNA and RNA(K₁).

CO2: classify prokaryotes and eukaryotes, DNA and RNA, physical and chemical methods of sterilization, sterilization and disinfectant, antigen and antibody and humoral and cell mediated immunity(K₂).

CO3: prepare different types of media (K₃).

CO4: contrast different methods of staining and sterilization(K₄).

CO5: interpret the staining, organization of bacterial cell, DNA, RNA, sterilization, disinfectant, media preparation, pure culture techniques, nutrition, different phases of growth and growth curve of bacteria, humoral immunity, cell mediated immunity, *S.aureus*, *Candida*, HIV and malaria (K₅).

UNIT – I

Microscope and its application, autoclave, laminar air flow chamber, incubator, Staining and its importance.

UNIT –II

Prokaryotes and Eukaryotes. Structure and organization of bacterial cell. Structure and function of DNA and RNA.

UNIT-III

Sterilization: methods of sterilization – physical and chemical methods; Disinfectant – definition and ideal characteristics.

UNIT IV

Media preparation, pure culture techniques, nutrition, different phases of growth and growth curve of bacteria.

UNIT V

Bacteria – *S.typhi*, Fungi – *Candida*, Virus – Hepatitis and Parasite – Malaria.

Reference Books:

1. Michael J Pelczar J.R, Chan E.C.S and Kreig N.R. 2006, Microbiology, Fifth edition, Tata McGraw-Hill INC. New York.
2. Richard A Goldsby, Thomas J Kindt. Barbara A Osborne. 2000, Kuby Immunology, Fourth edition, W H Freeman and company, New York.
3. Jawetz, Melnick, & Adelberg's. 2013, Medical Microbiology, Twenty-sixth edition, McGraw-Hill.
4. Patel A.H. 2005, Industrial microbiology, Mac Millan India Ltd., Chennai.
5. SubbaRao N.S. 2004, Soil Microbiology, Fourth edition, Oxford and IBH Publishing Co.Pvt. Ltd., New Delhi.

FIFTH SEMESTER



MANNAR THIRUMALAI NAICKER COLLEGE (Autonomous)
DEPARTMENT OF MICROBIOLOGY
(For those who joined in 2019-2020 and after)

Class : B.Sc (Microbiology)
Semester : V
Subject Code : 19UMBC51

Part III : Core
Hours : 05
Credits : 05

BASIC BIOTECHNOLOGY

Course Outcomes:

On successful completion of the course, the learners should be able to

- CO1:** define biotechnology, endonucleases, cloning vectors, gene cloning strategies and blotting techniques. (K₁).
- CO2:** associate applications of biotechnology in expression of vectors, gene transfer, gene cloning, screening of recombinants and blotting techniques (K₂).
- CO3:** illustrate properties of cloning vectors, gene transfer methods, gene cloning methods, PCR and DNA sequencing methods (K₃).
- CO4:** classify cloning vectors and gene transfer methods (K₄).
- CO5:** prepare mediated gene transfer (K₄).

UNIT I

Biotechnology: Introduction, History - Traditional and Modern Biotechnology, Branches and applications of Biotechnology. Biotechnology Institutions in India.

UNIT II

Restriction endonucleases - Types & properties -*EcoRI*, *HindIII*, *AluI*, *ScaI*, DNA Ligases and DNA modifying enzymes. Cloning vectors: Plasmids (PBR322, M13 and Ti), Bacteriophages (lambda phage), Hybrid vectors (Cosmids, phasmids). Expression vectors (shuttle vectors, YACs and BACs).

UNIT III

Gene transfer methods – Transformation, Conjugation, Electroporation, Liposome – mediated gene transfer, transduction, direct transfer of DNA and indirect transfer - *Agrobacterium* mediated gene transfer.

UNIT IV

Gene cloning strategies - Selection of desired DNA fragments, linkers and adapters. rDNA technology – Introduction, Definition of gene manipulation - Major steps involved in gene cloning. Screening of recombinants (colony hybridization, antibiotic based, blue white screening). Construction of genomic and cDNA libraries.

UNIT V

PCR- Principle, types and its application, Reverse transcriptase-PCR, DNA sequencing methods (Maxam Gilbert and Sanger), RAPD, RFLP and Blotting (Southern, Western and Northern) techniques .

Text book:

1. Dubey R.C, 2006. A text book of Biotechnology, 4th edition, S. Chand & Company Ltd Publications.

Reference books:

1. Brown T.A, 2015. Gene Cloning and DNA Analysis. 7th edition, Wiley Blackwell.
2. Nair A.J, 2008. Introduction to Biotechnology and Genetic engineering, Infinity science press LLc.
3. Primrose S.B and Twyman R.M, 2006. Principles of Gene Manipulation and Genomics, 7th edition, Wiley Blackwell.
4. [Bernard R. Glick](#), [Jack J. Pasternak](#), [Cheryl L. Patten](#), 2010. Molecular Biotechnology, Principles and Application of recombinant DNA, 4th edition, ASM Press, Washington.



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DEPARTMENT OF MICROBIOLOGY
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Class : B.Sc (Microbiology)
Semester : V
Subject Code : 19UMBC52

Part III : Core
Hours : 05
Credits : 05

INDUSTRIAL MICROBIOLOGY

Course Outcomes:

On successful completion of the course, the learners should be able to

- CO1:** define industrial microbiology, fermentation, Bioreactors, Down-stream processing and Microbial production (K₁).
- CO2:** classify straining, types of fermentation, fermenters, and steps in downstream processing (K₂).
- CO3:** explain the process of fermentation, down-streaming and microbial production of beverages (K₂).
- CO4:** prepare Media and ingredients for industrial fermentations and alcoholic beverages (K₃).
- CO5:** outline the role of buffers, precursors, inhibitors, inducers in fermentation and monitoring of different parameters in industrial microbiology (K₄).

UNIT I

Introduction to industrial microbiology, Brief history and developments in industrial microbiology, Isolation of Industrially important microorganisms - Screening Techniques-Primary and Secondary - Preservation of cultures - Strain improvement - Maintenance of strain.

UNIT II

Types of fermentations – batch, fed-batch, continuous and solid state fermentation, Media and ingredients for industrial fermentations – crude and synthetic media, carbon, nitrogen, vitamin and mineral sources, role of buffers, precursors, inhibitors, inducers and antifoams, surfactants. Sterilization – instruments, medium and air.

UNIT III

Bioreactors / fermenters – components of typical fermenter, types of fermenters – Aerated fermenter, Agitated fermenter and Air lift fermenter. Control and monitoring of different parameters in fermenters – pH, temperature, dissolved oxygen, foaming and aeration. Fermenters for microbial and animal cell culture.

UNIT IV

Down-stream processing – filtration, centrifugation, cell disruption, solvent extraction, precipitation, chromatography (GC-MS & HPLC), ultra-filtration, lyophilization, solid - liquid extraction, liquid-liquid extraction and crystallization.

UNIT V

Microbial production of alcoholic beverages – beer & ethanol. Organic acids - Acetic acid. Amino acid- Lysine. Enzyme- Alpha amylase. Vitamin - cyanocobalamin. Antibiotics- Penicillin.

Text book:

1. Patel A.H, 2005. Industrial Microbiology. Published by Macmillan India Ltd., New Delhi.

Reference books:

1. Stanbury P.F, A.Whitaker and S.J,Hall, 1999. Principles of Fermentation Technology. 2nd edition, Aditya Book (p) Ltd., New Delhi.
2. Kalaichelvan PT and Arul Pandi. Bioprocess Technology, 2007. MJP Publishers, Chennai.
3. Casida LE Jr, 1993. Industrial Microbiology, 5th edition, Wiley Eastern Ltd., New Delhi.
4. Siva Kumar P.K, Joe, M.M and Sukesh K, 2010. An introduction to Industrial Microbiology. First edition, Chand, S & Company Ltd., New Delhi.



MANNAR THIRUMALAI NAICKER COLLEGE (Autonomous)
DEPARTMENT OF MICROBIOLOGY
(For those who joined in 2019-2020 and after)

Class : B.Sc (Microbiology)
Semester : V
Subject Code : 19UMBCP5

Part III : Core
Hours : 03
Credits : 02

BIOTECHNOLOGY – PRACTICAL

Course Outcomes:

On successful completion of the course, the learners should be able to

- CO1:** describe Restriction digestion of DNA (K₁).
- CO2:** detection of proteins (K₂).
- CO3:** identify the media preparation methods for plants and animal cell culture (K₂).
- CO4:** construct callus induction and protoplast isolation (K₃).
- CO5:** examine synthetic seeds (K₄).

1. Restriction digestion of DNA
2. Detection of proteins by S D S - P A G E method
3. Preparation of media for plant tissue culture
4. Callus induction
5. Protoplast isolation
6. Shoot tip culture
7. Anther culture
8. Preparation of synthetic seeds
9. Preparation of Animal cell culture media
10. Gene transfer technique – Demonstration

Text books:

1. Janarthanan, S. and Vincent, S. 2007. Practical Biotechnology: Methods and protocols, University Press.
2. Seidman & Moore, 2009. Basic Laboratory Methods for Biotechnology: Text book & Laboratory Reference, 2nd edition, Prentice Hall.

Reference books:

1. Ashishs verma *et al.*, 2014. Laboratory manual for biotechnology, S. Chand & Company Ltd publications.
2. Lisa A. Seidman & Cynthia J. Moore, 1999. Basic Laboratory Methods for Biotechnology, Prentice Hall.
3. Swami, P.M. 2009. Lab Manual of Biotechnology. Rastogi Publications, Meerut.
4. Anjana R & Joy P.P, 2014. A Plant Biotechnology Laboratory Manual, 1st Edition, Aromatic and Medicinal plants Research station.



MANNAR THIRUMALAI NAICKER COLLEGE (Autonomous)
DEPARTMENT OF MICROBIOLOGY
(For those who joined in 2019-2020 and after)

Class : B.Sc (Microbiology)
Semester : V
Subject Code : 19UMBCP6

Part III : Core
Hours : 03
Credits : 02

INDUSTRIAL MICROBIOLOGY - PRACTICAL

Course Outcomes:

On successful completion of the course, the learners should be able to

- CO1:** recognize antibiotic producing microbes (K₁).
- CO2:** describe alcohol fermentation (K₂)
- CO3:** discuss preservation, purification and production of Microorganisms (K₂).
- CO4:** demonstrate yeast cell immobilization (K₃).
- CO5:** appraise the techniques and products of microbial production (K₄).

1. Screening of antibiotic producing microbes
2. Screening of bacterial strains for enzyme alpha amylase production.
3. Production of protease by *Bacillus subtilis*
4. Methods of preservation of industrially important microbes (slant and glycerol)
5. Lyophilization of bacterial culture (demonstration)
6. Yeast biomass estimation by turbidity method
7. Yeast cell immobilization by sodium alginate method
8. Production of citric acid by *Aspergillus niger*
9. Alcohol fermentation by *Saccharomyces cerevisiae*
10. Estimation of alcohol using Potassium di-chromate method.

Text books:

1. Cappuccino J.G and Sherman N, 2014. Microbiology - A laboratory manual, 10th edition. Benjamin Cummins, New York.
2. Goldman, Emanuel and Lorrence H, 2009. Green. Practical Handbook of Microbiology, Boca Raton, FL: CRC press, Francis.

Reference books:

1. Richard H. Baltz *et al.*, 2010. Manual of Industrial Microbiology and Biotechnology, 3rd edition, ASM press, Washington.
2. Gunasekaran P, 2008. Laboratory Manual in Microbiology, New Age International (P) Ltd. Publishers, New Delhi
3. Dr.S.Rajan and Mrs.R.Selvi Christy, Experimental procedures in Life Sciences, Anjana book house, Chennai.



MANNAR THIRUMALAI NAICKER COLLEGE (Autonomous)
DEPARTMENT OF MICROBIOLOGY
(For those who joined in 2019-2020 and after)

Class : B.Sc (Microbiology)
Semester : V
Subject Code : 19UMBE51

Part III : Core Elective
Hours : 05
Credits : 05

FUNDAMENTALS OF ALGAE AND FUNGI

Course Outcomes:

On successful completion of the course, the learners should be able to

- CO1:** describe general characters, habitat, structure and reproduction of algae, fungi and Lichens (K₁).
- CO2:** classify the life cycle of algae, fungi and Lichens (K₂).
- CO3:** discuss the properties of algae, fungi and Lichens (K₂).
- CO4:** demonstrate biological importance of algae, fungi and Lichens (K₃).
- CO5:** contrast economic importance of algae, fungi and Lichens (K₄).

UNIT – I

General characteristics of algae. Classification (F.E.Fritsch and Smith), diverse habitat, Range of thallus structure, Photosynthetic pigments and food reserves. Reproduction (vegetative, asexual and sexual), Economic importance (algae as food and fodder, algae in agriculture, pharmaceuticals and industries).

UNIT – II

Habitat, structure, reproduction and life cycle of algae: Chlorophyceae – Volvox, Coleochaete, Xanthophyceae – Vaucheria Phaeophyceae – Ectocarpus Rhodophyceae – Polysiphonia.

UNIT – III

General characteristics of fungi: Definition, Classification of fungi. (Saccardo and Ainsworth's), occurrence, thallus organization, asexual and sexual reproduction, biological and economic importance of fungi.

UNIT – IV

Habitat, structure, reproduction and life cycle of fungi: Yeast, Rhizopus, Aspergillus, Peziza, Agaricus.

UNIT-V

Lichens: General characters, habitat, structure, reproduction and economic importance of lichens, importance of lichens as colonizers and indicators of environment.

Text books:

1. Sambamurty A.V.S.S, 2013. A Text book of Algae, I.K International publications
2. Sharma O.P, 1989. A Text book of Fungi, Tata McGraw - Hill Education.

Reference books:

1. Prescott, Harley and Klein, 2006. Microbiology, 6th Ed., Tata McGraw Hills.
2. Alexopoulos C. J and Mims C. W, 2000. Introductory Mycology, 3rd Ed., Wiley Eastern Publications.
3. [Geeta Sumbali](#), [B. M. Johri](#), 2005. The Fungi, Alpha Science International Publications.



MANNAR THIRUMALAI NAICKER COLLEGE (Autonomous)
DEPARTMENT OF MICROBIOLOGY
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Class : B.Sc (Microbiology)
Semester : V
Subject Code : 19UMBE52

Part III : Core Elective
Hours : 05
Credits : 05

FUNDAMENTALS OF BOTANY AND ZOOLOGY

Course Outcomes:

On successful completion of the course, the learners should be able to

- CO1:** define nomenclature, salient features of plant kingdom, plant physiology, animal kingdom and human physiology (K₁).
- CO2:** identify the application of Mendelism (K₁).
- CO3:** classify plant and animal kingdom, fertilisation, invertebrates and vertebrates (K₂).
- CO4:** organise plant kingdom, theory of evolution, mendelism and functions of body parts (K₃).
- CO5:** contrast the distribution, economic, environmental importance of plant and animal kingdom (K₄).

UNIT I

Introduction to plant kingdom, Plant nomenclature- Binomial system, International code of Botanical Nomenclature (ICBN). Classification - Artificial and Natural system.

UNIT II

Salient features, distribution and economic importance of angiosperms, gymnosperms, pteridophytes, bryophytes and Lichens.

UNIT III

Tissues - Meristematic and permanent tissues. Structure of mature anther. Structure of mature ovule and its types. Fertilization. Photosynthesis – light reaction - Calvin cycle. Mendelism - Monohybrid and dihybrid crosses.

UNIT IV

Introduction to animal kingdom – General classification of invertebrates and vertebrates. Evolution: Theories of Lamarkism & Darwinism- Stages of Gametes-fertilization- development of chick embryo.

UNIT V

Human Physiology: Digestion, Respiratory system - blood components, structure & functions of heart. Excretion - structure of kidney and mechanism of urine formation.

Text books:

1. Ashok Bendre, A.K and Pandey P.C, 1975. Introductory Botany. Rastogi Publication Meerut.
2. Ekambaranatha Ayyar and Ananthakrishnan T.N, 1993. Outlines of Zoology, Vol I & II, Viswanathan and Co, Madras.

Reference books:

1. Ganguly A.K and Kumar N.C, 1971. General Botany Vol. I & Vol. II, Emkay Publication, Delhi.
2. Rao, K.N, Krishnamoorthy, K.V and Rao G, 1975. Ancillary Botany. S. Viswanathan Private. Ltd., Chennai.
3. Sambasiviah I, Kamalakara Rao A.P, Augustine Chellappa S, 1983. Text book of Animal Physiology, Chand S & Co., New Delhi.



MANNAR THIRUMALAI NAICKER COLLEGE (Autonomous)
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(For those who joined in 2019-2020 and after)

Class : B.Sc (Microbiology)
Semester : V
Subject Code : 19UMBE53

Part III : Core Elective
Hours : 05
Credits : 05

PLANT AND ANIMAL BIOTECHNOLOGY

Course Outcomes:

On successful completion of the course, the learners should be able to

- CO1:** define plant tissue culture, protoplast fusion, transgenic plants, cell culture and animal cloning (K₁).
- CO2:** classify media preparation and transgenic plants (K₂)
- CO3:** demonstrate protoplast culture, somatic hybridization, haploid plants, monoclonal variation, micro propagation and mapping of human genome (K₂).
- CO4:** illustrate gene transfer methods, gene cloning methods in plant and animals (K₃)
- CO5:** outline animal cloning techniques and transgenic plants (K₄).

UNIT-I

Plant tissue culture, media preparation, surface sterilization, callus culture, suspension culture and application of plant tissue culture. Protoplast preparation - isolation and purification of protoplasts, viability test for protoplasts, protoplast culture, direct transformation of protoplasts by electroporation.

UNIT-II

Somatic hybridization - protoplast fusion, cybridization. Production of haploid plants - anther and pollen culture. somoclonal variation, micropropagation, organogenesis, somatic-embryogenesis and artificial seeds.

UNIT-III

Tumour induction in plants by *Agrobacterium*. Transgenic plants: Insect resistance, Herbicide resistant plants, virus free plants and golden rice. Plants as bioreactors.

UNIT-IV

Animal cell culture: Primary and Continuous Cell culture, adherent and suspension cultures; functional characteristics of cultured cells. Composition of animal cell culture media. Cryopreservation of animal cells, Applications of animal cell culture.

UNIT-V

Animal cloning -Dolly (nuclear transfer method), Mice and Fishes. Somatic cell genesis – Apoptosis – Measurement of cell death. Mapping of human genome – PFLP and applications. Ethical issues in animal biotechnology.

Text books:

1. Chawla HS. 2011. Introduction to Plant Biotechnology. Oxford and IBH Publishing Co. Pvt Ltd.
2. Sasidhara R. 2006. Animal Biotechnology. MJP publishers.

Reference books :

1. Dubey R.C. 2014. A text book of Biotechnology. 5th Edition. S.Chand Co Ltd.
2. Sathyanarayana U. 2008. Biotechnology. Books and Allied (P) Ltd.
3. Ranga M. 2006. Animal Biotechnology. Studam publishers.
4. Singh B D. 2006. Plant Biotechnology. Kalyani Publications.



MANNAR THIRUMALAI NAICKER COLLEGE (Autonomous)
DEPARTMENT OF MICROBIOLOGY
 (For those who joined in 2019-2020 and after)

Class : B.Sc (Microbiology)
Semester : V
Subject Code : 19UMBIP1

Part III : Core
Hours : 07
Credits : 06

IN-PLANT TRAINING

| | | |
|-------------------|---|--|
| Each Group | – | 5 Students |
| Area of Learning | - | Quality checking, production of beneficial microbes and entrepreneurship skills. |
| Record submission | – | A hard bound report to be submitted to the Department. |
| Evaluation | – | Oral presentation followed by a brief Viva. |
| Internal | – | 40 Marks |
| External | – | 60 Marks |

Course Description

The In-Plant training is conducted by the following Course Pattern.

Internal

| | | |
|--------------|---|-----------|
| Presentation | } | 40 |
| Submission | | |

External

| | | |
|-----------|---|-----------|
| Report | } | 60 |
| Viva Voce | | |

| | | |
|--------------|---|------------|
| Total | - | 100 |
|--------------|---|------------|



MANNAR THIRUMALAI NAICKER COLLEGE (Autonomous)
DEPARTMENT OF MICROBIOLOGY
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Class : B.Sc (Microbiology)
Semester : V
Subject Code : 19UMBS51

Part IV : Skill
Hours : 02
Credits : 02

COMPUTER APPLICATIONS IN BIOLOGY

Course Outcomes:

On successful completion of the course, the learners should be able to

CO1: explain the basics of computer in hardware and software aspects (K₁).

CO2: outline the MS Windows applications (K₂).

CO3: demonstrate the computer applications in bioinformatics (K₃).

CO4: relate bioinformatics to the clinical microbiology (K₃).

CO5: illustrate the search and contribution in biological database (K₄).

UNIT-I

Computer-Introduction: History of Computers, Components of Computers. Input and output devices, hardware and software. Operating system.

UNIT-II

MS Word, Data bases and graph generation: MS-Excel, project presentation: MS-PowerPoint.

UNIT-III

Applications of computers in clinical microbiology - Computer applications in fermentation Technology. Computers applications in Drug designing using software (Accelrys & Auto Dock).

UNIT-IV

Introduction to bioinformatics – history and its development – Scope and applications of bioinformatics.

UNIT-V

Biological database – NCBI-GenBank, EMBL, DDBJ. Sequence Alignment Pairwise (BLAST and FASTA) and multiple sequence alignment (ClustalW).

Text books:

1. Dave Taylor, 1995. HTML, Tata McGraw - Hill Publishing Company Ltd, New Delhi.
2. Paul M.c, Fedries, 1997. Microsoft office 97, Sams publishing techmedia, New Delhi.

Reference books:

1. Rajagopalan, 1987. Understanding Computers, Tata McGraw-Hill Publishing Company Ltd, New Delhi.
2. Sharon Crawford, 1998. Windows 98 No Experience Required. BPB publications, New Delhi.
3. Murthy C.S.V, 2003. Bioinformatics, Himalaya publishing house.
4. Rastogi S.C, Mendiratta N and Rastogi P, 2003. Bioinformatics – Concepts, Skills & amp; Applications, CBS Publishers & Distributors.

SIXTH SEMESTER



MANNAR THIRUMALAI NAICKER COLLEGE (Autonomous)
DEPARTMENT OF MICROBIOLOGY
(For those who joined in 2019-2020 and after)

Class : B.Sc (Microbiology)
Semester : VI
Subject Code : 19UMBC61

Part III : Core
Hours : 06
Credits : 06

MEDICAL MICROBIOLOGY

Course Outcomes:

On successful completion of the course, the learners should be able to

- CO1:** define normal flora, pathogenicity of bacterial, fungal, viral and protozoal diseases (K₁).
- CO2:** discuss virulence factors, Causative agent and the morphology of organisms causing infections and life cycle of protozoa (K₂).
- CO3:** compare host parasite relationships of bacterial, fungal, viral and protozoal diseases (K₂).
- CO4:** determine the diagnosis, treatment and preventive ways of disease caused by pathogenic organisms (K₃).
- CO5:** analyze the infection control methods and the role in waste disposal. (K₄).

UNIT-I

Normal flora: Definition and General Features. Normal microbial flora of human body - General attributes and virulence factors of bacteria causing infections. Host-Parasite relationships. Nonspecific defense mechanisms - general factors - physical, mechanical and chemical barriers.

Unit – II

Causative agent, morphology, cultural characteristics, pathogenicity, epidemiology, Lab diagnosis, Treatment and prevention of bacterial diseases – *Staphylococcus aureus*, *Salmonella typhi*, *Vibrio cholera*, *Mycobacterium tuberculosis* and *Clostridium tetani*.

Unit – III

Causative agent, clinical symptoms, pathogenesis, mode of transmission, prevention and treatment of fungal infections: Superficial Mycosis – Black and white piedra, Cutaneous mycosis – Trichophyton, Subcutaneous mycosis – Sporothrix, Systemic mycosis – Histoplasmosis, Opportunistic mycosis – Aspergillosis.

Unit - IV

Causative agent, clinical symptoms, pathogenesis, mode of transmission, prevention and treatment of viral infections: Herpes, Hepatitis, Rhabdo, SARS and H1N1- Influenza A virus. Sub viral agents - Viroids, Prions.

Unit – V

Life cycle of *Entamoeba histolytica*, *Plasmodium vivax* and *Taenia solium*. Hospital acquired infections and their control; Hospital waste disposal; Ethical committee and their functions.

Text books:

1. David Greenwood, Mike Barer, Richard Slack and Will Irving, 2012. Medical Microbiology. A Guide to Microbial Infections: Pathogenesis, immunity, Laboratory investigation and Control, 18th edition, Churchill Livingstone.
2. Ananthanarayanan R and Jeyaram Paniker C.K, 1990. Medical Microbiology, Orient Publications, New Delhi.

Reference books:

1. Joan Stokes E, Ridgway G.L and Wren M.W.D, 1993. Clinical Microbiology, 7th Edition, A Hodder Arnold Publication.
2. Schaechter M, Medoff G and Eisenstein B.C, 1993. Mechanism of Microbial Diseases. 2nd edition, Williams and Wilkins, Baltimore.



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DEPARTMENT OF MICROBIOLOGY
(For those who joined in 2019-2020 and after)

Class : B.Sc (Microbiology)
Semester : VI
Subject Code : 19UMBC62

Part III : Core
Hours : 06
Credits : 06

VIROLOGY

Course Outcomes:

On successful completion of the course, the learners should be able to

- CO1:** recognize history, morphology, multiplication, animal viral, plant viral diseases and host response (K₁).
- CO2:** classify properties of virus, components of viral multiplication, bacteriophages, plant viruses and antiviral therapy (K₂).
- CO3:** illustrate viral cell transformation, transmission, multiplication, symptoms and control of animal and plant viral diseases (K₃).
- CO4:** examine viral transmission (K₄).
- CO5:** summarize the immune responses to viruses, Interferon and other cytokines (K₄).

UNIT-I

Introduction to Virus - History, Occurrence, Morphology of viruses - Helical, Icosahedral and Complex viruses - LHT and ICTV system of classification - Properties of viruses.

UNIT-II

Cultivation and quantification of viruses, Separation and characterization of viral components. Viral multiplication - Attachment, entry, un-coating, replication, assembly, release, Cell transformations.

UNIT-III

Bacteriophages -Introduction, Classification of bacteriophage- phage M13- phage lambda. Animal viruses- Introduction, Classification- Transmission, Multiplication, symptoms and control of following animal viral diseases: Simion Virus 40, Adenoviruses and Retroviruses.

UNIT-IV

Introduction to Plant viruses-Classification - Transmission, Multiplication, symptoms and control of following plant viral diseases: Cauliflower mosaic virus, Tobacco mosaic virus, Potato leaf roll virus. Subviral agents - Virusoids and Satellite virus.

UNIT-V

Host response and antiviral agents - Immune responses to viruses, Interferon and other cytokines, Antiviral therapy, Viral titre / assay methods.

Text books:

1. Ann Giudici Fettner, 1990. The science of viruses, 2nd edition, Quill, William Marrow, New York.
2. Dimmock N.J and Primerose S.B, 2007. Introduction to modern virology, 6th edition, Blackwell scientific publication, Oxford, London.

Reference books:

1. Villarreal L.P, 2005. Viruses and the Evolution of Life. A.S.M Press, Washington D.C.
2. Roger Hull, Mathews, 2002. Plant Virology, 4th edition, Academic press- A Harcourt Science and technology company, New York.
3. Topley and Wilson, 2005. Principles of bacteriology, Virology and immunity, 11th edition, vol 4, Edward Arnold, London.
4. Robert I Krasner, 2002. The Microbial challenge: Human Microbe Interaction, American Society for Microbiology, 2nd edition, Washington.



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DEPARTMENT OF MICROBIOLOGY
(For those who joined in 2019-2020 and after)

Class : B.Sc (Microbiology)
Semester : VI
Subject Code : 19UMBCP7

Part III : Core
Hours : 04
Credits : 03

MEDICAL MICROBIOLOGY AND VIROLOGY – PRACTICAL

Course Outcomes:

On successful completion of the course, the learners should be able to

- CO1:** show isolation of bacteria from samples (K₁).
- CO2:** outline identification of bacterial pathogens (K₂).
- CO3:** construct straining techniques (K₃).
- CO4:** compare cultivation of viruses (K₄).
- CO5:** explain the cultivation of viruses by embryonated egg method (K₄)

1. Collection and processing of clinical specimen for microbiological examination.
2. Isolation of normal bacterial flora of skin by swab method
3. Isolation of bacteria from sputum sample
4. Isolation and Identification of bacterial pathogens from Urine sample –*Staphylococcus aureus* & *E.coli*
5. Differentiation of *Staphylococci* sp. by coagulase test
6. Serodiagnosis of bacterial infection-Widal Test
7. Antibacterial sensitivity test - Kirby- Bauer method
8. Determination of MIC & MBC
9. Isolation of Dermatophytic fungus - *Candida albicans*
10. Saline and iodine wet mount to demonstrate protozoan parasites
11. Giemsa staining for the demonstration of blood parasites
12. Isolation of Bacteriophage from sewage and concentration of bacteriophages
13. Demonstration of mechanical transfer of viruses in plants
14. Demonstration of cultivation of viruses by embryonated egg method

Text books:

1. Rajan S and Selvi Christy R, 2015. Experiments in Microbiology. Anjana Books House, Chennai.
2. Florence G Burleson, Thomas M Chambers and Danny L Wiedbrauk, 1992. Virology: A laboratory Manual. Academic Press, UK.

Reference books:

1. Ranjan Kumar De, 2007. Diagnostic Microbiology, Jaypee Brothers publishing, New Delhi.
2. Gunasekaran P, 1995. Laboratory Manual in Microbiology. New Age International (P) Ltd. Publishers, New Delhi.
3. Kannan N, 1996. Laboratory Manual in General Microbiology, Palani Paramount Publication, Palani.
4. James G, Cappuccino, 1996. Microbiology. The Benjamin / Cummings Pub. Co. California.
5. Morag C, Timbury, 1994. Medical Virology. 10th edition, Churchill Livingston.



MANNAR THIRUMALAI NAICKER COLLEGE (Autonomous)
DEPARTMENT OF MICROBIOLOGY
(For those who joined in 2019-2020 and after)

Class : B.Sc (Microbiology)
Semester : VI
Subject Code : 19UMBE61

Part III : Core Elective
Hours : 05
Credits : 05

BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS

Course Outcomes:

On successful completion of the course, the learners should be able to

CO1: state biosafety and IPR (K₁).

CO2: discuss biosafety guidelines and GMO (K₂).

CO3: summarize legal protection of biotechnological inventions (K₂).

CO4: illustrate patent licensing and agreement (K₃).

CO5: point out patent filing, and some well-known / well-publicized case studies related to IPR (K₄).

Unit - I

Biosafety: Definition - Biosafety issues in biotechnology; Biological Safety Cabinets & their types; Primary Containment for Biohazards; Biosafety Levels of Specific Microorganisms.

Unit - II

Biosafety guidelines and regulations (National and International); GMOs / LMOs- Concerns and Challenges; Role of Institutional Biosafety Committees (IBSC), RCGM, GEAC etc. for GMO applications in food and agriculture.

Unit - III

Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Overview of International Agreements - Cartagena Protocol. RES guidelines for using radioisotopes in laboratories and precautions.

Unit - IV

Intellectual Property: Introduction and Importance of IPR - Patents: Types, Trademarks, Copyright & Related Rights, Industrial Design and Rights - patentable and non patentables - patenting life - legal protection of biotechnological inventions.

Unit - V

Grant of Patent and Patenting Authorities: Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition; An introduction to Patent Filing Procedures; Patent licensing and agreement. Rights and Duties of patent owner.

Text books:

1. Goel D & Prashar S (2013). IPR, Biosafety and Bioethics. Pearson
2. Singh K K (2015). Biotechnology and Intellectual Property Rights: Legal and Social Implications, Springer India.

Reference books:

1. Kankanala C (2007). Genetic Patent Law & Strategy, 1st Edition, Manupatra Information Solution Pvt. Ltd. New Delhi.
2. Mittal, D.P. (1999). Indian Patents Law, Taxmann, Allied Services (p) Ltd.
3. Senthil Kumar Sadhasivam and Mohammed Jaabir, M. S. 2008. IPR, Biosafety and biotechnology Management. Jasen Publications, Tiruchirappalli, India.
4. Bare Act, 2007. Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., New Delhi.



MANNAR THIRUMALAI NAICKER COLLEGE (Autonomous)
DEPARTMENT OF MICROBIOLOGY
(For those who joined in 2019-2020 and after)

Class : B.Sc (Microbiology)

Semester : VI

Subject Code : 19UMBE62

Part III : Core Elective

Hours : 05

Credits : 05

BIOSTATISTICS

Course Outcomes:

On successful completion of the course, the learners should be able to

CO1: define biostatistics and the methodology including data collection, sampling, data interpretation and its presentation (K₁).

CO2: identify sources of data in life science, sampling technique, measures of central tendency, dispersion and forms of presentation (K₂).

CO3: interpret the data classification, data validation and diagrammatic representation (K₃).

CO4: experiment study using data collection, sampling, data analysis and disseminating results with data presentation (K₄).

CO5: compare the types of sampling (K₄).

Unit - I

Introduction-Biostatistics, Classification of data - Geographical, chronological, quantitative and qualitative, Objectives of data classification, Sources of data in life science..

Unit - II

Collection of data – Primary data - Secondary data -Types of Variables - Tabulation and presentation of data - Kinds of biological data - Functions of statistics and limitation of statistics.

Unit - III

Sampling - Introduction and Theory of sampling, Types of sampling- random and non- random sampling methods.

Unit - IV

Measures of central tendency - Mean, Median and Mode – Measures of dispersion – range, quartile deviation, standard deviation.

Unit - V

Data presentation - Introduction, three forms of presentation - textual form, tabular form and graphical form. Frequency - types of diagram - bar, pie, histogram and line diagram.

Text book :

Gurumani N, 2004. An Introduction to Biostatistics. MJP publishers, Chennai.

Reference books:

1. Arora P.N and P.K, Malhan 2008. Biostatistics. Himalaya Publications, Mumbai.
2. Daniel W.W, 2006. Biostatistics-A foundation for analysis in health sciences, John Wiley (Asia) & sons, Singapore.
3. Gupta S.P, 1987, Statistical Methods. Sultan Chand & Sons Publishers, New Delhi
4. Sundar Rao, P.S.S and Righard J, 2002. An Introduction to Biostatistics. 5th edn PHI, Learning private Ltd, New Delhi.



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DEPARTMENT OF MICROBIOLOGY
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Class : B.Sc (Microbiology)
Semester : VI
Subject Code : 19UMBE63

Part III : Core Elective
Hours : 05
Credits : 05

DIAGNOSTIC MICROBIOLOGY

Course Outcomes:

On successful completion of the course, the learners should be able to

- CO1:** describe microscopical diagnosis of bacteria, fungi and parasites (K1).
- CO2:** categorise culture media for the isolation of pathogens (K2).
- CO3:** prepare serological diagnosis for pathogens (K3).
- CO4:** analyse bacterial, fungal, viral and parasitic infections (K4).
- CO5:** correlate the infections with the environment (K4).

Unit-I

Diagnostic Microbiology - Introduction - Methods of collection, transport and processing of clinical specimens - Blood, Urine, Sputum, skin, CSF, Pus & Faeces for microbiological examination. Separation of blood and serum.

Unit-II

Diagnosis of Bacterial Infections: Microscopic examination, culture media and incubation, serological test - Widal, Antibacterial susceptibility testing. Laboratory diagnosis of urinary tract infections & respiratory tract infections.

Unit-III

Diagnosis of fungal infections: Microscopic examination, culture media and incubation, serological test for fungi - Antifungal susceptibility test. Laboratory diagnosis of skin and foot infections.

Unit-IV

Diagnosis of Viral infections: Virus culture - specimen processing - isolation and identification of viruses, viral antigen detection: fluorescent antibody and solid phase immunoassays - viral serology.

Unit-V

Laboratory methods for parasitic infection - Diagnostic techniques for faecal, Gastro - intestinal and urino-genital specimen. Microscopic examination and its significance. Identification of intestinal protozoa, Blood protozoa, Intestinal and Blood helminths.

Text books:

1. Bailey & Scott's (2014). Diagnostic Microbiology. 13th edition, The C.V. Mosby Company
2. Ranjan Kumar De, (2007). Diagnostic Microbiology, Jaypee Brothers publishing, New Delhi.

Reference books:

1. Gunasekaran, P. (1995). Laboratory Manual in Microbiology, New Age International (P) Ltd. Publishers, New Delhi.
2. Kannan, N. (1996). Laboratory Manual in General Microbiology, Palani Paramount Publication, Palani.
3. Rajan S and Selvi Christy R. 2015. Experiments in Microbiology. Anjana Books House, Chennai



MANNAR THIRUMALAI NAICKER COLLEGE (Autonomous)

**DEPARTMENT OF MICROBIOLOGY
(For those who joined in 2019-2020 and after)**

**Class : B.Sc (Microbiology)
Semester : VI
Subject Code : 19UMBPR1**

**Part III : Core
Hours : 07
Credits : 05**

PROJECT

- Group Project – Maximum 4 Students in a group
- Record submission – A hard bound report to be submitted to the Department.
- Evaluation – Project (oral) presentation followed by a brief Viva.
- Internal – 40 Marks (Course Teacher)
- External – 60 Marks (Course Teacher and External Member)

Course Description

The Project is conducted by the following Course Pattern.

Internal

| | | |
|--------------|---|-----------|
| Presentation | } | 40 |
| Submission | | |

External

| | | |
|----------------|---|-----------|
| Project Report | } | 60 |
| Viva Voce | | |

| | | |
|--------------|---|------------|
| Total | - | 100 |
|--------------|---|------------|



MANNAR THIRUMALAI NAICKER COLLEGE (Autonomous)
DEPARTMENT OF MICROBIOLOGY
(For those who joined in 2019-2020 and after)

Class : B.Sc (Microbiology)
Semester : VI
Subject Code : 19UMBS61

Part IV : Skill
Hours : 02
Credits : 02

ENTREPRENEURIAL MICROBIOLOGY

Course Outcomes:

On successful completion of the course, the learners should be able to

- CO1:** outline entrepreneurial microbiology, Microbial pharmacology, Cosmetic microbiology and Microorganisms in food (K₁).
- CO2:** discuss food preservation methods (K₂).
- CO3:** extend entrepreneur development in microbial drug, vaccines, cosmetic preparation and microbial production (K₃).
- CO4:** prepare entrepreneurial activity plan in Microbial pharmacology, Cosmetic microbiology and microorganisms in food (K₄).
- CO5:** compare the contribution and risk assessment in entrepreneurial microbiology (K₄).

UNIT-I

Entrepreneurial Microbiology- Introduction - Entrepreneur development, activity, Institutes involved, Government contributions to entrepreneur, risk assessment.

UNIT – II

Microbial Pharmacology- Definitions - Pharmacognosy, Pharmacodynamic and Pharmacogenomics. Microbial drugs and edible vaccines. Biopharmaceuticals- source, production methods of cytokines, haemopoietic growth factors, hormones and therapeutic enzymes.

UNIT-III

History of Cosmetic Microbiology - Need for cosmetic microbiology, Scope of cosmetic microbiology - Role of microbes in cosmetics preparation.

UNIT-IV

Microorganisms in food - Food preservation – Principles, Asepsis - anaerobic condition, high temperature, low temperature & drying, Food additives, Canning.

UNIT-V

Microbial production - Organic acid – Citric acid, Antibiotics – Streptomycin, Enzyme – Protease, Alcohol- Wine.

Text book:

1. Prescott LM, Harley JP and Helin DA, 2002. Microbiology, fifth edition, McGraw Hill, New Delhi.

Reference books:

1. Frazier WC and West Hoff DC, 1988. Food Microbiology. Fourth edition, McGraw Hill, New York.
2. Prescott and Dunn., 2004. Industrial Microbiology, 4th edition, CBS Publishers & Distributors, Delhi.
3. N.K.Jain, 2019. Pharmaceutical Microbiology, 3rd edition Vallabh Prakashan, Delhi.
4. Daniel K, Brannan. 1997. Cosmetic Microbiology: A practical handbook, CRC Press.