

ಮೈಸೂರು ವಿಶ್ವವಿದ್ಯಾನಿಲಯ



**University of Mysore**  
(Estd.1916)

**M.Sc. MICROBIOLOGY**

**Credit Based Choice  
Based Continuous  
Evaluation Pattern  
System**



**UNIVERSITY OF MYSORE**

**Department of Studies in Microbiology**

**Manasagangotri, Mysuru-570006**

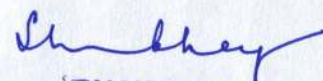
**Regulations and Syllabus**

**Master of Science in Microbiology (M.Sc.)**

**(Two-year semester scheme)**

**Under**

**Credit Based Choice Based Continuous Evaluation Pattern  
System**



**CHAIRMAN  
BOARD OF STUDIES  
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UNIVERSITY OF MYSORE**

**UNIVERSITY OF MYSORE**  
**GUIDELINES AND REGULATIONS LEADING TO**  
**MASTER OF SCIENCE IN MICROBIOLOGY**  
**(TWO-YEAR SEMESTER SCHEME) UNDER**  
**CREDIT BASED CHOICE BASED CONTINUOUS EVALUATION PATTERN SYSTEM**

**Programme Details**

<b>Name of the Department</b>	: Department of Studies in Microbiology
<b>Subject</b>	: Microbiology
<b>Faculty</b>	: Science and Technology
<b>Name of the Programme</b>	: Master of Science in Microbiology (M.Sc.)
<b>Duration of the Programme</b>	: 2 years divided into 4 semesters

**Programme Outcomes**

On completion of M.Sc. (Microbiology), students are able to:

1. Instill the intellectual skills to analyze the molecules using advance biophysical techniques such as HPLC, GC, AAS, PCR etc.
2. Perform the quantitative/ qualitative analysis of biomolecules and understand various biochemical pathways
3. Acquire knowledge and understanding the concepts of microbial genetics, molecular biology, Immunology, Enzymology.
4. Explore the scientific literature effectively and use computational tools such as bio-statistics and bioinformatics
5. Implement the knowledge in industry with regard to scale up, production, down stream processing and quality control of the various microbial products
6. Conduct the basic research related to industry-environmental issues and use of agricultural for sustainable products



### **Programme Specific Outcomes**

1. Understand and be able to explain different branches of microbiology such as bacteriology and virology.
2. To develop laboratory skills applicable to Microbiological research in the field of environmental microbiology, industrial microbiology, food microbiology and microbial pathogenesis.
3. Design and execute experiments related to basic microbiology, immunology, molecular biology, recombinant DNA technology and microbial genetics, which will enable to execute a short research project under the supervision of teachers.
4. Equip to take up a suitable position in academia or industry, and to pursue a career in research if so desired.

**University of Mysore**  
Department of Studies in Microbiology  
**Credit Based Choice Based Continuous Evaluation Pattern System**

### **SCHEME OF THE STUDY**

#### **For B.Sc. (Honors) in Microbiology**

Credits to be earned	: 40 credits
Hard core papers	: 16 credits
Soft core paper	: 16 credits
Open elective paper	: 04 credits
Project work / term work	: 04 credits

#### **For M. Sc. in Microbiology**

Credits to be earned	: 76 credits
Cumulative total of credits to be completed	: 40 credits (Honors ) + 36 credits
Hard core papers	: 36 credits
Soft core papers	: 32 credits
Project work / term work	: 08 credits

**M.Sc. in Microbiology (76 credits)**  
Credit Based Choice Based Continuous Evaluation Pattern System  
Proposed Semester-wise distribution of the course structure for the year 2018-2019

**First Semester: 20 Credits**

No	Paper Code	Title Of The Course Paper	HC/S C/ OE	L:T:P	Credits
1	18251	Virology	HC	3:1:0	4
2	18252	Bacteriology	HC	3:1:0	4
<b>Select 4 out of 5 papers</b>					
3	18253	Mycology	SC	3:1:0	4
4	18254	Microbial Genetics	SC	3:1:0	4
5	18255	Microbial Ecology & Diversity	SC	3:1:0	4
6		Practical I (Virology & Bacteriology)	SC	0:0:2	2
7		Practical II (Mycology & Microbial Genetics)	SC	0:0:2	2

HC=02; SC=04; OE=0

**Second Semester: 20 Credit**

No	Paper Code	Title Of The Course Paper	HC/SC /OE	L:T:P	Credits
1	18261	Microbial Physiology	HC	3:1:0	4
2	18262	Immunology	HC	3:1:0	4
<b>Select 3 out of 4 papers</b>					
3	18263	Food Microbiology	SC	3:1:0	
4	18264	Soil Microbiology	SC	3:1:0	4
5		Practical III (Microbial Physiology & Immunology)	SC	0:0:2	2

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6		Practical IV (Food Microbiology)	SC	0:0:2	2
7	18265	Microbial Diversity	OE	2:2:0	4

HC=02; SC=03; OE=1

**Third semester: 20 credit**

NO	Paper Code	Title Of The Course Paper	HC/SC /OE	L:T:P	Credits
1	18271	Molecular Biology	HC	3:1:0	4
2	18272	Genetic Engineering	HC	3:1:0	4
3	18273	Industrial Microbiology	HC	3:1:0	4
<b>Select 3 out of 4 papers</b>					
4	18274	Medical Microbiology	SC	3:1:0	4
5	18275	Clinical & Diagnostic	SC	3:1:0	4
6		Practical V (Molecular Biology & Genetic Engineering)	SC	0:0:2	2
7		Practical VI (Industrial Microbiology & Medical Microbiology)	SC	0:0:2	2
8	18276	Techniques in Microbiology	OE	1:1:0	2

HC=02; SC=03; OE=01

**Fourth Semester: 18 credit**

NO	Paper Code	Title Of The Course Paper	HC/SC /OE	L:T:P	Credits
1	18281	Agricultural Microbiology	HC	3:1:0	4
<b>Select 2 out of 3 papers</b>					
2	18282	Environmental Microbiology	SC	3:1:0	4

3	18283	Genomics & Proteomics	SC	3:1:0	4
4		Practical VII (Agricultural Microbiology & Environmental Microbiology)	SC	0:0:2	2
5		Project Work	HC	0:2:6	8

HC=01; SC=02; PW=01

**Grand Total Credits: 76**

### FIRST SEMESTER

#### HARDCORE

#### COURSE-I: VIROLOGY

48 Hr

#### Course Outcome

Upon successful completion of the course, the student would have gained knowledge regarding the following aspects;

- classification of viruses
- Tools and methods employed for studying viruses mode of transmission, patterns of infection, virus virulence, and host defense against virus infection
- Knowledge about existing viral vaccines and anti-viral drugs, emerging viruses.

#### Pedagogy

Virology is a sub-discipline of Microbiology which focuses on the basic knowledge of viruses, their reproduction and pathogenesis within a host cell. The contents of the course are divided into four units. This course will emphasize basic concepts of viruses, their diversity (structural, host range and genetic), various methods employed in virus studies, replication strategies, host virus interactions, emerging viral diseases, antiviral strategies in prevention and control of viral diseases and their applications, evolution and future prospective. These concepts are taught across thirty two hours, which include lectures in which students are provided information and illustrations of various virus aspects, and tutorials in which students present seminars of the topics assigned. The lecture will impart students with knowledge and make them understand how viruses are built, replicate and evolve, cause disease, prevention of infection and their applications. The knowledge gained about viruses helps the students to develop interest in this field and helps the students to work in laboratories that are interested in isolation of viruses from various ecological niche, molecular pathogenesis, vaccines, antiviral drugs, applications such as virus vectors development and in health and diagnostic laboratories.

#### Course Content:

48 Hr

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## UNIT-I

12 Hr

**The science of virology:** Concept and scope of virology. Definitive properties of viruses: Morphology, Ultra structure, Chemical composition - proteins, nucleic acids, and other contents. Classification and nomenclature of viruses. Evolutionary importance of viruses.

**Working with viruses:** Visualization and enumeration of virus particles, Biological activity of viruses, Physical and chemical manipulation of the structural components of viruses, Characterization of viral product expressed in the infected cells. Isolation and purification of viruses, Detection of viruses: physical, biological, immunological and molecular methods.

## UNIT-II

12 Hr

**Virus replication Strategies:** Principal events involved in replication: Adsorption, penetration, uncoating nucleic acid and protein synthesis, intracellular trafficking, assembly, maturation and release, viral-host interaction, Host response to viral infection.

**Replication patterns of specific viruses:** Identification of virus prototypes associated with different virus replication schemes; Details on important viruses namely Herpes virus, Poliovirus, Influenza virus, SV40 and Adeno Virus, Poxviruses, Hepatitis Viruses, Retroviruses.

## UNIT-III

12 Hr

**Propagation, purification, characterization and identification and genomics of plant viruses:** General methods of propagation of plant viruses; purification of plant viruses using centrifugation, chromatography and electrophoresis techniques, methods employed in identification of plant viruses.

**Sub-viral particles:** Discovery, Structure, Classification, replication and diseases caused by Satellite, Satellites virus, Virusoids, Viroids and Prions.

**Anti-viral strategies-prevention and control of viral diseases:** Host specific and Non specific defense mechanisms involved in resistance to and recovery from virus infections. Role of interferon in viral infections. Viral Chemotherapy: Nucleoside analogs, reverse transcriptase inhibitors, protease inhibitors, History of vaccines especially smallpox and polio. New methods: subunit vaccines, antiidiotype and DNA vaccines.

## UNIT-IV

12 Hr

**Microbial viruses:** Diversity, classification, characteristics and applications of bacteriophages, and general account on algal, fungal and protozoan viruses.

**Viruses and the future:** Promises and problems. Emerging diseases, sources and causes of emergent virus diseases.

### References:

1. Marc H.V. van Regenmortel , Brian W.J. Mahy (2009) Desk Encyclopedia of General Virology , 1 edition, AcademicPress.
2. Alan J. Cann (2011) Principles of Molecular Virology, 5th edition ,Elsevier
3. Clokie, Martha R. J., Kropinski, Andrew (2009) Bacteriophages, Methods and Protocols, Volume 1: Isolation, Characterization, and Interactions, HumanaPress



4. Edward K. Wagner, Martinez J. Hewlett , David C. Bloom , David Camerini (2007), Basic Virology, 3rd Edition, John Wiley & Sons.
5. Hunter-Fujita, Frances R., Philip F. Entwistle, Hugh F. Evans, and Norman E. Crook. Insect viruses and pest management. John Wiley & Sons Ltd, 1998.
6. Jane S. Flint, Lynn W Enquist, Anna Marie Shalka (2004) Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses, American Society for Microbiology
7. John Carter, Venetia A. Saunders, (2007), Virology: Principles and Applications. John Wiley & Sons, West Sussex, England.
8. Lobočka, Malgorzata, and Waclaw T. Szybalski, eds. (2012) Bacteriophages. Part 2 , Academic Press
9. Matthews, Richard Ellis Ford, and Roger Hull. (2002) Matthews' plant virology. 4th edition, Gulf Professional Publishing.
10. Nigel Dimmock, Andrew Easton, Keith Leppard, 2009, Introduction to Modern Virology, 6<sup>th</sup> Edition, Wiley-Blackwell.

## **COURSE-II: BACTERIOLOGY**

**48 Hr**

### **Course Outcome:**

Upon successful completion of the course, the student:

- Are able to describe the morphological features, cell arrangement and structural components of bacterial cell in detail and differentiate between Gram-positive and Gram-negative bacteria.
- Will have gained knowledge about cell wall structure and extracellular appendages in different bacteria and will be acquainted with current methodologies available for production of protoplasts and L-forms
- Know key features of some model archaeal organisms.
- Understand Quorum sensing in bacteria and its significance in competence, sporulation and antibiotic resistance.

### **Pedagogy:**

Bacteriology is the sub-disciplinary course of Microbiology. Bacteriology is the study of bacteria and their importance in medicinal and other areas such as agriculture, industries. Bacteria are single celled microorganisms which can live as independent organisms or dependently as parasites. Superficially bacteria appear to be relatively simple forms of life; in fact they are sophisticated and highly adaptable.

The discipline of bacteriology evolved from the need to test and apply the germ theory of disease and from economic concern relating to the spoilage of food and wine. The contents of this course are divided into various units and each unit focuses on various aspects of bacteriology such as serial dilution technique, microscopy, staining technique, classification and taxonomy and economic importance of bacteria.

The knowledge gained under this subject helps the student to work in laboratories, pharmacological industries, and in any industries where microorganisms are used as chief source.

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## Course Content

### UNIT-I

12 Hr

**Introduction:** Important events in development of bacteriology, Scope and relevance of bacteriology. Economic importance of bacteria.

**Cell Structure:** An overview of bacterial size, shape and arrangement, structure, chemical composition of cell wall of Archaeobacteria, gram-negative bacteria, gram-positive bacteria and acid fast bacteria, cell wall deficient organisms including L-form structure, composition and function of cell membrane, capsule, flagella, pili, Inclusion bodies, ribosomes, mesosomes, reserve food materials, magnetosomes and phycobilisomes, endospores, bacterial nucleic acids – chromosome, plasmid, transposons, integrons and antibiotic resistance cassettes.

**Microscopy:** Working Principles of bright field microscope, fluorescent microscope, dark field microscope, phase contrast microscope, stereo microscope, confocal microscopy and electron microscope. Preparation of sample for electron microscopic studies. Application and importance of above microscopes. Measurement of microscopic objects.

### UNIT-II

12 Hr

**Bacterial classification and taxonomy:** Criteria for the classification of bacteria. Phenetic, Phylogenetic, Genotypic, Numerical taxonomy. Techniques for determining microbial taxonomy and Phylogeny. ICNB rules. Classification systems of major categories and groups of bacteria according to Bergey are manual of Systematic Bacteriology and Determinative Bacteriology. Non-culturable methods for the identification of pathogenic microorganisms.

### UNIT-III

12 Hr

**Growth, Cultivation and control of Bacteria:** Nutrient requirements, nutritional types of bacteria, culture media, classification of media. Growth: Nutritional uptake, Growth kinetics, generation time, growth curve, factors affecting growth. Methods for measurement of microbial growth – direct microscopy, viable count estimates, turbidometry, and biomass. Aerobic, anaerobic, batch, continuous and synchronous cultures. Methods of pure culture isolation, Enrichment culturing techniques, single cell isolation, and pure culture development. Preservation and Maintenance of Microbial cultures: Repeated sub culturing, preservation at low temperature, sterile soil preservation, mineral oil preservation, deep freezing and liquid nitrogen preservation, lyophilization. Advantages and disadvantages of each method. Control of

microorganisms: Antimicrobial agents, physical and chemical methods. Principles, functioning and types of Biosafety cabinets.

#### UNIT-IV

12 Hr

**Characteristics and Salient features of major groups of Bacteria: Archaeobacteria:** general characteristics and classification; extremophiles, halophiles, thermophiles and barophiles; General characteristics, classification, diversity and distribution, economic importance of **Actinomycetes, Cyanobacteria. Bioluminescent bacteria;** characteristics and examples, mechanism of bioluminescence. General characteristics, life cycle, growth, multiplication and significance of **Mycoplasma, Rickettsiae and Chlamydia**

#### References:

1. Sherwood, and Woolverton Willey (2007), Prescott, Harley, and Klein's Microbiology (7<sup>th</sup> International Edition), McGraw-Hill
2. Mara, Duncan, and Nigel J. Horan, (2003). Handbook of water and wastewater Microbiology, Academic Press.
3. Michael T. Madigan, David P. Clark, David Stahl, John M. Martinko, 2012, Brock Biology of Microorganisms 13th Edition, Benjamin Cummings
4. Jacquelyn G. Black (2012) Microbiology: Principles and Explorations ,8th edition, Wiley
5. Michael J. Leboffe, Burton E. Pierce , David Ferguson (2012) Microbiology Laboratory Theory & Application, Brief, 2nd Edition, Morton Publishing Company
6. Jeffrey C. Pommerville (2010) Alcamo's Fundamentals of Microbiology, 9th Revised edition, Jones and Bartlett Publishers, Inc
7. Jeffrey C. Pommerville (2010) Alcamo's Laboratory Fundamentals of Microbiology, Jones and Bartlett Publishers, Inc
8. Alfred Brown (2011) Benson's Microbiological Applications Short Version (Brown, Microbiological Applications), 12th edition, McGraw-Hill Science/Engineering/Math.
9. Jerome J. Perry , James Staley , Stephen Lory (2002), Microbial Life, Sinauer Associates.
10. Stuart Hogg (2013) Essential Microbiology, 2nd Edition, Wiley-Blackwell

#### COURSE- III: MYCOLOGY

48 Hr

#### Course outcome:

- To understand the world of fungi and lichens,
- Appreciate the adaptive strategies of the fungi and lichens,
- understand the economic and pathological importance of fungi, and identify common plant diseases and devise control measures
- In tutorial classes they do group discussions on use full and pathogenesis of different fungi involved in daily life.

- In practical classes they mount the fungi, learn microscopic views and the key characteristics to identify different species of fungi.

### **Pedagogy:**

Mycology is the sub-branch of Microbiology, which is concerned with the study of fungi. It includes the study of taxonomic classification, fungal genetics, and biochemical properties. Fungi are fundamental for life as symbionts, also takes part in biodegradation process. They are socially and economically important as they are capable of causing diseases in plants, animals and human beings.

Study of fungi is highly important as it plays major role in production of food supplements like SCP, fermentation industries, vitamins, enzymes, organic acids. Another notable element is production of secondary metabolites like antibiotics which acts against other microbes. In agriculture, knowledge pertaining to fungi should be maximum as it causes plant diseases leading to economic loss. Fungal infections have more devastating effects on human health and hence clinical significance of fungi has gained more attention, due to its wide applications and effects, the study of fungi is highly recommended.

### **Course Content**

#### **UNIT-I** **12 Hr**

**Introduction:** History and Development of Mycology, scope of mycology. Recent developments in Mycology.

**Fungal taxonomy:** Taxonomic problems associated with variation in fungi, Classification of fungi (Alexopoulos and Mims).

#### **UNIT-II** **12 Hr**

**General characteristics of fungi and reproduction:** Morphology and somatic structures: The thallus, organization, fungal cell, nuclear components, specialized somatic structures; Aggregation of hyphae, tissues, mycangia, General aspects of fungal nutrition and reproduction (Asexual, Sexual reproduction, Heterothalism and Parasexuality)

#### **UNIT-III** **12 Hr**

**Salient features of fungal major groups:** Chytridiomycota, Zygomycota, Basidiomycota, Ascomycota, Deuteromycota, Oomycota, Hypochytrio mycota, Labyrinthulomycota, Plasmodiophoromycota and Myxomycota. Symbiotic fungi-Lichens.

#### **UNIT-IV** **12 Hr**

**Economic importance of fungi:** Fungi as biocontrol agent, Economic importance of Fungi in Agriculture, Industry and medicine. Fungi as SCP, Fungi as parasites of human and plants. Role of fungi in bio deterioration of wood and paper. Mycorrhiza – ectomycorrhiza, endomycorrhiza, vesicular arbuscularmycorrhiza. Fungi as insect symbiont.

**Reference:**

1. Alexopoulos C J and Mims C W, 1979 Introductory Mycology 3rd edn, Wiley Eastern.,NewDelhi.
2. Deacon, J W, 1997- Modern Mycology 3rd Edition, Blackwell Science publishers,London.
3. Mehrotra, RS &Aneja, K R, 1998. An Introduction to Mycology. New Age International Pvt. Ltd. NewDelhi.
4. Odum, E.P. 1971. Fundamentals of Ecology; Third Edition. Toppan Co. Ltd. Tokyo, Japan.
5. Mercedes S. Foster& Gerald F. Bills (2011) Biodiversity of Fungi: Inventory and Monitoring Methods. AcademicPress
6. Michael John Carlile, Sarah C. Watkinson, G. W. Gooday (2007) The fungi. Academic Press. London, U. K
7. Kevin Kavanagh (2011) Fungi: Biology and Applications. John Wiley & Sons, Sussex,U.K.
8. David Moore, Geoffrey D. Robson, Anthony P. J. Trinci (2011) 21st Century Guidebook to Fungi. Cambridge UniversityPress.

**COURSE-IV: MICROBIAL GENETICS****48 Hr****Course outcome:**

- Can discuss the importance of mutation analysis, can analyze mutations by complementation and recombination tests, and can design a strategy to create gene replacement in bacteria
- Is able to explain how plasmid copy number is regulated, can differentiate between Hfr strains and strains carrying F plasmid, and can construct a genetic map of bacterial genome using conjugation-based method
- Is able to compare and contrast generalized versus specialized transduction, knows how to construct genetic linkage maps using two-factor and three factor cross, is able to discuss the basis of natural competence in bacteria.
- Is able to list the events in the lytic and lysogenic phases of lambda phage life cycle and the regulatory factors and events involved.
- Can list the outcomes of transposition events, can design strategies to mutagenize bacteria using transposons, can explain the construction of conditional knockouts
- Can differentiate between positive and negative regulation of gene expression, inducible and repressible systems. Can describe the regulation of the lac, trp, gal,ara and tol operons.
- Will have learnt about the model organisms used in biological studies.

**Pedagogy:**

Microbial genetics deals with the transmission of hereditary characters in microorganisms like bacteria, viruses and algae which play a unique role in developing field of molecular and cell biology and plays wide role in applications in the field of medicine, agriculture, food and pharmaceutical industry. The benefits of microbial

genetics in the field of agriculture are increased in crop yields which reduce the cost for food or drug production, reduce need for pesticide and medical benefits to the worlds growing population by recombinant DNA technology and as vectors.

The importance of genetics study involves; to understand the gene function of microorganisms. Microbes provide relatively simple system for studying genetic phenomenon and thus useful to other higher organisms.

Microbes provide many value added products like antibiotics, growth hormones etc. Microbial genetics will be helpful to increase these products productivity by microbial technology. Understanding the genetics of disease-causing microorganisms especially virus, bacteria will help to develop strategies to control disease. Microbial genetics will be useful to study the gene transfer from one organism to another and its contribution for genetic variations such as virulence, antibiotic resistance etc.

### Course Content

#### UNIT-I

12 Hr

**Concepts in Microbial Genetics:** History and developments of Microbial genetics. Essentials of microbial genetics: Microbes as Genetic Tools for Basic and Applied Genetic studies. Advantages and disadvantages of Microbes, Generalized reproductive cycles of microbes- *Neurospora*, *Saccharomyces*, *Chlamydomonas* and *Acetabularia*.

#### UNIT-II

12 Hr

**Viral Genetics:** Lytic and Lysogenic cycles, Phage Phenotypes, Phenotypic Mixing, Recombination in viruses: Mutations, Recombination and Mapping.

**Bacterial Genetics:** Bacterial Transformation: Types of transformation mechanisms found in prokaryotes, Bacterial Conjugation: properties of the F plasmid, F<sup>+</sup> x F<sup>-</sup> mating, F' x F<sup>-</sup> conjugation, Hfr conjugation. Transduction: Generalized and specialized transduction, Transposable elements.

#### UNIT-III

12 Hr

**Fungal Genetics:** *Neurospora*- Tetrad analysis and linkage detection - 2 point and 3 point crosses, chromatid and chiasma interference, Mitotic recombination in *Neurospora* and *Aspergillus*.

**Algal Genetics:** *Chlamydomonas*- unordered tetrad analysis - Recombination and Mapping, Nucleocytoplasmic interactions and gene expression in *Acetabularia*. Extra nuclear (Cytoplasmic) inheritance.

#### UNIT-IV

12 Hr

**Mutation and mutagenesis:** Nature, type and effects of mutations. Mutagenesis – physical and chemical mutagens, base and nucleoside analog, alkylating agents, interrelating agents, ionizing radiation. Induction and detection of mutation in microorganisms. Site directed mutagenesis and its applications.

### References:

1. Larry Snyder, Joseph E. Peters, Tina M. Henkin, Wendy Champness (2013) Molecular Genetics of Bacteria, 4th Edition; ASM Press
2. D. Peter Snustad, Michael J. Simmons (2011) Principles of Genetics, 6th Edition; Wiley
3. Stanley R. Maloy, Jhon E. Cronan, Jr. David Freifelder (1994) Microbial Genetics (Jones and Bartlett Series in Biology), 2nd edition; Jones and Bartlett Publishers
4. Uldis N. Streips, Ronald E. Yasbin (2002) Modern Microbial Genetics, 2nd edition; Wiley-Liss
5. Nancy Jo Trun, J. E. Trempy (2003) Fundamental Bacterial Genetics; Wiley-Blackwell
6. John R. S. Fincham (1996) Microbial and Molecular Genetics; Hodder Arnold
7. Venetia A. Saunders (1987) Microbial genetics applied to biotechnology : principles and techniques of gene transfer and manipulation; Springer
8. Sriram Sridhar (2005) Genetics and Microbial Biotechnology; Dominant Publishers & Distributors
9. Dr. Evelyn J. Biluk (2012) Microbiology Study Guide: Microbial Genetics, Controlling Microbial Growth, and Antimicrobial Agents; CreateSpace Independent Publishing Platform
10. Royston C. Clowes, William Hayes (1968) Experiments in Microbial Genetics; Blackwell Science Ltd
11. Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick (2012) Lewin's GENES XI, 11 edition; Jones & Bartlett Learning
12. James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick (2013) Molecular Biology of the Gene, 7 edition; Benjamin Cummings

## SOFTCORE

### **COURSE-V: MICROBIAL ECOLOGY AND DIVERSITY**

**48 Hr**

#### **Course Outcome**

- To understand the ubiquitous nature of microbes.
- To provide knowledge on characteristics of Microbes Outcome
- Students able to differentiate various groups of Microbes
- Get knowledge on adaptability of extremophiles
- Knowledge about microbial taxonomy.
- To create awareness on evolutionary relationship of ecosystem
- To learn about individual ecosystem and its interactions.
- To understand the concepts of community ecology Outcome
- Able to understand the role of microbes in ecology

#### **Pedagogy**

Microbial ecology and diversity is a sub discipline of microbiology (environmental Microbiology) which focuses on the huge diversity of microbes, its interaction among themselves and the ecosystem. Microbes in their natural environments, microbes interact with each other, with plants and animals. Such interactions are essential for ecosystem function and may relate to plant and animal health, biogeochemical cycles and numerous other processes.

Overall this course enables students to learn how the microbial world rules over the entire ecosystem focusing on their interactions which form the basis of survival. The study helps us improve our lives via the use of microbes in environmental restoration, food production, bio-engineering of useful products such as antibiotics, food supplements and chemicals. This course is for all biology, allied health, environmentalists and microbiology students.

The knowledge gained under this subject helps the students to work in laboratories like pharmacological industries, clinical health and diagnostic laboratories, environmental research fields, microbial research and any industry where microorganisms are involved. The need of the hour is to focus on the importance of conservation of microbial diversity mainly the role of culture centers in conservation.

### Course Content

#### UNIT-I

12 Hr

**Introduction to microbial ecology:** Structure of microbial communities. Interaction among microbial populations. Interaction between microorganisms and plants. Biotransformation, biodegradation, bioremediation and phytoremediation. Ecological and Evolutionary diversity (Genetic diversity) of microbial world  
**Development of Microbial communities:** Dynamics of community, ecological succession, structure, dispersion, microbial communities in nature and ecosystem models

#### UNIT-II

12 Hr

**Physiological Ecology of microorganisms:** Adaptation to environmental conditions - abiotic limitations to microbial growth.  
**Viral Diversity:** Group I – T2 Bacteriophage, Group II – Banana bunchy top virus, Group III – Reovirus, Group IV- TMV, Group V – Rhabdovirus, Group VI – HIV, Group VII – Hepatitis virus.  
**Sub-viral particles:** Discovery, Structure, Classification, replication and diseases caused by Satellite, Satellites virus, Virusoids, Viroids and Prions.

#### UNIT-III

12 Hr

**Bacterial Diversity:** Archaeobacteria, Photosynthetic Eubacteria, Chemoautotrophic and Methophilic Eubacteria, Gliding Eubacteria, Spirochetes, Rickettsiae and Chlamydiae, Actinomycetes, Mollicutes, Protists  
**Fungal Diversity:** salient features of the following group: Zygomycota (*Rhizopus*), Ascomycota (*Neurospora*), Basidiomycota (*Agaricus*), Deuteromycota (*Penicillium*), Chytridiomycota (*Allomyces*) Myxomycota and Yeast.

#### UNIT-IV

12 Hr

**Importance and Conservation of Microbial Diversity:** Importance of microbial diversity in environment, pharmaceuticals & human health. Metagenomics. Importance of conservation. *In situ* conservation and *Ex situ* conservation. Role of culture collection centers in conservation.

### References



1. OladeleOgunseitan (2008) Microbial Diversity: Form and Function in Prokaryotes; Wiley-Blackwell
2. Ronald M. Atlas, Richard Bartha (1997) Microbial Ecology: Fundamentals and Applications (4th Edition); Benjamin Cummings
3. David L. Kirchman (2012) Processes in Microbial Ecology; Oxford University Press
4. David L. Kirchman (2008) Microbial Ecology of the Oceans; Wiley-Liss
5. McArthur, J. Vaun (2006) Microbial Ecology An Evolutionary Approach; Academic Press
6. Atlas, Ronald M., Bartha, Richard (1997) Microbial Ecology Fundamentals and Applications; Addison-Wesley
7. Nelson, Karen E. (1997) Advances in Microbial Ecology; Springer
8. Pierre Davet (2004) Microbial Ecology of the Soil and Plant Growth; Science Publ Inc
9. Osborn, A. M., Smith, Cindy (2005) Molecular Microbial Ecology; Taylor & Francis Group
10. OladeleOgunseitan (2004) Microbial Diversity: Form and Function in Prokaryotes; Wiley-Blackwell
11. Satyanarayana, T., Johri, B. N. (2005) Microbial Diversity: Current Perspectives and Potential Applications; I.K. International Publishing House Pvt., Limited
12. James W. Brown (2014) Principles of Microbial Diversity; ASM Press
13. Colwell, R. R., Simidu, Usio, Ohwada, Kouicki (1996) Microbial Diversity in Time and Space; Springer

### **Practical's I (Virology and Bacteriology)**

1. Laboratory safety rules
2. Microscopic measurement of microorganisms by micrometry
3. Culturing and maintenance of bacterial cultures
4. Isolation and enumeration of bacteria from soil
5. Isolation and enumeration of bacteria from water
6. Cultural characteristics of bacteria
7. Staining techniques – simple (positive and negative), differential (Grams and acid fast), structural (endospore and capsule)
8. Motility test (hanging drop method and soft agar method)
9. Biochemical tests for the identification of bacteria – catalase, oxidase, IMViC, Urease, TSIA, Nitrate reduction, gelatin, starch, casein, chitin and esculin hydrolysis.
10. Determination of growth curve in E.coli.
11. Diauxic growth curve in E.coli
12. Isolation of coliphages from sewage
13. Study of morphological changes due to viral infection in plants

### **Practicals II (Mycology and Microbial Genetics)**

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1. Isolation of slime molds.
2. Isolation of aquatic fungi.
3. Isolation of soil fungi.
4. Isolation of fungi from air.
5. Isolation of fungi from cereals and cereal based products.
6. Study of the following representative genera: *Aspergillus*, *Penicillium*, *Fusarium*, *Neurospora*, *Saccharomyces*, *Erysiphae*, *Polyporus*, *Agaricus*, *Puccinia*, *Ustilago*, *Alternaria*, *Drechslera*, *Saprolegnia*, *Rhizopus*, *Trichoderma* and symbiotic fungi-Lichens.
7. Measurement of concentration of fungal conidia by Haemocytometer.
8. Measurement of fungal cells by Micrometer.
9. Replica plating technique for transfer of bacterial colonies.
10. Ultra-violet killing curve and determination of mutant types in *Saccharomyces cerevisiae*.
11. Induction of mutation
12. Isolation of streptomycin resistant strain of *E. coli* by gradient plate method.
13. Ames test
14. Isolation of genomic DNA from bacteria by heat lysis method.
15. Isolation of genomic DNA from yeast by DNA spooning method.

## SECOND SEMESTER

### HARDCORE

#### COURSE-I: MICROBIAL PHYSIOLOGY

48 Hr

##### Course Outcome:

- Learn the methods of measuring microbial growth, calculating growth kinetic parameters with understanding of steady state and continuous growth.
- Knowledge of primary, secondary and group translocation transport systems existing in bacteria, simultaneously learning membrane transport proteins and kinetics of solute transport.
- Understand the central metabolic pathways for carbon metabolism in bacteria and their regulation in diverse physiological conditions. This allows students to apply the acquired knowledge in engineering metabolic pathways for developing industrially useful strains as well as lipid and nucleotide metabolism in bacteria.
- Learn and understand the basic concepts of enzyme biochemistry, kinetics and regulation.
- Knowledge about stress response in bacteria

##### Pedagogy:

Microbial physiology is defined as the study of microbial cell functions which includes the study of microbial growth, microbial metabolism and microbial cell structures. The contents of the course are divided into four main chapters or units those are: A) Microbial physiology, B) Carbohydrate metabolism, C) lipid metabolism, D) Microbial photosynthesis and each unit focuses on various aspects of microbial physiology.

Microbial physiology is an important research field, not only in fundamental research on microbial species but also in all applied aspects of microbiology including physiology of the aerobic microorganisms and anaerobic microbial communities that play an important role in environmental biotechnological processes, such as waste water treatment, soil remediation, production of chemicals, biofuels and recovery of metals.

### Course Content

#### UNIT-I

12 Hr

**Microbial Physiology:** Microbial Energetics, The role of ATP in metabolism. Microbial enzymes: Structure and Classification, Mechanism of Enzyme actions: Lock and Key model, induced fit Theory, Factors affecting rates of enzyme mediated reactions (pH, temperature and substrate and enzyme concentration), Enzyme Inhibition and Enzyme regulation.

#### UNIT-II

12 Hr

**Metabolism of Carbohydrate:** Glycolysis, Citric acid Cycle and different types of Phosphorylation, Fates of pyruvate, Fermentation. Utilization of sugars other than glucose: Lactose, Galactose, Maltose, Mannitol. Degradation of cellulose, Starch and Glycogen.

#### UNIT-III

12 Hr

**Metabolism of other Substrates: Lipid metabolism:**  $\beta$ -oxidation, Biosynthesis of fatty acids, degradation of fatty acids. **Nitrogen metabolism:** Nitrogen metabolism, Biological nitrogen fixation process, symbiotic and non-symbiotic nitrogen fixation. Urea cycle, degradation and biosynthesis of essential and non-essential amino acids. **Nucleic acid metabolism:** Biosynthesis and degradation of purines and pyrimidines.

#### UNIT-IV

12 Hr

**Microbial Photosynthesis:** Photosynthetic Pigments and apparatus in bacteria. Oxygenic and Anoxygenic. Photosynthesis. Autotrophic CO<sub>2</sub> fixation and mechanism of Photosynthesis. Utilization of light energy by Halobacteria.

**Autotrophic Mechanisms in bacteria:** Hydrogen bacteria, Nitrifying bacteria, Purple sulphur bacteria, Non-sulfur bacteria, Green sulfur bacteria, Iron bacteria, Methylophs. **Microbial Stress Responses:** Oxidative stress, Thermal stress, Starvation stress, Aerobic to anaerobic transitions. Biofilm and quorum sensing

#### References:

1. Albert G. Moat, Michael P. Spector John W. Foster (2009) Microbial Physiology,; BWSTM
2. Albert G. Moat, Michael P. Spector John W. Foster (2009) Microbial Physiology,; BWSTM
3. Byung Hong Kim, Geoffrey Michael Gadd (2008) Bacterial Physiology and Metabolism; Cambridge University Press
4. Daniel R. Caldwell (1999) Microbial Physiology and metabolism; Star PubCo

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7. Frederick C. Neidhardt, John L. Ingraham , Moselio Schaechter (1990) Physiology of the Bacterial Cell: A Molecular Approach; Sinauer Associates Inc
8. Robert K. Poole (2014) Advances in Microbial Systems Biology, Volume 64 (Advances in Microbial Physiology); Academic Press
9. Rose, Anthony H. () Advances in Microbial Physiology, Vol. 9; Elsevier Science & Technology Book
10. Rose, Anthony H. (1976) Chemical Microbiology An Introduction to Microbial Physiology; Basic Books

## **Course-II: Immunology**

**48 Hr**

### **Course Outcome:**

- Will be able to understand the fundamental bases of immune system and immune response
- Will be able to gather information about the structure and organization of various components of the immune system
- Will be able to understand the genetic organization of the genes meant for expression of immune cell receptors and the bases of the generation of their diversity
- Will be able to understand the operation and the mechanisms which underlie the immune response
- Will be able to apply the knowledge gained to understand the phenomena like host defense, hypersensitivity (allergy), organ transplantation and certain immunological diseases

### **Pedagogy:**

Immunology is the branch of biology which deals with various aspects that forms an integrated network of cells, molecules, and organs within the immune system. This course helps students to learn and understand basic concepts as well as its application in various fields of biology.

The content of the course consist of four units where each unit focuses on basic aspects of immunology and its application. The course begins with the brief introduction regarding overview of immune system followed by the mechanism of immunological reactions, immunotechniques, immunodiagnosis and its application in the field of medicine. At the end of each unit a student is able to understand the development of immune system immune response against diseases, and autoimmunity.

Studying this subject will equip students with basic practical skills to work in vast fields like pathology, pharmacy industries, diagnostics and hospitals.

### **Course Content**

#### **UNIT-I**

**12 Hr**

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**Introduction to Immunology:** An overview of immune system, Phagocytes, Natural killer cells, mast cells, basophils, Dendritic cells and other cells of the innate immune system. Immunity: Types- Innate immunity: (nonspecific) physical, biochemical and genetic factors involved in governing innate immunity, molecules of innate immunity – complement, acute phase proteins and interferons; Chemokines and Cytokines . Acquired immunity: (specific) natural, artificial, passive immunity, humoral or antibody mediated immunity, cell mediatedimmunity.

**Antigens and Antibodies:** Antigen processing and presentation, properties of antigen, Super antigen, Hapten; Haptens and the study of antigenicity Microbes as antigen Antigen recognition and MHC molecules. Antibodies (Immunooglobulins) – structure and function, clonal selection, monoclonal antibodies and its clinical applications, Antibody engineering (Construction of monoclonal antibodies Lymphoma and other diseases by genetically engineeredantibodies).

## UNIT-II

12 Hr

**Hypersensitivity:** Hypersensitivity reactions, Types and their roles in Immunopathologicalprocesses.

**Autoimmune processes:** Immunologic tolerance, genetic predisposition to the development of autoimmune processes. Autoimmune disorders- Immunopathogenesis of celiac disease, myasthenia gravis, sclerosis multiplex, psoriasis vulgaris, Rheumatoid arthritis) Immunodeficiency diseases, Hormones and environmental factors in induction of autoimmune processes.

## UNIT-III

12 Hr

**Transplantation of tissues and organs:** Nomenclature of transplantations. Recognition of self and non- self-Transplantation reactions HvG and GvH. Exception from rejections.Kidney and bone marrow transplantations.

**Tumours and immune system:** Etiology of malignant transformations of cells (physical, chemical and biological factors involved in). Immunological surveillance. Escape mechanisms of tumor cells from immunological surveillance. Metastatic processes. Immunodiagnosis and Immunotherapy.

## UNIT-IV

12 Hr

**Vaccines and Vaccination:** Vaccines – definition, types, Antigens used as Vaccines, effectiveness of vaccines, Vaccine safety, current vaccines, adjuvants, active immunization and passive immunization .**Manipulation of immune mechanisms:** Immunoprevention, Immunoprophylaxis, Immunostimulatory and Immunosuppressivedrugs.

**Immunotechniques and Immunodiagnosis:** Antigens and Antibody reactions *in vitro*; Agglutination, complement fixation, ELISA, Immunodiffusion,

Immuno-electrophoresis, Immunofluorescence, Immunoprecipitation,  
Radioimmunoassay and serotyping.

**References:**

1. Abul K. Abbas (2014) Cellular and Molecular Immunology, ;Saunders
2. Judy Owen , Jenni Punt, Sharon Stranford (2013) Kuby Immunology; W. H.Freeman
3. Abul K. Abbas , Andrew H. H. Lichtman , Shiv Pillai (2012) Basic Immunology: Functions and Disorders of the Immune System, ;Saunders
4. Peter Parham (2009) The Immune System, 3rd Edition; Garland Science
5. Abul K. Abbas , Andrew H. H. Lichtman , Shiv Pillai (2011) Cellular and Molecular Immunology; Saunders
6. George Pinchuk (2001) Schaum's Outline of Immunology; McGraw-Hill
7. William E. Paul (2012) Fundamental Immunology; LWW
8. Helen Chapel , Mansel Haeney, Siraj Misbah, Neil Snowden (2014) Essentials of Clinical Immunology; Wiley-Blackwell
9. Louise Hawley, Benjamin Clarke, Richard J. Ziegler (2013) Microbiology and Immunology; LWW
10. Delves, Peter J., Martin, Seamus J., Burton, Dennis R. (2011) Roitt's Essential Immunology; Wiley & Sons, Incorporated, John.

**SOFTCORE**

**COURSE –III: FOOD MICROBIOLOGY**

**48Hr**

**Course Outcome:**

- Learn about production and evaluation of the quality of starter cultures and fermented milk products and understands the use and production of probiotics, prebiotics and nutraceuticals.
- Knowledge about fermentation protocols for production of microbial biomass such as edible yeasts, mushrooms, single cell proteins and single cell oils. The student also learns about production of microbial carotenoid pigments such as lycopene and  $\beta$ -carotene.
- To know microbes causing food intoxications and food-borne infections.
- Know traditional food preservation techniques, chemical preservation and irradiation.
- Is able to utilize modern techniques viz. high-pressure processing (HPP), bacteriocins, manosonication (MS) and pulsed electric field (PEF) for effective food preservation. The student can also calculate kinetics of inactivation, process and product parameters.
- Gain knowledge about conventional methods for food quality analysis and is able to use the most recent and non-invasive techniques of quantification and detection of food borne microbes and pathogens such as ESS and various new imaging techniques.
- Understands the relevance of microbial standards for food safety, quality assurance programs that revolutionize food safety.

## **Pedagogy:**

Food microbiology is a sub-discipline of Microbiology which focuses on the study of the microorganisms that ferment, inhibit or contaminate food. It also includes the study of microorganisms that cause food spoilage and those with other useful roles.

The course emphasizes basic concepts of food microbiology, contamination and food spoilage, dairy microbiology, food poisoning and intoxication, food produced by microbes, detection of food borne microorganisms and microbial indicators of food safety quality control, food law and legislation.

The study encompasses food borne diseases of microbial origin, microbial food spoilage, beneficial uses of microbes in food, control of microbial growth in foods, destruction of microbes in foods, microbial food fermentation, pro-biotic bacteria, regulatory aspects to ensure consumers related to microbial hazards in food.

The lecture will impart students with knowledge, how microorganisms are useful to produce food, how they contaminate, spoil and cause diseases and how to detect their presence in the food. The knowledge gained about food microbiology helps the students to develop interest in this field and helps the students to work in the food industries that are interested in isolation, detection of food borne pathogens and production of food products from microorganisms.

## **Course Content**

### **UNIT-I**

**12 Hr**

**Introduction to food microbiology:** Definition, concepts and scope. Food as substrate for microbes. Factors influencing microbial growth in food-Extrinsic and intrinsic factors. Principles of food preservation- Chemical preservatives and Food additives Asepsis-Removal of microorganisms, (anaerobic conditions, high temperatures, low temperatures, drying).Canning, processing for Heat treatment.

### **UNIT-II**

**Contamination and food spoilage:** Cereals, sugar products, vegetables, fruits, meat and meat products, Fish and sea foods- poultry- spoilage of cannedfoods.

**Dairy Microbiology:** Microbiology of raw milk, Milk as a vehicle of pathogens, Prevention of contamination of raw milk, Microbiology of processed milk, Spoilage and defects fermented milk and milk products, Microbiological standards for milk and milk products. Cream and butterbacteriology.

### **UNIT-III**

**12 Hr**

**Food poisoning and intoxication:** Significance of food borne diseases, Staphylo Food poisoning and intoxication: Significance of food borne diseases, Staphylococcal, Gastroenteritis and enterotoxins: Types and incidence, Prevention of Staphylococcal and other food poisoning syndromes, *Clostridium perfringens* food poisoning and Botulism, *Bacillus cereus* food poisoning, Food borne Listeriosis by *Listeria monocytogenes*, Food borne Gastroenteritis by *Salmonella* and *Shigella*, *Vibrio*, *Campylobacter* and *Yersinia*, fungal spoilage and Mycotoxins.

**Food produced by Microbes:** Microbial cells as food (single cell proteins) – mushroom cultivation. Bioconversions- production of alcohol-fermented beverages- beer and wine. Genetically modified foods.

#### UNIT-IV

12 Hr

**Detection of food-borne microorganisms:** Culture, Microscopic and Sampling methods.. Chemical: Thermostable nuclease *Limulus* Lysate for Endotoxins, Nucleic Acid (DNA) probes, DNA Amplification (PCR), Adenosine- Triphosphate Measurement, Radiometry, Fluoro-and Chromogenic substrates. Immunologic Methods: Fluorescent Antibody, Enrichment Serology, Salmonella 1-2. Test, Radioimmunoassay, ELISA.

**Microbial indicators of food safety and quality control:** Principles of quality control and microbiological criteria, Indicators of product quality and microbiological safety of foods, Hazard analysis, critical control points (HACCP), Good manufacturing process (GMP) Microbiological standards Codex Alimentarius and Foodlegislation.

#### References:

1. Adams M. R. and Moss M. O. 2007. Food Microbiology 3rd Edition. Royal Society of Chemistry.UK.
2. Ahmed E.Y. and Carlstrom C. 2003 Food Microbiology: A Laboratory Manual, John Wiley and Sons, Inc. NewJersey.
3. Bibek Ray, ArunBhunia. 2013. Fundamental Food Microbiology, Fifth Edition. CRCPress
4. C Blackburn.2006. Food Spoilage Microorganisms. WoodheadPublishing.
5. Dongyou Liu. 2009. Molecular Detection of Foodborne Pathogens. CRCPress.
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7. Frazier W.C. and Westhoff C.D. 2008 Food Microbiology. Tata McGraw Hill Publishing Company Limited, New Delhi. IndianEdition.
8. Jay, James M., Loessner, Martin J., Golden, David A. 2004.Modern Food Microbiology. 7th ed. Springer
9. Marshall, Richard J. (Ed.). 2007. Food Safety.Springer.
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11. Pitt, John I., Hocking, Ailsa D. 2009. Fungi and Food Spoilage 3rd Edition.Springer.
12. Sperber, William H., Doyle, Michael P. (Eds.). 2010. Compendium of the Microbiological Spoilage of Foods and Beverages.Springer.
13. Stephen J. Forsythe. 2010. The Microbiology of Safe Food, 2nd Edition.Wiley-Blackwell.

#### Course-IV: SOIL MICROBIOLOGY

48 Hr

#### Course Outcome:

- Students will learn that the soil is an excellent habitat for multitude of microorganisms balancing the soil ecosystem.



- The knowledge acquired in Soil Microbiology will enhance the students' competency in the performance of their duties as future employees in the field of Agronomy/Soil Science.
- Attainment of course objectives will mean realization of the various beneficial effects of soil microorganisms on soil health, which is instrumental in the production of food and fiber. Conversely, students learned that some soil microbes are deleterious to agronomic crops
- Students will learn that some soil animals and what they eat are of ecological importance; thus, plant-eating insects and mollusks may add organic matter to the soil; insects, arachnids, and worms that consume dung and plant litter mix it with soil and speed up its decay; and, plant parasitic nematodes reduce soil's productivity.

#### **Pedagogy:**

Soil microbiology is the study of all microorganisms that exist in the soil, specifically the ways they function and affect soil properties. Our soils are pulsating with life, serving as excellent hosts for the growth and development of various organisms. In fact, there are more microbes in one teaspoon of soil than there are people on the planet. This collection of organisms consists of bacteria, fungi, and algae that serve many vital roles in the overall nourishment of soils.

Bacteria are largely responsible for the process of nitrogen fixation; converting atmospheric nitrogen into compounds that can be used by plants. Although not as commonly abundant as bacteria, fungi also assist with extremely significant functions of soil health. While one of their main activities is decomposition of organic matter, fungi also perform necessary services related to water and nutrient cycling. Fungi are responsible for binding soil particles together, assembling a system to increase water filtration and water holding capacities. In a similar manner as fungi, earthworms also break down organic matter, such as dead leaves, and produce natural fertilizers. They too support soil fertility with the transportation of water throughout the soil, as well as air.

#### **Course content**

##### **UNIT-I**

**Soil Microbiology:** Historical accounts and the "Golden Age" of soil microbiology and significant contributions of pioneer soil microbiologists. **Soil Microbial diversity:** Diversity and abundance of dominant soil microorganisms, Methods of isolation of soil microflora, soil organic matter decomposition.

##### **Unit-II**

**12 Hr**

**Biogeochemical cycles:** carbon, sulphur and iron cycles in soil.

**Soil microbe interaction** - Antagonism, commensalism, mutualism, symbiosis, predators and parasite relationship and competition. Interaction of soil microflora with vascular plants - Rhizosphere, rhizoplane microorganisms, *Rhizobium*, *Azotobacter*, *Azospirillum*, *Cyanobacteria* and *Azolla*.

##### **Unit-III**

**12 Hr**

**Applied soil microbiology:** soil microbial inoculants, Manipulations of soil microorganisms for agriculture, Soil environmental contaminants and Bioremediation, Microbial products- Plant growth promoting Hormones, Antibiotics, Toxins and Enzymes

**Unit-IV**

**12 Hr**

**Soil-Borne Diseases and Human Health:** *Clostridium tetani*(tetanus), Toxoplasmosis, Aspergillosis, Actinomyces.

**Soil microorganisms in agro ecosystems:** Types of microbial communities; soil microbial

diversity: significance and conservation; effect of agricultural practices on soil organisms. Biological nitrogen-fixation: The range of nitrogen fixing organisms; mechanism of nitrogen fixation (biochemistry of nitrogenase); genetics of nitrogen-fixation; *Rhizobium*-Legume Association; Symplasmids, N<sub>2</sub> fixation by non-leguminous plants.

**References:**

1. Agrios, G. N. 2000. Plant pathology. Harcourt Asia Pvt.Ltd.
2. Bergersen, F.J. and Postgate, J.R. 1987. A Century of Nitrogen Fixation Research Present Status and Future Prospects. The Royal Soc.,London.
3. Buchanan, B.B., Gruissem, W. and Jones, R.L. 2000. Biochemistry and Molecular Biology of Plants. I.K. International Pvt. Ltd.
4. Burges, H.D. 1981. Microbial control of insect pests, Mites and plant diseases. Academic,London.
5. Dixon, R.O.D. and Wheeler, C.T. 1986. Nitrogen Fixation in plants. Blackie USA, Chapman and Hall, NewYork.
6. Kannaiyan, S. 1999. Bioresources Technology for sustainable agriculture. Assoc. Pub. Co. New Delhi.
7. Mehrotra, R.S. 2000. Plant pathology. Tata McGraw-Hill Publishing Company Limited.
8. Metcalf, R.L. and Luckmann, W.H. 1994. Introduction to insect pest management 3ed edn. John Willey and Sons,Inc.
9. Motsara, I.M.R., Bhattacharyya, P. and Srivastava, B. 1995. Biofertilizer Technology, Marketing and usage-A source Book-cum- glossary- FDCO, New Delhi.
10. Somasegaran, PandH.J.Hoben, 1994. Handbook for Rhizobia; methods in legume eRhizobium Technology. Springer-Verlan, New York.

**PRACTICAL-III (Microbial Physiology and Immunology)**

1. Population growth of yeast – *S.cerevisiae*.
2. Population growth of bacteria – *Ecoli*.
3. Sugar fermentation tests.
4. Catalase activity.
5. Hydrolytic rancidity.
6. Casein hydrolysis.
6. Carbohydrate catabolism by microbes
7. Study of acid and pH stress tolerance by microbes.

8. Effect of molecular oxygen on microbial growth.
9. Effect of osmotic pressure on microbial growth.
10. Effect of relative humidity on microbial growth.
11. Effect of different wavelengths of light on microbial growth.
12. Immunological Methods used for organism detection – production of antibodies for use in laboratory testing.
13. Serological Diagnosis of Infectious diseases – Serologic test Methods.
14. Precipitin test, ELISA, Ouchterlony Immunodiffusion test, Immunoelectrophoresis, Complement fixation test.
15. Isolation of Antigens and raising antibodies from animals (from different Models),
16. Development of polyclonal antibodies, purification of antibodies.
17. WIDAL Test.
18. VDRL Test (RPR).
19. HBs Ag Test.
20. HCG test (Agglutination inhibition test).
21. Detection of RA factor.
22. CRP test.
23. ASO Test (Anti streptolysin 'O' Test).

#### **PRACTICAL-IV (FOOD AND DAIRY MICROBIOLOGY)**

1. Bacterial examination of drinking water by membrane filter technique.
2. Study of important microbes in the degradation of wastes.
3. Determination of TDT.
4. Determination of TDP.
5. Detection and quantification of Aflatoxin B1.
6. Detection of food-borne bacteria by immunoassays.
7. Detection and enumeration of Microorganisms present in Utensils.
8. Isolation and identification of pathogenic microorganisms from canned food.
9. Enumeration of bacteria in raw and pasteurized milk by SPC method.
10. Determination of quality of a milk sample by MBRT.
11. Detection of number of bacteria in milk by breed-count method
12. Litmus milk test.
13. Microbial quality of milk products.
14. Microbiological examination of Ice-cream and Dairy products
15. Soil microbes interaction *In vitro* by dual culture method
16. Isolation, identification and enumeration of Rhizosphere and Rhizoplane microorganism
17. Isolation of *Rhizobium* from roots of leguminous plant.

#### **OPEN ELECTIVE**

#### **COURSE –VII: MICROBIAL DIVERSITY**

**48 Hr**

#### **Course Outcome:**

- To gain insights into common groups of bacteria and archaea in different ecosystems, and their role in biogeochemical key processes in these environments.

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- To understand cultivation-independent methods for studies of the composition of microbial communities and for the function and occurrence of individual groups.
- Genomic and meta genomic based methods to study microbial diversity in nature
- To understand interactions within microbial communities and between microorganisms and plants and animals.
- Use bioinformatic tools and databases that are used to study microbial diversity.
- Acquire a fairly good understanding of the Diversity of the microbes and activities/importance of microbes.; practical skills of handling microorganisms in the laboratory for study

### **Pedagogy:**

Microbial diversity is a sub discipline of microbiology focuses on the huge diversity of microbes, its interaction with the ecosystem. Such interactions are essential for ecosystem function and may relate to plant and animal health, biogeochemical cycles and numerous other processes.

Overall this course enables students to learn how the microbial world rules over the entire ecosystem focusing on their interactions which form the basis of survival. The study helps us improve our lives via the use of microbes in environmental restoration, food production, bio-engineering of useful products such as antibiotics, food supplements and chemicals.

The knowledge gained under this subject helps the students to work in laboratories like pharmacological industries, clinical health and diagnostic laboratories, environmental research fields, microbial research and any industry where microorganisms and involved. The need of the hour is to focus on the importance of conservation of microbial diversity mainly the role of culture centers in conservation.

### **COURSE CONTENT**

#### **UNIT-I**

**12 Hr**

**Viral Diversity:** Morphology, ultra structure, chemical composition of virus, classification of viruses, Group I – T2 Bacteriophage, Group II – Banana bunchy top virus, Group III – Reovirus, Group IV- TMV, Group V – Rhabdovirus, Group VI – HIV, Group VII – Hepatitis virus.

**Sub-viral particles:** Discovery, Structure, Classification, replication and diseases caused by Satellite, Satellites virus, Virusoids, Viroids and Prions.

#### **UNIT-II**

**12 Hr**

**Bacterial Diversity:** Archaeobacteria, Photosynthetic Eubacteria, Chemoautotrophic and Methophilic Eubacteria, Gliding Eubacteria, Spirochetes, Rickettsiae and Chlamydiae, Actinomycetes, Mollicutes, Protists. Classification based on Bergey's manual (Determinative & Systematic).

#### **UNIT-III**

**12 Hr**

**Fungal Diversity:** Classification, Distribution, Importance, Structure, reproduction and general characteristics of the fungal divisions: Zygomycota (*Rhizopus*), Ascomycota

(*Neurospora*), Basidiomycota (*Agaricus*), Deuteromycota (*Penicillium*), Chytridiomycota (*Allomyces*), Myxomycota and Yeast.

#### UNIT-IV

12 Hr

**Importance and Conservation of Microbial Diversity:** Importance of microbial diversity in agriculture, forestry, environment, industrial & food biotechnology, animal & human health. Metagenomics. Importance of conservation. *In situ* conservation and *Ex situ* conservation. Role of culture collection centers in conservation.

#### References

1. Alexopoulos, C. J. and Mims, C. W. 1979. Introductory Mycology. III edition, Wiley Eastern, New Delhi.
2. Dimmock, N. J., Easton, A. J. and Leppard, K. N. 2001. Introduction to Modern Virology. 5<sup>th</sup> edn. Blackwell publishing, USA.
3. Ghosh, A. 2003. Natural Resource Conservation and Environment Management. Aph Publishing Corp. Calcutta.
4. Landecker, E. M. 1972. Fundamentals of Fungi. Prentice-Hall, Angelwood Cliff, New Jersey.
5. Madigan M.T., Martinko M. J. and Parker, J. 2003. Brock Biology of microorganisms. Pearson education., New Jersey.
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8. Prescott, L. M., Harley, J. P. and Klein, D. A. 1999. Microbiology. 4th edn. WCB McGraw- Hill, New Delhi.
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12. Wagner, E.K. and Hewlett, M.J. 1999. Basic Virology. Blackwell Science. Inc.

### THIRD SEMESTER

#### HARDCORE

#### COURSE-1: MOLECULAR BIOLOGY

48Hr

##### Course Outcome:

- Understand the structure of DNA and RNA, organization of eukaryotic/prokaryotic genome, replication, , transcription, Mutations and DNA repair
- Insights into gene regulation in both prokaryotic and eukaryotic organisms
- Is able to describe post-transcriptional processes, RNA editing, RNAi and miRNA
- Is able to describe translation mechanism in prokaryotes and eukaryotes, regulation of translation, and post-translational processing
- Is able to describe post-translational processes.

**Pedagogy:**

Molecular biology is the root branch of biology which deals with biomolecules, its modifications and other molecular level mechanisms occurring in the body of living organisms. This field is developed out of related fields like genetics, biochemistry, biophysics and microbiology. Molecular biology gives a wide information on basic concepts of DNA structure and replication, DNA damage and recombination, synthesis of proteins by transcription, translation and regulation of gene expression in bacteria, bacteriophage, eukaryotes. Each unit is well presented with basic descriptions of cellular mechanisms of both prokaryotes and eukaryotes. In this discipline the major interest is drawn towards the differences in the molecular mechanisms in prokaryotes and eukaryotes.

The students view is synchronized into the world of biomolecules for the better understanding of molecular mechanism, cell to cell interaction, cell replication, mutations. This discipline allows the students to understand the molecular mechanisms so that they can study the cause of evolutionary existence of life and also the various diseases that result due to the changes in the biomolecules.

**COURSE CONTENT****UNIT-I****12Hr**

**Concepts in Molecular Biology:** Microbes in molecular biology.

**Organization of Genomes:** Prokaryotic genome- Genetic and Physical organization of bacterial genome, Eukaryotic genome – Genetic and Physical organization of nucleargenome **DNA structure and Replication:** DNA as Genetic material, Chemistry of DNA, Modes of DNA Replication, Enzymes of DNA replication, Molecular mechanism of DNA replication, Differences in prokaryotic and eukaryotic DNA replication.

**UNIT-II****12Hr**

**DNA damage and recombination:** Types of DNA damage - deamination, oxidative damage, alkylation and pyrimidine dimers; DNA repair – mismatch, short patch repair, nucleotide/base, excision repair, recombination repair and SOS repair. Molecular basis of mutation, Recombination; Site specific recombination, Homologous recombination, transposition

**UNIT-III****12Hr**

**Gene Expression: Structure of RNA-** Classes of RNA, Chemistry of RNA.

**Transcription:** Transcription in prokaryotes and eukaryotes, Eukaryotic transcription factors. RNA processing, Ribozymes, Antisense RNA, Inhibitors of transcription and their mechanism of action.

**Translation:** Role of ribosome and different types on RNA in protein synthesis, basic feature of genetic code, mechanism of initiation, elongation and termination, Translational control and posttranslational events.

**UNIT-IV****12Hr**

**Regulation of Gene expression:** Regulation of gene expression in prokaryotes and Eukaryotes. Regulation of gene expression in bacteriophages, gene silencing – gene regulation after transcription.

**References:**

1. Benjamin, L. 1990. Gene 4th edn. Oxford Univ. Press, Oxford.
2. Brown, T. A. 1991. Essential Molecular Biology. A Practical Approach Vol-I & Vol.-II, Oxford Univ. Press, Oxford.
3. Flint, S.J., Enquist, L.W., Drug, R.M., Racaniello, V.R. and Skalka, A.M. 2000. Principles of Virology- Molecular Biology, Pathogenesis and Control. ASM Press, Washington, D.C.
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**COURSE-II: GENETIC ENGINEERING**

**48Hr**

**Course Outcome:**

- Students will become familiar with the tools and techniques of genetic engineering DNA manipulation enzymes, genome and transcriptome analysis and manipulation tools, gene expression regulation, production and characterization of recombinant proteins.
- This course exposes students to the applications of genetic engineering in biological research.
- Students will be able to perform basic genetic engineering experiments at the end of course.
- Students will acquire knowledge of advances in biotechnology- healthcare, agriculture and environment cleanup via recombinant DNA technology.
- Given the impact of genetic engineering in modern society, the students should be endowed with strong theoretical knowledge of this technology. In conjunction with the practicals in molecular biology & genetic engineering, the students should be able to take up biological research as well as placement in the relevant biotech industry

**Pedagogy:**

Genetic Engineering is an inter-disciplinary subject of biology which focuses on gene manipulation techniques using living systems and the applications of manipulated genes. This course helps students learning the components, techniques of gene manipulation in organisms and use of these techniques to create novel products (vaccines, enzymes, GMOs).

The contents of the course are divided into four units. Each unit focuses on tools, techniques used in gene manipulation, applications of recombinant DNA, ethics concerned with gene manipulation and bioinformatics. Overall, this course teaches students the importance and scope of genetic engineering in the current world.

The lecture will impart knowledge of using these techniques in various fields such as agriculture to create transgenic plants, in therapeutics or medicine to create vaccines, to cure genetic diseases. In industries to increase efficiency of production of various microbial products, in forensic science to identify suspects, paternity issues etc., this subject has wide scope and great significance in the world.

## COURSE CONTENT

### UNIT-I

12Hr

**Introduction to Genetic Engineering:** Historical perspectives and milestones in Recombinant DNA Technology. Importance of gene cloning and future perspectives.

**Tools in Genetic Engineering:** Enzymes in genetic engineering. Cloning vectors: Ti Plasmid, pBR322, pUC –series. Phage vectors-M13 phage vectors, Cosmids-Types, Phasmids or Phagemids, Shuttle vectors. YAC and BAC vectors, Adenovirus vector, Synthetic construction of vectors, Ti cloningvector

### UNIT-II

12Hr

**rDNA Technology:** The basic principles of gene cloning strategies: Preparation, Manipulation and Insertion of desired DNA into vector. Introduction of DNA into host cells – Transformation, Transduction, Transfection, Microinjection, Biolistics, Electroporation, Liposome fusion. Shotgun cloning. Genomic and c-DNA Libraries. Cloning and expression in bacteria, yeasts, Identification and Selection of recombinants.

### UNIT-III

12Hr

**Analysis of gene and gene products:** Isolation and purification of nucleic acids, staining, Molecular markers in genome analysis: RFLP, RAPD, AFLP and ISSR analysis, DNA sequencing. Blotting techniques- Southern, Northern and Western blotting techniques. PCR –principles, types, and applications.

**Introduction to Bioinformatics and Molecular Databases,** Primary Databanks – NCBI, EMBL, DDBJ; Secondary Databases – UNIPROT; Structural Database –PDB; Database similarity search (FASTA, BLAST); Alignment: Pairwise and Multiple sequence alignment; Genome Annotation and Gene Prediction; Primer Designing; Phylogenetics analysis and Tree construction; Protein Sequence Analysis; DNA microarrays. DNA sequencing methodology – Sangers dideoxymethod.

### UNIT-IV

12Hr

**Applications of gene cloning and Ethics in Genetic Engineering:** Applications of gene cloning in Biotechnology, Medicine, Agriculture, Forensic Science, Antisense technology. RNAi and Gene silencing, Gene therapy.

**Safety of recombinant DNA technology:** Restriction and regulation for the release of GMOs into Environment. Ethical, Legal, Social and Environmental Issues related to rDNA technology.

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2. Brown, T.A. (2011) Introduction to Genetics: A Molecular Approach 1st Ed.
3. Setlow, Jane K. (2004) Genetic Engineering: Principles and Methods. Springer.
4. Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger (2007) Molecular Cell Biology 6th Ed. W.H. Freeman and Company, New York.
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6. H.-J. Rehm, G. Reed. (2008) Biotechnology: Genetic Fundamentals and Genetic Engineering, Volume 2, Second Edition. Wiley.
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10. P. K. Gupta. (2008) Molecular Biology and Genetic Engineering. Deep and Deep Publications. India.
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### **COURSE-III: INDUSTRIAL MICROBIOLOGY**

**48Hr**

#### **Course Outcome:**

- Get equipped with a theoretical and practical understanding of industrial microbiology
  - Appreciate how microbiology is applied in manufacture of industrial products
  - Know about design of bioreactors, factors affecting growth and production, heat transfer, oxygen transfer
  - Understand the rationale in medium formulation & design for microbial fermentation, sterilization of medium and air
  - Appreciate the different types of fermentation processes
  - Understand the biochemistry of various fermentations
  - Identify techniques applicable for improvement of microorganisms based on known biochemical pathways and regulatory mechanisms
- Comprehend the techniques and the underlying principles in downstream processing.

#### **Pedagogy:**

Industrial microbiology is a branch of applied microbiology. Which deals with the microorganisms and fermentation technology used for production of high value added products such as therapeutic agents, fuels, food items, chemicals, sweeteners, detergents, beverages, enzymes, vitamins, and proteins. The course imparts detailed fundamental principles and of industrial microbial processes.

The course contained four units and focuses on basic industrial equipment's, isolation and screening of microorganisms, media formulation, production and key factors for optimum maintenance, recovery process and production economics, commercial value

and their applications. The course provides the basic knowledge of the industrial processes and biosynthesis of potent microbial agents.

This course makes the students as entrepreneurs and gives so many jobs for the people, and helps the students to work in the pharmaceutical, chemical, food ,beverages and dairy industries and biotechnological sectors includes biomedical, bio prospecting and biomass industries.

### Course Content

#### UNIT-I

12Hr

**Introduction: Fermenter design and types of fermenters, achievement and maintenance of aseptic conditions,** Types of fermentation processes (Surface, submerged, Batch, Continuous, solid-substrate, Dual, Fed batch fermentation and its applications),

**Industrial Microorganisms:** Screening, Isolation. Identification and characterization of industrially important microbes. Strain improvement- mutation, recombination- gene regulation and genetic manipulation. Preservation of industrially important microbes. Culture collection centers.

#### UNIT-II

12Hr

**Media for Industrial Fermentations:** Media formulation, growth factors, carbon, nitrogen, Energy and Mineral sources, buffers, inhibitors, precursors, inducers, Oxygen requirements Antifoam agents and others, Sterilization: Sterilization of bioreactor, media, air and exhaust air and filter sterilization

**Downstream processing and fermentation economics:** Steps in recovery and purification Methods of cell separation – filtration and centrifugation, cell disruption, liquid liquid extraction, chromatography, membrane processes. Fermentation economics- expenses for industrial organisms, strain improvement, media sterilization, heating, cooling, aeration and agitation. Cost of Plant and equipments, batch process cycle time, continuous culture, recovery and effluent treatment, cast recovery due to waste usages and recycling.

#### UNIT-III

12Hr

**Industrial production of energy fuels:** Industrial alcohol production: Biosynthesis, methods of production, recovery and applications of ethanol, acetone – butanol and glycerol through microbial process.

**Industrial production of Organic acids and Enzymes:** biosynthesis, media, production process, product recovery and application of citric acid and lactic acid, Enzymes: Fungal and Bacterial Amylase; Bacterial proteases.

#### UNIT-IV

12Hr

**Industrial production of food additives:** amino acid production, methods of production, product recovery of L-Glutamic acid and L-lysine. Commercial uses of Amino acids Vitamins: Commercial production of Vitamin B<sub>12</sub>, and Riboflavin. Alcoholic beverages (Beer, Wine,)

**Industrial production of health care product: Industrial production of  $\beta$ -lactum antibiotic**

(Penicillin): Biosynthesis, production and recovery. Streptomycin. Biosynthesis, production and recovery. Antitumor and anticholesterol agents, SCP and SCO, I P R: Patent Laws: Patent regulations of processes, products and microorganisms.

#### References:

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5. Demain, A.L. and Davies, J.E. 1999. Manual of Industrial Microbiology and Biotechnology IInd Edition. ASM Press, Washington.
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20. Raymond Bonnett 2010 Wine Microbiology and Biotechnology CRC press
21. Reed. G. 1999. Prescott and Dunn's Industrial Microbiology. CBS Publishers and Distributors.

**Course-IV: MEDICAL MICROBIOLOGY**

**48Hr**

**Course Outcome:**

- This course provides knowledge regarding basic principles of medical microbiology and infectious disease.
- It covers mechanisms of infectious disease transmission, principles of aseptic practice, and the role of the human body's normal microflora
- It also provides opportunities to develop informatics and diagnostic skills, including the use and interpretation of laboratory tests in the diagnosis of infectious diseases.
- To understand the importance of pathogenic bacteria in human disease with respect to infections of the respiratory tract, gastrointestinal tract, urinary tract, skin and soft tissue and the methods to control diseases, e.g. chemotherapy & vaccines.

## Pedagogy

Medical microbiology, the large subset of microbiology that is applied to medicine, is a branch of medical science concerned with the prevention, diagnosis and treatment of infectious diseases. In addition, this field of science studies various clinical applications of microbes for the improvement of health. It is the study of microbes, such as bacteria, viruses, fungi and parasites, which cause human illness and their role in the disease.

Clinical microbiology laboratories perform aerobic and anaerobic bacteriology, parasitology, mycobacteriology, mycology, and virology. Clinical microbiology is also a rather complex discipline because it utilizes many different types of methodologies and constantly undergoes changes in testing methods. Methods used to diagnose microbial diseases, and the microbiology laboratory may comprise several disciplines (e.g., classical culture methods, antigen detection methods, molecular methods, and serological methods are often performed under the purview of microbiology). The wide variety of pathogens and testing methods that are available makes microbiological testing challenging. In the clinical microbiology laboratory, as in every other discipline, the frequency of analytical errors has been reduced considerably with the implementation of quality control and quality assurance programs.

## COURSE CONTENT

### UNIT-I

12Hr

**Introduction to Medical Microbiology:** History, Development and scope of Medical Microbiology. Concept of Disease, disorder, syndrome, Communicable diseases- Microbial infections and diseases. Factors responsible for microbial pathogenicity.

**Microbial infections:** Types of infections, modes of transmission, portal of entry: Urinary tract infection, sexually transmissible infection, Infection of the central nervous system, Infections of circulatory system, Oral cavity and respiratory infection, gastrointestinal infection.

### UNIT-II

12Hr

**Nosocomial infection:** Incidence of nosocomial infections, types of nosocomial infections, emergence of antibiotic resistant microorganisms, hospital infection control programmes, preventing nosocomial infections and surveillance, General concepts for specimen collection and handling of specimen, specimen processing and biosafety.

**Chemotherapeutic agents:** antibiotics (Classification based on chemical structure, mode of action and range of effectiveness). Recent trends-Drug resistance and its consequences, antibiotic policy, NCCLS (CLSI) guidelines and standards, WHO guidelines.

### UNIT-III

12Hr

**Epidemiology, Pathogenesis, Spectrum of disease, Laboratory diagnosis and Prevention:** Diseases caused by Viruses: Chicken pox, Rabies virus, hepatitis, encephalitis, AIDS, Herpes simplex infections, Influenza, Dengue

**Diseases caused by Bacteria:** Tuberculosis, Leprosy, Cholera, Typhoid, Botulism, Shigellosis, Helicobacter pylori infection, Salmonellosis, Tetanus. Diseases caused by Fungi: Candidiasis, Histoplasmosis, Blastomycosis, Coccidiomycosis, Dermatophytosis, Aspergillosis and Cryptococcosis, Anthrax

### UNIT-IV

12Hr

**Diseases caused by Mycoplasma:** *Mycoplasma pneumoniae*, *M. urealyticum*, *M. hominis*.

**Diseases caused by Protozoa:** Giardiasis, Trichomoniasis, Cerebral Malaria, Toxoplasmosis, Cryptosporidium.

**Disease caused by Chlamydiae:** Psittacosis, Lymphogranuloma Venereum, Trachoma and Inclusion conjunctivitis.

**Emergent Diseases:** Hemorrhagic fever, Swine flu, SARS, Chikungunya, Ebola, Hanta, Leptospirosis, Marburg

### References:

1. Robert W. Bauman Ph.D. (2011) Microbiology with Diseases by Body System (3<sup>rd</sup> Edition); Benjamin Cummings
2. Patrick R. Murray PhD, Ken S. Rosenthal PhD, Michael A. Pfaller MD (2012) Medical Microbiology; Saunders
3. Brooks, Geo F., Carroll, Karen C., Butel, Janet S. (2012) Jawetz Melnick & Adelbergs Medical Microbiology ; McGraw-Hill Medical Publishing Division
4. Kenneth Ryan, C. George Ray , Nafees Ahmad , W. Lawrence Drew, Michael Lagunoff , Paul Pottinger, L. Barth Reller, Charles R. Sterling (2014) Sherris Medical Microbiology, Sixth Edition; McGraw-Hill Medical
5. Robert W. Bauman Ph.D. (2011) Microbiology with Diseases by Body System (3rd Edition); Benjamin Cummings
6. Timothy JJ Inglis (2013) Clinical Microbiology and Infectious Diseases; Point of Care Publications
7. Patricia Tille (2013) Bailey & Scott's Diagnostic Microbiology; Mosby Marjorie Kelly Cowan (2012) Microbiology Fundamentals: A Clinical Approach; McGraw-Hill Science/Engineering/Math
8. Connie R. Mahon , Donald C. Lehman , George Manuselis Jr. (2010) Textbook of Diagnostic Microbiology ; Saunders
9. Ananthanarayan , Paniker (2009) Textbook of Microbiology , 8th Edition; University Press
10. Jawetz (2010) Medical Microbiology , 25th Edition; Tata McGraw - Hill Education

## COURSE-V: CLINICAL & DIAGNOSTIC MICROBIOLOGY

48Hr

### Course Outcome:

- Various bacterial, viral, fungal and protozoal disease their causative agent, mode of infection, epidemiology, treatment, lab diagnosis, prophylaxis.
- students will develop skill regarding Isolate and identify microorganism from laboratory sample,
- Antibiotics sensitivity and resistance test
- Detection of parasite
- Handling of blood and body fluids

### Pedagogy:

Clinical and Diagnostic Microbiology is a specialty within the sciences which focuses on applying microbiology to medical application. Similarly to being concerned with the identification of a disorder-inflicting organism, diagnostic microbiology can also be a part of modifying a treatment plan. Microbes including bacteria, protozoans, and fungi play a vital factor in many disease processes. The various laboratory techniques like microscopy, immunological assessments, radiology, biomarker tests, ELISA, serology checks, vaccines vectors are the primary diagnostic tests which are currently in use. Many microbes have developed resistance to medications. Hence, it's far essential for the scientists to give smarter methods of diagnosing those microbes and their pathogenic mechanisms.

### Course Content

#### UNIT-I

12Hr

**Introduction to clinical Microbiology:** Role of Microbiologist in Diagnostic laboratory, General concepts for specimen collection, handling, transportation, processing, specimen workup, Laboratory safety and infection control.

**Scientific and Laboratory basis for Clinical/Diagnostic Microbiology:** Microscopic examination of infectious diseases, Growth and biochemical characteristics, Rapid methods of identification.

#### UNIT-II

12Hr

**Immunotechniques and Immunodiagnosis:** Antigens and Antibody reactions *in vitro*; Agglutination, complement fixation, ELISA, Western Blotting Immunodiffusion, Immunoelectrophoresis, Immunofluorescence, Immunoprecipitation, Radioimmunoassay and serotyping.

**Vaccines and Vaccination:** Vaccines – definition, types, Antigens used as Vaccines, effectiveness of vaccines, Vaccine safety, current vaccines, adjuvants, active immunization and passive immunization.

#### UNIT-III

12Hr

**Recent Diagnostic tools and techniques:** Principle, working and application of a) Autoanalyser b) Biosensor glucometer c) Diagnostic kits- ELISA, Western Blot  
**Enzymes in Disease diagnosis and therapy:** Lactate dehydrogenase, Aspartate aminotransferase, Alkaline phosphatase, Creatine kinase, Acid phosphatase, Cholinesterase.

#### UNIT-IV

12Hr

**Antimicrobial Chemotherapy:** Development of chemotherapy; General characteristics of drugs and their testing; Mechanism of action. Antibacterial drugs; antifungal drugs, antiviral and antiprotozoan drugs; antibiotic sensitivity testing, MIC, Drug resistance; mechanism of drug resistance; multi drug resistance.

#### Reference

1. GouraKudesia (2009) Clinical and Diagnostic Virology. Cambridge University Press.UK.
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10. HuwLlewelyn , Hock AunAng, Keir E Lewis and Anees Al-Abdullah (2009). Oxford Handbook of Clinical Diagnosis. Oxfordpublications.
11. Peter Hu MadhuriHegde and Patrick Alan Lennon (2012). Modern Clinical Molecular Techniques. Springerpublications.
12. HenrikWinther and Jan T. Jorgensen (2010). Molecular Diagnostics. Springerpublications.
13. Prakash S. Bisen, MousumiDebnath and GBKS Prasad (2010) Molecular Diagnostics: Promises and Possibilities. Springerpublications

#### PRACTICAL V (Molecular Biology and Genetic engineering)

1. Isolation of Genomic DNA from *E. coli*.
2. Determination of purity and concentration of isolated DNA using spectrophotometer
3. Separation of proteins by SDS PAGE.
4. Salt fractionation of Yeast protein and quantification.
5. Isolation of plasmids from bacteria by agarose gelelectrophoresis.
6. Estimation of DNA
7. Estimation of RNA
8. Estimation of protein by Lowry's method

9. Digestion of the gene of interest with suitable restriction enzymes.
10. Ligation of the digested gene in a vector.
11. Preparation of competent *E. coli* cells for Bacterial transformation.
12. Transformation of the vector into the host cell and selection of the desired clones.
13. Induction of gene expression and purification of the induced protein from the host.
14. Amplification, Purification and separation of PCR product.
15. Determination of DNase activity on isolated DNA.
16. Determination of RNase activity on isolated RNA.
17. Determination of Proteinase activity on proteins.

### **PRACTICAL VI (Industrial and Medical Microbiology)**

1. Study design of Fermentor and Parameters
2. Isolation of antibiotic/ amino acid/organic acid producing microbes and their preservation.
3. Batch fermentation of Citric acid production, recovery and estimation of citric acid.
4. Production of any vitamin and its quantification by bioassay.
5. Antibiotic fermentation and estimation of penicillin.
6. Preparation of wine and estimation of alcohol by specific gravity method.
7. Alcoholic fermentation and determination of total acidity and non-reducing sugars
8. Preparation of banana juice using Pectinase
9. Pathogenic fungi of the skin (Dermatophytes).
10. Microbial flora of mouth – teeth crevices.
11. Microbial flora of saliva.
12. Microorganisms of respiratory tract – examination of sputum/ AFB acid – fast bacteria.
13. Estimation of bacteria in urine by calibrated loop direct streak method.
14. Antimicrobial assay – sensitivity test (MIC) for pathogenic bacteria.
15. Laboratory diagnosis of important human diseases: Diphtheria, Tuberculosis, Typhoid, Wound infections, Malaria, Leprosy, AIDS and Hepatitis.

### **OPEN ELECTIVE**

**Course-VIII : MICROBIAL TECHNOLOGY**

**48Hr**

#### **Course Outcome:**

- To acquire knowledge on food product analysis
- To enable them to know about preservation of pharmaceutical products
- Learn to assess the microbial quality of marine foods Outcome
- Acquire Knowledge on food product analysis
- Impart knowledge of preservation technology.
- Knowledge on quality analysis of marine food products

#### **Pedagogy:**



It is a sub-discipline of Microbiology which focuses on microbiological techniques or methods used for the study of microbes, including bacteria, fungi and protists. This course helps students learning fundamental procedures and safety guidelines followed in the microbiology laboratory.

This course teaches students the basic skills necessary to be successful in the laboratory as well as provides easy to follow, step-by-step, directions on how to perform each technique based in microbiology. The lecture will impart the students with knowledge and skills about how to culture, stain, identify, preserve and control of microorganisms. The skills and knowledge gained about techniques in microbiology helps the students to work in the laboratories like food and dairy industries, pharmacological industries, clinical, health and diagnostics laboratories, and any industries where microorganisms are used.

## COURSE CONTENT

### UNIT-I

12Hr

**Microscopy:** Light microscopy- Simple microscopy (dissection microscope), Compound microscopy (Bright field, Dark field, phase contrast, and Fluorescence microscopy) and stereomicroscopy. Electron microscopy: Principles, construction and mode of operation of scanning and Transmission electron microscopy, limitations. Preparation of specimens for electron microscopic studies (Ultra-thin sectioning, negative staining, shadow casting and freeze etching).

### UNIT-II

12Hr

**Microbiological stains and staining techniques:** Types of stains and principles of staining. Stains for bacteria, fungi, algae and protozoa, spirochetes, stains for azotobacter cysts, stains for mycoplasma. Preparation of bacterial smears for light microscopy: Fixation, simple staining, Differential staining, Structural staining (Capsule, Flagella, Cell wall and Endospore of bacteria), and nuclear staining.

### UNIT-III

12Hr

**Culture media for Microbes** Types of media- general purpose media, special purpose mediaselective, elective, diagnostic, resuscitation media, Media for fungi, algae, bacteria, mycoplasma andviruses.

**Sterilization techniques:** Principles, types of Sterilization, and their mode of action. Physical methods: Heat-dry heat (Hot-Air oven), Incineration, Moist heat (Autoclave and Pressure cooker), Tyndalization (Fractional Sterilization), Filtration-Types of filters, Laminar airflow. Radiation methods (UV radiation, x- rays and cathoderays).

### UNIT-IV

12Hr

**Control of Microorganisms:** Chemical methods: Definition of terms- Disinfectants, Antiseptics, Sanitizers, Microbicides (bactericide, fungicide and Sporicide),

Microbistatic (bacteristatic and fungi static agents). Use and mode of action of Alcohols, Aldehydes, Halogens, Phenols, Heavy metals, and Detergents.

**Pure culture techniques:** Different types of inoculation techniques - Spread plate, Pour plate and Streak plate methods

**References:**

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2. Aneja, K.R. 1993. Experiments in Microbiology, Plant Pathology. Rastogi and Company, Meerut.
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9. Schaechter, M. Ingraham, J.L. and Neidhardt, F.C. 2006. Microbe. ASM Press, Washington. D.C.
10. Stainer, R. Y., Ingraha, J L, Wheelis, M. L. and Painter, P. K. 1986. General Microbiology. McMillan Edun. Ltd. London.
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**FOURTH SEMESTER  
HARDCORE**

**Course-I: AGRICULTURAL MICROBIOLOGY**

**48Hr**

**Course Outcome:**

- Approaches used in agriculture to control disease in plant
- Microbial ecology and microbial interaction
- Pathogenic interactions with plant

- Microbial biocontrol agents

### **Pedagogy:**

Agricultural microbiology is a branch of microbiology dealing with plant associated microbes. It also deals with microbiology of soil fertility, such as microbial degradation of organic matter and soil nutrient transformations. It aims to address problem in agricultural practices usually caused by lack of biodiversity in microbial communities.

An understanding of microbial strains relevant to agricultural applications is useful in the enhancement of factors such as soil nutrient, plant pathogen resistance, crops robustness fertilization uptake effectively. The many symbiotic relationship between plant and microbes can ultimately be exploited for greater food production necessary to feed expanding new population safer to minimize the ecological disruption. The microbes are also used as bio fertilizers, bio pesticides, and fungicides. Agricultural microbiology also explains about the plant pathogen and the control measures. The use of techniques for the proper harvest and storage of the crops and its prevention from the contamination by microorganisms.

The syllabus includes four disciplines which deal with the introduction to agricultural microbiology, the plant pathology, parasitism and disease development, the defense mechanism of plant, plant disease and their management, the microbes and plant interaction and the bio pesticides.

### **Course Content**

#### **UNIT-I**

**12Hr**

**Introduction to Agricultural Microbiology:**, Introduction to agricultural microbiology, concepts and scope of agricultural microbiology, Agronomy and production of important crop plants, Green revolution. **Plant Pathology:** Concept of disease, History of Plant Pathology, Significance of plant diseases, Symptoms and types of plant diseases.

**Plant Pathology in Practice:** Plant Clinic and Plant Doctor Concept. Diagnosis of Plant Diseases – Infectious diseases, Non-infectious diseases, Kochs' rules;

#### **UNIT-II**

**12Hr**

**Parasitism and Disease Development** Parasitism and pathogenicity, Host range of pathogens, Disease triangle, Diseases cycle / Infection cycle, Relationship between disease cycles and epidemics; Pathogens Attack Plants – Mechanical forces, Microbial enzymes and toxins, Growth regulators. Effect on physiology of Host – Photosynthesis, Translocation and transpiration, Respiration, Permeability, Transcription and translation. Environment and Plant Disease– Effect of Temperature, Moisture, Wind, Light, Soil, pH and structure, Nutrition and Herbicides.

**Defense Mechanisms of Plant:** Disease Pre-existing structural and chemical defenses, Induced structural and biochemical defenses. Microbe mediated strategies for abiotic stress management.

#### **UNIT-III**

**12Hr**

**Plant Disease & their management:** Tobacco Mosaic Disease, Sandal Spike Disease, Bacterial blight of Paddy, Citrus canker, Angular leaf spot of cotton, Late Blight of

Potato, Downy Mildew of Bajra, Blast of paddy, Tikka disease of ground nut, Rust of coffee, Grain and Head smut of Sorghum. Powdery mildew of Cucurbits, Wilt of Tomato, and Root Knot of Mulberry. Bunchy top of Banana.

#### UNIT-IV

12Hr

**Microbes and Plant interaction**-Mycorrhizae-Biology and their applications, Biofertilizers - microbial inoculants. Production and application of *Rhizobium*, *Azospirillum*, *Azotobacter*, phosphor bacteria and Cyanobacteria. PGPR's plant growth promoting *Rhizobacteria* and their uses.

**Biopesticides:** Definition, types-bacterial, viral, fungal and protozoan, mode of action, target pests, use of transgenic plants. mode of action, Bacteria-endo and ecto-toxins production by *Bacillus thuringiensis*, and *Pseudomonas*. Fungi- *Beauveria*, *Cephalosporium*, and *Trichoderma*.

#### References:

1. George. N. Agrios (2005), Plant pathology, Elsevier academic press, 5th edition, U.K.
2. Mehrotra. R.S. and Ashok Aggarwal (2002), Plant pathology, Tata MC Graw-Hill publishers, 2nd edition, Delhi.
3. Kannaiyan. S. (2002), Biotechnology of Biofertilizers, Alpha science international, 1<sup>st</sup> edition.
4. Bagyaraj D.G. and Rangaswami. G. (2005). Agricultural Microbiology, Prentice- Hall of India, 2nd edition, New Delhi.
5. Neelima Rajvaidya and Dilip Kumar Markandey. (2006). Agricultural Applications of Microbiology, Nangia S.B. and A.P.H. publishing corporation, New Delhi.
6. Oerke, E.C. Dehne, H.C. Schönbeck, F. Weber, A. (1999). Crop Production and Crop Protection, Elsevier academic press, 5th edition, U.K.
8. Roger Hull (2013). Plant virology, Elsevier academic press, 1th edition, U.K.
9. Hermann H. Prell, Peter R. Day. (2001). Plant-Fungal Pathogen Interaction: A Classical and Molecular View, 1st edition, Springer-Verlag Berlin Heidelberg, Germany.
10. Geoffrey Clough Ainsworth (1981). Introduction to the History of Plant Pathology 1<sup>st</sup> edition, Cambridge university press, U.K.
11. Vidhyasekaran, P. (2007). Fungal Pathogenesis in Plants and Crops: Molecular Biology and Host Defense Mechanisms, 2nd edition, APS press, U.S.A

#### SOFTCORE

#### COURSE -II: ENVIRONMENTAL MICROBIOLOGY

48Hr

#### Course Outcome:

- Will have an overview of the till date developments in the field of environmental microbiology with special emphasis on the role of microbes in mitigating environment pollution.
- Will have become acquainted with various cultural, biochemical and molecular techniques used in understanding microbial diversity.
- Will be knowledgeable about the diversity, adaptations and biotechnological applications of microbes of extreme environment.
- Is able to describe the role of microbes in solid and liquid waste management, gaining knowledge of various methods employed in sewage treatment and solid waste treatment.
- Understands the role of microbes in bioremediation of environmental pollutants like petroleum hydrocarbons, pesticides, plastic and electronic waste; also understands utility of microbes in mineral and oil recovery.

### **Pedagogy:**

Microbial communities control nutrient cycles and biogeochemical transformations in natural, managed and engineered ecosystems. Microorganisms recycle organic matter, transform contaminants, and maintain ecosystem health. Understanding the ecology of natural microbial communities will deepen our understanding of how ecosystems function. Since microbial communities are critical for ecosystem function, microbial ecology can also assist the development of models to predict how ecosystems will respond to future environmental conditions.

Environmental Microbiology introduces students to the diversity of microbial populations and their important roles in environmental processes in air, water, soils, and sediments. Microbial community ecology and interactions with plants and animals will also be discussed. Students will learn how microbial activities sustain natural ecosystems. Techniques for characterizing microorganisms and investigating microbial processes will also be discussed. The lectures impart knowledge to utilize bio wastes from industrial and agricultural fields. This recycling of bio wastes leads to costless and environment clean .

## **COURSE CONTENT**

### **UNIT-I**

**12Hr**

**Air Microbiology:** Airspora of indoor and outdoor environment, factors affecting airspora, Techniques of trapping air borne microorganisms.

**Aquatic Microbiology:** Distribution of microorganisms in the aquatic environment, Water pollution sources, Biological indicators of water pollution, Determination of sanitary quality of water, Waste water microbiology-Primary, secondary, tertiary treatment and reclamation of waste water

### **UNIT-II**

**12Hr**

**Soil Microbiology:** Characteristics and classification of soil. Interactions between microorganisms: Mutualism, commensalism, ammensalism synergism, parasitism, predation, competition. Rhizosphere, rhizosphere, microflora and its beneficial activity. Role of microorganism in nitrogen, phosphorous and sulphur cycle. Detrimental effects of diverted biogeochemical cycles. Biological nitrogen fixation in detail:

Symbiotic, asymbiotic and associated nitrogen fixation. Structure, function and genetic regulation of nitrogenases. Viable but nonculturable bacteria.

### UNIT-III

12Hr

**Microbes in extreme environment:** Microbes of extreme environments, Thermophiles, acidophiles, alkaliphiles, halophiles, barophiles and their survival mechanisms.

Space microbiology: Historical development of space microbiology, Life detection methods

a) Evidence of metabolism (Gulliver) b) Evidence of photosynthesis (autotrophic and heterotrophic).

### UNIT-IV

12Hr

**Microbes in the degradation of wastes:** Treatment of solid and liquid industrial wastes, Microbial degradation of pesticides, Xenobiotics, degradation of lignin, cellulose and pectin. Bioremediation. Geomicrobiology: Microbes in metal extraction, mineral leaching and mining, copper extraction by leaching and microbes in petroleum product formation. Global Environmental Problems: Global Warming, Acid rain, Ozone depletion. Bio deterioration of wood and metals.

### COURSE-III: GENOMICS AND PROTEOMICS

48Hr

#### Course Outcome:

- The aim of this course is to teach genomics, transcriptomics, proteomics, metabolomics and phenomics using model organisms representing plants and animals.
- The course will cover recent developments in genomics, gene expression and small RNAs, synthetic biology, epigenetics, proteomics, fast-forward genetics and next-generation mapping.
- An objective of the course is to develop skills in experimental design within the context of learning about biology including: regulation of transcription and translation, stress response, signal transduction and the engineering and regulation of metabolic pathways.

#### Pedagogy:

Genomics is the study of entire genomes, including the complete set of genes, their nucleotide sequence and organization, and their interactions within a species and with other species. The advances in genomics have been made possible by DNA sequencing technology. Genomic information is used to create similar maps of the DNA of different organisms. *Proteomics* generally refers to the large-scale experimental analysis of proteins and proteomes

Bioinformatics helps the students to understand Genomics and proteomics which uses the computational knowledge to extract the knowledge from biological database. This helps in data analysis, visualization, prediction, primer designing, data storage etc., through web based tools like NCBI. Students are able to understand and use the knowledge of bioinformatics and do Insilco analysis to verify and test their hypothesis

before they start their wet lab experiments. Bioinformatics helps in drug discovery and students will be placed in pharmaceutical and drug companies.

## **COURSE CONTENT**

### **UNIT-I**

**12Hr**

**Genome** - Overview Of Genome; Sequence Of Genome Acquisition And Analysis - Homologies - Snps - Genetic Analysis, Linkage Mapping, High **Resolution Chromosome Mapping And Analysis** - Physical Mapping, Yac, Hybrid Mapping, Strategies, Sequence Specific Tags (Sst), Sequence Tagged Sites(Sts), Ish, Fish, Rflp,Rapd.

### **UNIT-II**

**12Hr**

**DNA Sequencing** - Methods, MaxamAnd Gilbert Method, Ladder, Fluorescent, Shot Gun, Mass Spectrometry, Automation Sequencing – Find Gene Mutations, Implications of DNA – Sequencing And Sequencing Genomes.

**Genome Data Bank, Metabolic Pathway Data** - Construction And Screening Of cDNA, Libraries And Microarrays - Application Of DNA Arrays - PCR - Variations In PCR - Gene Disruptions – Sage And Sade, Pharmacogenomics.

### **UNIT-III**

**12Hr**

**Protein Sequence Analysis** - Introduction - Sequence Data Banks - Wbrf – Pir - Swissport - Databases, Data Mining - Algorithms Of Proteomics And Its Applications - Protein Expression

**Profiling** - Protein - Protein Interaction - Protein Modifications. Automation - Nucleic Acid Data Bank – EMBL Nucleotide Sequence Data Bank - Aids Virus Sequence Data Bank - RNA DataBank.

### **UNIT-IV**

**12Hr**

**Tools For Data Bank** - Pairwise Alignment - Needleman And WunschAlgorithm – Smith Waterman - Multiple Alignment - Clustral - Pras - Blast - Fast, Algorithms To Analyse Sequence Data - Pdb, Cambridge Structure Data Base (Lsd), 2d Electrophoresis, Ief, Hplc, Protein Digestion Technique, Mass Spectrometry, Maldi, Tof, Peptides, Mass Finger, Printing,Protein.

### **References**

1. Lynn Jorde , Peter Little , Mike Dunn and Shankar Subramaniam (2014). Encyclopedia of Genetics, Genomics, Proteomics and Bioinformatics. Wiley Publication.UK
2. Suhai, Sándor (2002). Genomics and Proteomics. Springerpublications.
3. Nawin Mishra (2010). Applications of Proteomics I: Proteomics, Human Disease, and Medicine. Wiley publication.UK
4. Ganapathy Subramaniam and Nawin Mishra (2012). Science of Proteomics: Historical Perspectives and Possible Role in Human Healthcare. Wiley Publications.UK

5. Ferenc Darvas, András Guttman, György Dormán (2013). Chemical Genomics and Proteomics (2nd Ed). CRC Press.
7. Ruchi Singh (2014). BIOINFORMATICS: GENOMICS AND PROTEOMICS. Vikas Publications. New Delhi.
8. Metin Akay (2007). Genomics and Proteomics Engineering in Medicine and Biology. Wiley Publications. UK.
9. Devarajan Thangadurai and Jeybalan Sangeetha (2015). Genomics and Proteomics Principles, Technologies, and Applications. Apple Academic Press.
10. Malcolm Campbell, Laurie J. Heyer (2003). Discovering genomics, proteomics and bioinformatics. Benjamin Cummings publications.
11. Nachimuthu Saraswathy and Ponnusamy Ramalingam (2011). Concepts and Techniques in Genomics and Proteomics . Woodhead Publishing groups.
12. R.S. Dassanayake, Y. I. N. Silva Gunawardene (2011). Genomic and Proteomic Techniques: In Post Genomics Era. Narosa Book Distributors.



**COURSE-IV: PRACTICAL VII (Agricultural Microbiology & Environmental Microbiology)**

1. Isolation, culturing and seed inoculation of *Rhizobium* and testing of nodulation ability and beneficial effects.
2. Isolation and testing the efficiency of various biofertilizers like *Rhizobium*, *Azotobacter*, *Azospirillum*.
3. Mass multiplication techniques of *Azolla*.
4. Estimation of total phenols in diseased and healthy plant tissues.
5. Seed health testing by SBM.
6. Collection and Identification of following disease: Tobacco mosaic disease, Bunchy top of Banana, Bean Mosaic, Sandal spike, Bacterial blight of paddy. Citrus canker, Downy mildew of Bajra, Powdery mildew of mulberry, Head smut of sorghum, Leaf rust of coffee, Blast disease of paddy, Tikka disease of groundnut, Leaf spot of paddy and Grassy shoot of sugarcane.
7. Isolation and identification of micro flora of soil, sewage and air
8. Microbes as indicators of water pollution – Determination of indices of water quality.
9. Determination of BOD of pollution water.
10. Determination of COD of polluted water.
11. Degradation of cellulose by *Chaetomium globosum*.
12. Bacterial examination of drinking water by membrane filter technique.
13. Study of associated soil microorganisms with plants, Actinorhiza, Mycorrhiza.
14. Study of important microbes in the degradation of wastes.
15. Isolation of cellulose degraders, chitinase and pesticide degraders
16. Determination of TS and MLSS

