

WEST BENGAL STATE UNIVERSITY

DRAFT SYLLABUS BASED ON NEP, 2020

FOR

FOUR-YEAR MICROBIOLOGY HONOURS/HONOURS WITH

RESEARCH/THREE YEAR MULTIDISCIPLINARY DEGREE

COURSE

Structure of B. Sc. Honours/Honours with research in Microbiology
Based on NEP

Major/DSC Course

(Opted by students of Microbiology Honours)

DS-1: Theory – 3 credits; Practical – 2 credits

- Introduction to Microbiology and Microbial Diversity [Semester 1]

DS-2: Theory – 3 credits; Practical – 2 credits

- Bacteriology [Semester 2]

Minor Course

(Opted by students other than Microbiology Honours/3-year Multidisciplinary UG programme)

MA -1: Theory – 3 credits; Practical – 2 credits

- Microbial diversity & their application [Semester 1]

MA -2: Theory – 3 credits; Practical – 2 credits

- Microbes in Environment [Semester 2]

Multidisciplinary Course (MDC)

To be completed from a pool of topics in Life Science (for students of Microbiology Honours) – 3 credits (theory)

- Bioremediation
- Role of Microbes in One Health Concept
- Genetic Engineering in Human welfare
- Industrial use of Microbes
- Microbes in Food safety and hygiene
- Sustainable development in Agriculture

Skill Enhancement Course (SEC)

(Opted by students of Microbiology Honours)

SE-1: Microbiological Analysis of Air and Water (Semester 1)

SE -2: Food Fermentation Techniques (Semester 2)

4-Year B.Sc (HONOURS) MICROBIOLOGY (BASED ON NEP,2020)

SEMESTER –I

DS-1: INTRODUCTION TO MICROBIOLOGY AND MICROBIAL DIVERSITY (THEORY)

TOTAL HOURS: 45

CREDITS: 3

Unit 1 History of Development of Microbiology

No. of Hours: 10

Development of microbiology as a discipline, Spontaneous generation vs. biogenesis. Contributions of Anton von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Alexander Fleming Role of microorganisms in fermentation, Germ theory of disease, Development of various microbiological techniques and golden era of microbiology, Development of the field of soil microbiology: Contributions of Martinus W. Beijerinck, Sergei N. Winogradsky, Selman A. Waksman
Establishment of fields of medical microbiology and immunology through the work of Paul Ehrlich, Elie Metchnikoff, Edward Jenner

Unit 2 Diversity of Microbial World

No. of Hours: 35

A. Systems of classification

Binomial Nomenclature, Whittaker's five kingdom and Carl Woese's three kingdom classification systems and their utility. Difference between prokaryotic and eukaryotic microorganisms

B. General characteristics of different groups: **Acellular** microorganisms (Viruses, Viroids, Prions) and **Cellular** microorganisms (Bacteria, Algae, Fungi and Protozoa) with emphasis on distribution and occurrence, morphology, mode of reproduction and economic importance.

• Algae

History of phycology with emphasis on contributions of Indian scientists; General characteristics of algae including occurrence, thallus organization, algae cell ultra structure, pigments, flagella, eyespot food reserves and vegetative, asexual and sexual reproduction. Different types of life cycles in algae with suitable examples: Haplobiontic, Haplontic, Diplontic, Diplobiontic and Diplohaplontic life cycles. Applications of algae in agriculture, industry, environment and food

• Fungi

Historical developments in the field of Mycology including significant contributions of eminent mycologists. General characteristics of fungi including habitat, distribution, nutritional requirements, fungal cell ultra- structure, thallus organization and aggregation, fungal wall structure and synthesis, asexual reproduction, sexual reproduction, heterokaryosis, heterothallism and parasexual mechanism.

Economic importance of fungi with examples in agriculture, environment, Industry, medicine, food, biodeterioration and mycotoxins.

• Protozoa

General characteristics with special reference to *Amoeba*, *Paramecium*, *Plasmodium*, *Leishmania* and *Giardia*

DS-1P: INTRODUCTION TO MICROBIOLOGY AND MICROBIAL DIVERSITY

(PRACTICALS)

SEMESTER –I

TOTAL HOURS: 60

CREDITS: 2

1. Microbiology Good Laboratory Practices and safety measures.
2. To study the principle and applications of important instruments (Laminar Air Flow, autoclave, incubator, BOD incubator, hot air oven, light microscope, pH meter) used in the microbiology laboratory.
3. Preparation of Czapekdox Agar slant/plate.
4. Sterilization of medium using Autoclave and assessment for sterility
5. Inoculation of fungi (*Penicillium*, *Aspergillus*) in Czapekdox medium
6. Staining of fungi (*Rhizopus*, *Penicillium*, *Aspergillus*) using Lactophenol-Cotton blue

SUGGESTED READING

1. Tortora GJ, Funke BR and Case CL. (2008). Microbiology: An Introduction. 9th edition. Pearson Education
2. Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2014). Brock Biology of Microorganisms. 14th edition. Pearson International Edition
3. Cappuccino J and Sherman N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson Education Limited
4. Wiley JM, Sherwood LM and Woolverton CJ. (2013) Prescott's Microbiology. 9th Edition. McGraw Hill International.
5. Atlas RM. (1997). Principles of Microbiology. 2nd edition. W.M.T.Brown Publishers.
6. Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology. 5th edition. McGraw Hill Book Company.
7. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology. 5th edition. McMillan.

SE-1: MICROBIOLOGICAL ANALYSIS OF AIR & WATER

TOTAL HOURS: 45

CREDITS: 3

Unit 1 Aeromicrobiology

No of Hours: 6

Bioaerosols, Air borne microorganisms (bacteria, Viruses, fungi) and their impact on human health and environment, significance in food and pharma industries and operation theatres, allergens

Unit 2 Air Sample Collection and Analysis

No of Hours: 9

Bioaerosol sampling, air samplers, methods of analysis, CFU, culture media for bacteria and fungi, Identification characteristics

Unit 3 Control Measures

No of Hours: 6

Fate of bioaerosols, inactivation mechanisms – UV light, HEPA filters, desiccation, Incineration

Unit 4 Water Microbiology

No of Hours: 6

Water borne pathogens, water borne diseases

Unit 5 Microbiological Analysis of Water

No of Hours: 12

Sample Collection, Treatment and safety of drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive/MPN tests, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests

Unit 6 Control Measures

No of Hours: 6

Precipitation, chemical disinfection, filtration, high temperature, UV light

Suggested Reading

1. da Silva N, Taniwaki MH, Junqueira VC, Silveira N, Nascimento MS, Gomes RAR (2012) Microbiological Examination Methods of Food and Water A Laboratory Manual, CRC Press
2. Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th edition. Benjamin/Cummings Science Publishing, USA
3. Maier RM, Pepper IL and Gerba CP. (2009). Environmental Microbiology. 2nd edition, Academic Press
4. Hurst CJ, Crawford RL, Garland JL, Lipson DA (2007) Manual of Environmental Microbiology, 3rd edition, ASM press edition, ASM press

SEMESTER –II

DS-2T: BACTERIOLOGY (THEORY)

TOTAL HOURS: 45

CREDITS: 3

Unit 1 Cell organization

No. of Hours: 8

Cell size, shape and arrangement, glycocalyx, capsule, flagella, endoflagella, fimbriae and pili. Cell-wall: Composition and detailed structure of Gram-positive and Gram-negative cell walls, Archaeobacterial cell wall, Gram and acid fast staining mechanisms, lipopolysaccharide (LPS), sphaeroplasts, protoplasts, and L-forms. Effect of antibiotics and enzymes on the cell wall. Cell Membrane: Structure, function and chemical composition of bacterial and archaeal cell membranes. Cytoplasm: Ribosomes, mesosomes, inclusion bodies, nucleoid, chromosome and plasmids Endospore: Structure, formation, stages of sporulation.

Unit 2 Bacteriological techniques

No. of Hours: 3

Pure culture isolation: Streaking, serial dilution and plating methods; cultivation, maintenance and preservation/stocking of pure cultures; cultivation of anaerobic bacteria, and accessing non-culturable bacteria.

Unit 3 Microscopy

No. of Hours: 4

Bright Field Microscope, Dark Field Microscope, Phase Contrast Microscope, Fluorescence Microscope, Confocal microscopy, Scanning and Transmission Electron Microscope

Unit 4 Microbial Growth

No. of Hours: 7

Definitions of growth, Asexual methods of reproduction, logarithmic representation of bacterial populations, phases of growth, calculation of generation time and specific growth rate measurement of microbial growth, Batch culture, Continuous culture, generation time and specific growth rate, synchronous growth, diauxic growth curve Microbial growth in response to environment -Temperature, pH, solute and water activity, Oxygen, high pressure. Microbial growth in response to nutrition and energy – Autotroph/Phototroph, heterotrophy, Chemolithoautotroph, Chemolithoheterotroph, Chemoheterotroph, Chemolithotroph, photolithoautotroph, Photoorganoheterotroph.

Physical methods of microbial control: heat, low temperature, high pressure, filtration, desiccation, osmotic pressure, radiation

Chemical methods of microbial control: Acid, alkali, alcohol, detergent, phenol & phenolics, heavy metals: types and mode of action, disinfectants and antiseptics; basic concept of antibiotics

Unit 5 Reproduction in Bacteria

No. of Hours: 3

Asexual methods of reproduction, logarithmic representation of bacterial populations, phases of growth, calculation of generation time and specific growth rate

Unit 6 Bacterial Systematics

No. of Hours: 6

Aim and principles of classification, systematics and taxonomy, concept of species, taxa, strain; conventional, molecular and recent approaches to polyphasic bacterial taxonomy, evolutionary chronometers, rRNA oligonucleotide sequencing, signature sequences, and protein sequences. Differences between eubacteria and archaeobacteria

Unit 7 Important archaeal and eubacterial groups No. of Hours: 14

Archaeobacteria: General characteristics, phylogenetic overview, genera belonging to Nanoarchaeota (*Nanoarchaeum*), Crenarchaeota (*Sulfolobus*, *Thermoproteus*) and Euryarchaeota [Methanogens (*Methanobacterium*, *Methanocaldococcus*), thermophiles (*Thermococcus*, *Pyrococcus*, *Thermoplasma*), and Halophiles (*Halobacterium*, *Halococcus*)]

Eubacteria: Morphology, metabolism, ecological significance and economic importance of following groups:

Gram Negative:

Non proteobacteria: General characteristics with suitable examples

Alpha proteobacteria: General characteristics with suitable examples

Beta proteobacteria: General characteristics with suitable examples

Gamma proteobacteria: General characteristics with suitable examples

Delta proteobacteria: General characteristics with suitable examples

Epsilon proteobacteria: General characteristics with suitable examples

Zeta proteobacteria: General characteristics with suitable examples

Gram Positive:

Low G+ C (Firmicutes): General characteristics with suitable examples

High G+C (Actinobacteria): General characteristics with suitable examples

Cyanobacteria: An Introduction

DS-2: BACTERIOLOGY (PRACTICAL)

SEMESTER –II

TOTAL HOURS: 60

CREDITS: 2

1. Preparation of different media: Nutrient agar, Nutrient broth, Luria broth.
2. Simple staining
3. Negative staining
4. Gram's staining
5. Endospore staining.
6. Isolation of pure cultures of bacteria by streaking method.
7. Study and plot the growth curve of *E. coli* by turbidometric method.
8. Estimation of CFU count by spread plate method/pour plate method.
9. Determination of antibiotic sensitivity by paper disc method

SUGGESTED READINGS

1. Atlas RM. (1997). Principles of Microbiology. 2nd edition. WM.T.Brown Publishers.
2. Black JG. (2008). Microbiology: Principles and Explorations. 7th edition. Prentice Hall
3. Madigan MT, and Martinko JM. (2014). Brock Biology of Micro-organisms. 14th edition. Parker J. Prentice Hall International, Inc.

4. Pelczar Jr MJ, Chan ECS, and Krieg NR. (2004). Microbiology. 5th edition Tata McGraw Hill.
5. Srivastava S and Srivastava PS. (2003). Understanding Bacteria. Kluwer Academic Publishers, Dordrecht
6. Stanier RY, Ingraham JL, Wheelis ML and Painter PR. (2005). General Microbiology. 5th edition McMillan.
7. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9th edition Pearson Education.
8. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.
9. Cappucino J and Sherman N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson Education Limited

SE-2: FOOD FERMENTATION TECHNIQUES

TOTAL HOURS: 45

CREDITS: 3

Unit 1 Fermented Foods

No. of Hours: 6

Definition, types, advantages and health benefits

Unit 2 Milk Based Fermented Foods

No. of Hours: 12

Dahi, Yogurt, Buttermilk (Chach) and cheese: Preparation of inoculums, types of microorganisms and production process

Unit 3 Grain Based Fermented Foods

No. of Hours: 8

Soy sauce, Bread, Idli and Dosa: Microorganisms and production process

Unit 4 Vegetable Based Fermented Foods

No. of Hours: 6

Pickels, Saeurkraut: Microorganisms and production process

Unit 5 Fermented Meat and Fish

No. of Hours: 7

Types, microorganisms involved, fermentation process

Unit 6 Probiotic Foods

No. of Hours: 6

Definition, types, microorganisms and health benefits

Suggested Readings

1. Hui YH, Meunier-Goddik L, Josephsen J, Nip WK, Stanfield PS (2004) Handbook of food and fermentation technology, CRC Press
2. Holzapfel W (2014) Advances in Fermented Foods and Beverages, Woodhead Publishing.
3. Yadav JS, Grover, S and Batish VK (1993) A comprehensive dairy microbiology, Metropolitan
4. Jay JM, Loessner MJ, Golden DA (2005) Modern Food Microbiology, 7th edition. Springer

Multidisciplinary Course (MDC)

To be completed from a pool of topics in Life Science (for students of Microbiology Honours) – 3 credits (theory)

BIOREMEDIATION

Unit 1: Microorganism and Metal Pollutants

Biodegradation of TNT, PCB; Bioremediation: bioventing, biofiltration, bioaugmentation, problems and advantages, Microbial strategy to detoxify heavy metals. Change of state of heavy metals by microbial transformation

Unit 2: Waste Management

Biomass waste management of plant's residues: Lignocellulolytic microorganisms, enzymes and their biotechnological applications.

Liquid waste management: Treatment of sewage (Primary, Secondary and Tertiary treatments)

Unit 3: Bioremediation of Environmental Pollutants

Petroleum Hydrocarbons and Pesticides use of biosensors for their detection. Microbes in oil and mineral recovery, Bioleaching of Copper gold and uranium, electronic waste management.

Unit 4: Phytoremediation

Phytostabilization, phytodegradation, rhizofiltration, phytoextraction and phytovolatilization, Microbes used in phytoremediation, Benefits of phytoremediation

SUGGESTED READINGS

1. Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th edition. Benjamin/Cummings Science Publishing, USA
2. Madigan MT, Martinko JM and Parker J. (2014). Brock Biology of Microorganisms. 14th edition. Pearson/ Benjamin Cummings
3. Maier RM, Pepper IL and Gerba CP. (2009). Environmental Microbiology. 2nd edition, Academic Press
4. Okafor, N (2011). Environmental Microbiology of Aquatic & Waste systems. 1st edition, Springer, New York
5. Singh A, Kuhad, RC & Ward OP (2009). Advances in Applied Bioremediation. Volume 17, Springer-Verlag, Berlin Hedeilberg
6. Barton LL & Northup DE (2011). Microbial Ecology. 1st edition, Wiley Blackwell, USA
7. Campbell RE. (1983). Microbial Ecology. Blackwell Scientific Publication, Oxford, England.
8. Coyne MS. (2001). Soil Microbiology: An Exploratory Approach. Delmar Thomson Learning.
8. Lynch JM & Hobbie JE. (1988). Microorganisms in Action: Concepts & Application in Microbial Ecology. Blackwell Scientific Publication, U.K.
9. Martin A. (1977). An Introduction to Soil Microbiology. 2nd edition. John Wiley & Sons Inc. New York & London.
10. Stolp H. (1988). Microbial Ecology: Organisms Habitats Activities. Cambridge University Press, Cambridge, England.
11. Subba Rao NS. (1999). Soil Microbiology. 4th edition. Oxford & IBH Publishing Co. New Delhi.
12. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.

ROLE OF MICROBES IN ONE HEALTH CONCEPT

Unit 1 Importance of Diagnosis of Diseases

Bacterial, Viral, Fungal and Protozoan Diseases of various human body systems, Disease associated clinical samples for diagnosis.

Unit 2 Direct Microscopic Examination and Culture

Examination of sample by staining - Gram stain, Ziehl-Neelson staining for tuberculosis, Giemsa stained thin blood film for malaria

Use of culture media - Blood agar, Chocolate agar, Lowenstein-Jensen medium, MacConkey agar, Distinct colony properties of various bacterial pathogens.

Unit 3: Serological and Molecular Methods

Serological Methods - Agglutination, ELISA, immunofluorescence, Nucleic acid based methods - PCR, Nucleic acid probes, Kits based Rapid Detection of Pathogens : Typhoid, Dengue and HIV, Swine flu

Unit 4: Testing for Antibiotic Sensitivity in Bacteria

Importance, Determination of resistance/sensitivity of bacteria using disc diffusion method, Determination of minimal inhibitory concentration (MIC) of an antibiotic by serial double dilution method

SUGGESTED READING

1. Ananthanarayan R and Paniker CKJ (2009) Textbook of Microbiology, 8th edition, Universities Press Private Ltd.
2. Brooks G.F., Carroll K.C., Butel J.S., Morse S.A. and Mietzner, T.A. (2013) Jawetz, Melnick and Adelberg's Medical Microbiology. 26th edition. McGraw Hill Publication
3. Randhawa, VS, Mehta G and Sharma KB (2009) Practicals and Viva in Medical Microbiology 2nd edition, Elsevier India Pvt Ltd
4. Tille P (2013) Bailey's and Scott's Diagnostic Microbiology, 13th edition, Mosby
5. Collee JG, Fraser, AG, Marmion, BP, Simmons A (2007) Mackie and McCartney Practical Medical Microbiology, 14th edition, Elsevier.

GENETIC ENGINEERING IN HUMAN WELFARE

Unit 1 Introduction to genetic engineering

Milestones in genetic engineering and biotechnology: Restriction modification systems: Mode of action, applications of Type II restriction enzymes in genetic engineering DNA modifying enzymes and their applications: DNA polymerases. Terminal deoxynucleotidyl transferase, kinases and phosphatases, and DNA ligases, Agarose gel electrophoresis, SDS-PAGE, PCR

Unit 2 Vectors

Cloning Vectors: Definition and Properties, Plasmid vectors: pBR and pUC series

Expression vectors: *E.coli* lac and T7 promoter-based vectors

Unit 3 Application of Genetic Engineering and Biotechnology

Gene delivery: Microinjection, electroporation, biolistic method (gene gun), liposome and viral mediated delivery, *Agrobacterium* - mediated delivery, Products of recombinant DNA technology: Products of human therapeutic interest - insulin, hGH, antisense molecules. Bt transgenic - cotton, brinjal, flavo savo tomato, Gene therapy, recombinant vaccine, protein engineering

SUGGESTED READING

1. Brown TA. (2010). Gene Cloning and DNA Analysis. 6th edition. Blackwell Publishing, Oxford, U.K.
2. Clark DP and Pasternik NJ. (2009). Biotechnology: Applying the Genetic Revolution. Elsevier Academic Press, USA

3. Primrose SB and Twyman RM. (2006). Principles of Gene Manipulation and Genomics, 7th edition. Blackwell Publishing, Oxford, U.K.
4. Sambrook J and Russell D. (2001). Molecular Cloning-A Laboratory Manual. 3rd edition. Cold Spring Harbor Laboratory Press
5. Wiley JM, Sherwood LM and Woolverton CJ. (2013). Prescott, Harley and Klein's Microbiology. 8th edition, McGraw Hill Higher Education
6. Brown TA. (2007). Genomes-3. Garland Science Publishers
7. Primrose SB and Twyman RM. (2008). Genomics: Applications in human biology. Blackwell Publishing, Oxford, U.K.

INDUSTRIAL USE OF MICROBES

Unit 1 Introduction to Industrial microbiology

Types of fermentation processes - solid state, liquid state, batch, fed-batch and continuous
 Types of fermenters – laboratory, pilot-scale and production fermenters
 Components of a typical continuously stirred tank bioreactor, Primary and secondary screening
 Preservation and maintenance of industrial strains

Unit 2 Microbial fermentation processes

Downstream processing - filtration, centrifugation, cell disruption, solvent extraction. Microbial production of industrial products - citric acid, ethanol and penicillin. Industrial production and uses of the enzymes - amylases, proteases, lipases and cellulases, down stream processing

Unit 3 Enzyme immobilization

Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes

SUGGESTED READING

1. Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd Edition. Panima Publishing Company, New Delhi
2. Patel AH. (1996). Industrial Microbiology .1st Edition. MacMillan India Limited Publishing Company Ltd. New Delhi, India
3. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An introduction.9th Edition. Pearson Education
4. Willey JM, Sherwood LM AND Woolverton CJ (2013), Prescott, Harley and Klein's Microbiology.9th Edition. McGraw Hill Higher education
5. Casida LE. (1991). Industrial Microbiology. 1st edition. Wiley Eastern Limited.
6. Stanbury PF, Whitaker A and Hall SJ. (2006). Principles of Fermentation Technology. 2nd edition, Elsevier Science Ltd.

MICROBES IN FOOD SAFETY AND HYGIENE

Unit 1 Food as a substrate for microbial growth

Intrinsic and extrinsic parameters that affect microbial growth in food
 Microbial spoilage of food - milk, egg, bread and canned foods

Unit 2 Principles and methods of food preservation and food sanitation

Physical methods - high temperature, low temperature, irradiation, aseptic packaging
 Chemical methods - salt, sugar, benzoates, citric acid, ethylene oxide, nitrate and nitrite
 Food sanitation and control – HACCP

Unit 3 Dairy products, probiotics and Food-borne Diseases

Fermented dairy products - yogurt, acidophilus milk, kefir, dahi and cheese
 Probiotics definition, examples and benefits, Food intoxication by *Clostridium botulinum* and *Staphylococcus aureus*, Food infection by *Salmonella* and *E.coli*

Unit 4 Sanitation and hygiene

No. of Hours: 10

Importance of sanitation and hygiene in food, kitchen hygiene, employee's health, food plant hygiene, hygienic handling of food, precautions to be taken while handling pesticides, Prevention of Food adulteration act (PFA), AGMARK standard

SUGGESTED READINGS

1. Adams MR and Moss MO. (1995). Food Microbiology. 4th edition, New Age International (P) Limited Publishers, New Delhi, India.
2. Banwart JM. (1987). Basic Food Microbiology. 1st edition. CBS Publishers and Distributors, Delhi, India.
3. Davidson PM and Brannen AL. (1993). Antimicrobials in Foods. Marcel Dekker, New York.
4. Dillion VM and Board RG. (1996). Natural Antimicrobial Systems and Food Preservation. CAB International, Wallingford, Oxon.
5. Frazier WC and Westhoff DC. (1992). Food Microbiology. 3rd edition. Tata McGraw-Hill Publishing Company Ltd, New Delhi, India.
6. Gould GW. (1995). New Methods of Food Preservation. Blackie Academic and Professional, London.
7. Jay JM, Loessner MJ and Golden DA. (2005). Modern Food Microbiology. 7th edition, CBS Publishers and Distributors, Delhi, India.
8. Lund BM, Baird Parker AC, and Gould GW. (2000). The Microbiological Safety and Quality of Foods. Vol. 1-2, ASPEN Publication, Gaithersberg, MD.
9. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9th edition. Pearson Education.

SUSTAINABLE DEVELOPMENT IN AGRICULTURE

Unit 1 Soil Microbiology

Soil as Microbial Habitat, Soil profile and properties, Soil formation, Diversity and distribution of microorganisms in soil

Unit 2 Microbial Activity in Soil and Green House Gases

Carbon dioxide, methane, nitrous oxide, nitric oxide – production and control

Unit 3 Microbial Control of Soil Borne Plant Pathogens

Biocontrol mechanisms and ways, Microorganisms used as biocontrol agents against Microbial plant pathogens, Insects, Weeds,

Unit 4 Biofertilizers & Biopesticides

Plant growth promoting bacteria, biofertilizers – symbiotic (*Bradyrhizobium*, *Rhizobium*, *Frankia*), Non Symbiotic (*Azospirillum*, *Azotobacter*, Mycorrhizae, MHBs, Phosphate solubilizers, algae), Novel combination of microbes as biofertilizers, PGPRs, GM crops : Bt crops, golden rice,

SUGGESTED READINGS

1. Agrios GN. (2006). Plant Pathology. 5th edition. Academic press, San Diego,
2. Singh RS. (1998). Plant Diseases Management. 7th edition. Oxford & IBH, New Delhi.
3. Glick BR, Pasternak JJ, and Patten CL (2010) Molecular Biotechnology 4th edition, ASM Press,
4. Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th edition. Benjamin/Cummings Science Publishing, USA
5. Maier RM, Pepper IL and Gerba CP. (2009). Environmental Microbiology. 2nd edition, Academic Press
6. Barton LL & Northup DE (2011). Microbial Ecology. 1st edition, Wiley Blackwell, USA
7. Campbell RE. (1983). Microbial Ecology. Blackwell Scientific Publication, Oxford, England.
8. Coyne MS. (2001). Soil Microbiology: An Exploratory Approach. Delmar Thomson Learning.
9. Altman A (1998). Agriculture Biotechnology, 1st edition, Marcel decker Inc.

10. Mahendra K. Rai (2005). Hand Book of Microbial Biofertilizers, The Haworth Press, Inc. New York.
11. Reddy, S.M. et. al. (2002). Bioinoculants for Sustainable Agriculture and Forestry, Scientific Publishers.
12. Saleem F and Shakoori AR (2012) Development of Bioinsecticide, Lap Lambert Academic Publishing GmbH KG

Minor Course

(Opted by students other than Microbiology Honours/3-year Multidisciplinary UG programme)

SEMESTER 1

MA -1: MICROBIAL DIVERSITY & THEIR APPLICATION (THEORY)

TOTAL HOURS: 45

CREDITS: 3

Unit 1 History of Development of Microbiology

No. of Hours: 8

Development of microbiology as a discipline, Spontaneous generation vs. biogenesis. Contributions of Anton von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Alexander Fleming Role of microorganisms in fermentation, Germ theory of disease, Development of various microbiological techniques and golden era of microbiology, Establishment of fields of medical microbiology and immunology through the work of Paul Ehrlich, Elie Metchnikoff, Edward Jenner

Unit 2 Diversity of Microorganisms

No. of Hours: 10

Systems of classification : Binomial nomenclature, Whittaker's five kingdom and Carl Woese's three kingdom classification systems. Acellular microorganisms (Viruses, Viroids, Prions) and Cellular microorganisms (Prokarya: Archaea and Bacteria, Eukarya : Algae, Fungi and Protozoa): General characteristics and examples

Unit 3 Microscopy

No. of Hours: 6

Bright Field Microscope, Dark Field Microscope, Phase Contrast Microscope, Fluorescence Microscope, Transmission Electron Microscope, Scanning Electron Microscope

Unit 4 Sterilization

No. of Hours: 3

Moist Heat, Autoclave, Dry Heat, Hot Air Oven, Filtration.

Unit 5 Microbes in Human Health & Environment

No. of Hours: 10

Medical microbiology and immunology: List of important human diseases and their causative agents of various human systems. Definitions of immunity (active/passive), primary and secondary immune response, antigen, antibody and their types

Environmental microbiology:

Definitions and microorganisms used as biopesticides, biofertilizers, biodeterioration and bioremediation (*e.g.* hydrocarbons in oil spills)

Unit 6 Industrial Microbiology

No. of Hours: 8

Definition of fermentation, primary and secondary metabolites, types of fermentations (batch, fed batch, submerged, solid state) and microbes producing important industrial products through fermentation (Ethanol, curd, cheese, penicillin), concept of probiotics

MA-1: MICROBIAL DIVERSITY & THEIR APPLICATION (PRACTICALS)

TOTAL HOURS: 60

CREDITS: 2

1. Microbiology Laboratory Management and Biosafety.

2. To study the principle and applications of important instruments (Laminar Air Flow), autoclave, incubator, BOD incubator, hot air oven, light microscope, pH meter) used in the microbiology laboratory
3. Preparation of culture media for bacterial cultivation
4. Sterilization of medium using Autoclave and assessment for sterility
5. Sterilization of glassware using Hot Air Oven and assessment for sterility
6. Demonstration of presence of microflora in the environment by exposing nutrient agar plates to air.
8. Study of different shapes of bacteria using permanent slides
9. Study of *Rhizopus* and *Penicillium* using permanent mounts

SUGGESTED READING

1. Tortora GJ, Funke BR and Case CL. (2008). Microbiology: An Introduction. 9th edition. Pearson Education
2. Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2014). Brock Biology of Microorganisms. 14th edition. Pearson International Edition
3. Cappucino J and Sherman N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson Education Limited
4. Wiley JM, Sherwood LM and Woolverton CJ. (2013) Prescott's Microbiology. 9th Edition. McGraw Hill International.
5. Atlas RM. (1997). Principles of Microbiology. 2nd edition. WM.T.Brown Publishers.
6. Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology. 5th edition. McGraw Hill Book Company.
7. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology. 5th edition. McMillan.

SEMESTER 2

MA -2: MICROBES IN ENVIRONMENT (THEORY)

TOTAL HOURS: 45

CREDITS: 3

Unit 1 Microorganisms and their Habitats

No. of Hours: 10

Structure and function of ecosystems Terrestrial Environment: Soil profile and soil microflora
 Aquatic Environment: Microflora of fresh water and marine habitats,
 Atmosphere: Aeromicroflora and dispersal of microbes, Animal Environment: Microbes in/on human body (Microbiomics) & animal (ruminants) body.
 Extreme Habitats: Extremophiles: Microbes thriving at high & low temperatures, pH, high hydrostatic & osmotic pressures, salinity, & low nutrient levels.

Unit 2 Microbial Interactions

No. of Hours: 10

Microbe interactions: Mutualism, synergism, commensalism, competition, amensalism, parasitism, predation. Microbe-Plant interaction: Symbiotic and non symbiotic interactions
 Microbe-animal interaction: Microbes in ruminants, nematophagus fungi and symbiotic luminescent bacteria

Unit 3 Biogeochemical Cycling

No. of Hours: 6

Carbon cycle: Microbial degradation of cellulose, hemicelluloses, lignin and chitin
 Nitrogen cycle: Nitrogen fixation, ammonification, nitrification, denitrification and nitrate reduction

Unit 4 Waste Management

No. of Hours: 10

Solid Waste management: Sources and types of solid waste, Methods of solid waste disposal (composting and sanitary landfill)
 Liquid waste management: Composition and strength of sewage (BOD and COD), Primary, secondary (oxidation ponds, trickling filter, activated sludge process and septic tank) and tertiary sewage treatment

Unit 5 Microbial Bioremediation

No. of Hours: 4

Principles and degradation of common pesticides, hydrocarbons (oil spills).

Unit 6 Water Potability**No. of Hours: 5**

Treatment and safety of drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive test/MPN test, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests

MA-2: MICROBES IN ENVIRONMENT (PRACTICAL)**TOTAL HOURS: 60****CREDITS: 2**

1. Isolation of microbes (bacteria & fungi) from soil
2. Isolation of microbes (bacteria & fungi) from rhizosphere
3. Assessment of microbiological quality of water.
4. Study the presence of microbial activity by detecting (qualitatively) enzymes (amylase) in soil.
5. Isolation of *Rhizobium* from root nodules.

SUGGESTED READINGS

1. Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th edition. Benjamin/Cummings Science Publishing, USA
2. Madigan MT, Martinko JM and Parker J. (2014). Brock Biology of Microorganisms. 14th edition. Pearson/ Benjamin Cummings
3. Maier RM, Pepper IL and Gerba CP. (2009). Environmental Microbiology. 2nd edition, Academic Press
4. Okafor, N (2011). Environmental Microbiology of Aquatic & Waste systems. 1st edition, Springer, New York
5. Singh A, Kuhad, RC & Ward OP (2009). Advances in Applied Bioremediation. Volume 17, Springer-Verlag, Berlin Hedeilberg
6. Barton LL & Northup DE (2011). Microbial Ecology. 1st edition, Wiley Blackwell, USA
- Campbell RE. (1983). Microbial Ecology. Blackwell Scientific Publication, Oxford, England.
7. Coyne MS. (2001). Soil Microbiology: An Exploratory Approach. Delmar Thomson Learning.
8. Lynch JM & Hobbie JE. (1988). Microorganisms in Action: Concepts & Application in Microbial Ecology. Blackwell Scientific Publication, U.K.
9. Martin A. (1977). An Introduction to Soil Microbiology. 2nd edition. John Wiley & Sons Inc. New York & London.
10. Stolp H. (1988). Microbial Ecology: Organisms Habitats Activities. Cambridge University Press, Cambridge, England.
11. Subba Rao NS. (1999). Soil Microbiology. 4th edition. Oxford & IBH Publishing Co. New Delhi.
12. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.