

WEST BENGAL STATE UNIVERSITY

DRAFT SYLLABUS BASED ON NEP, 2020

FOR

**FOUR-YEAR MICROBIOLOGY HONOURS/HONOURS WITH
RESEARCH/THREE YEARS MULTIDISCIPLINARY DEGREE COURSE**

Proposed and approved by UG BOS in Microbiology and modified in July, 2024

Structure of B. Sc. 4 years Honours/Honours with research in Microbiology /3 year

Multidisciplinary programme Based on NEP

SEM	Major (DS) Theo.= 3 credits Prac.= 2 credits	Minor (MA) Theo.= 3 credits Prac.= 2 credits	SEC Theo.= 3 credits	MDC Theo.= 3 credits	Research (15 credits)
I	DS 1: Introduction to Microbiology and Microbial Diversity	MA 1: Microbial diversity & its application	SE 1: Microbiological Analysis of Air and Water	Students other than Biological Science at +2 level can opt Biological Science as MDC with following six modules of Microbiology topics in one of the three semesters: i) Bioremediation, ii) Role of microbes in Human, iii) Genetic engineering in Human welfare, iv) Industrial use of Microbes, v) Microbes in food safety and hygiene, vi) Sustainable development in Agriculture	
II	DS 2: Bacteriology	MA 2: Microbes in Environment	SE 2: Food Fermentation Techniques		
III	DS 3: Biochemistry	MA 3: Industrial & Food Microbiology	SE 3: Microbial Diagnostics & Public Health		
IV	DS 4: Microbial Physiology & Metabolism, DS 5: Environmental Microbiology, DS 6: Food & Dairy Microbiology, DS 7: Medical Microbiology	MA 4^: Medical Microbiology			
V	DS 8: Microbial Genetics, DS 9: Virology and Cancer Biology DS 10: Cell	MA 5^: Microbial Genetics & Molecular Biology			

	Biology DS 11: Molecular Biology				
VI	DS 12: Industrial Microbiology DS13: Immunology DS 14: Recombinant DNA Technology DS 15: Microbes in Sustainable Agriculture and Development	MA 6^: Immunology			
VII	DS 16: Eukaryotic Genetics DS 17: Biophysical Techniques in Research	Special Minor - SM 1: Environmental Biotechnology			
VIII	DS 18: Biomathematics and Biostatistics DS 19: Biosafety & IPR DS 20*: Genome Biology DS 21*: Bioinformatics				Only for the students of 4 years Hons. With Research

***DS 20 & 21: Only for the students of 4 years Honours without Research**

^MA4, 5 & 6: Only for the students of 3 years Multidisciplinary programme

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

SEMESTER –I

DS-1: INTRODUCTION TO MICROBIOLOGY (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 Systems of classification

No. of Hours: 05

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

Unit 3 Cell organization

No. of Hours: 15

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), spheroplasts, 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, and plasmids (definition and types), Endospore: Structure, formation, stages of sporulation.

Unit 4 Staining methods

No. of Hours: 05

Stain and dye, acidic and basic dyes, mordant, Simple staining, Gram staining, Negative staining, Acid fast staining, Basic mechanism of Gram staining, endospore and capsule staining, Basic mechanism of Lactophenol-cotton blue staining

Unit 5 Microscopy: Basic principles & application

No. of Hours: 10

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

DS-1P: INTRODUCTION TO MICROBIOLOGY (PRACTICALS)

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 different media: Nutrient Agar & broth, Luria broth
4. Simple staining
5. Negative staining
6. Gram staining
7. Endospore staining.
8. 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. 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. 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.

DS-1P: INTRODUCTION TO MICROBIOLOGY

TOTAL HOURS: 60

CREDITS:

2

1. Microbiology Good Laboratory Practices 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 Nutrient Agar slant, Nutrient broth & 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
7. Sterilization of glassware using Hot Air Oven and assessment for sterility
8. Study of *Spirogyra* and *Chlamydomonas*, *Volvox* using temporary Mounts
10. Study of the following protozoans using permanent mounts/photographs: *Amoeba*, *Entamoeba*, *Paramecium* and *Plasmodium*

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.

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

SEMESTER –II

DS-2T: BACTERIOLOGY AND MICROBIAL DIVERSITY (THEORY)

TOTAL HOURS: 45

CREDITS:

3

Unit 1 Bacteriological techniques

No. of Hours: 04

Pure culture isolation: Streaking, serial dilution and plating methods; cultivation, maintenance and preservation/stocking of pure cultures; cultivation of anaerobic bacteria, non-culturable bacteria. Culture media: components of media, natural and synthetic media, chemically defined media, complex media, selective, differential, indicator, enriched and enrichment media.

Unit 2 Microbial Growth and Effect of Environment on Microbial Growth

No. of Hours: 11

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, Chemolithoautotrophs, Chemolithoheterotrophs, Chemoheterotrophs, Chemolithotrophs, Photolithoautotrophs, Photoorganoheterotrophs.

%. 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 3 Diversity of Microbial World

No. of Hours: 30

%. 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.

%. **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:** 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: Introductory idea with suitable examples.

%. **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-2P: BACTERIOLOGY AND MICROBIAL DIVERSITY (PRACTICAL)

TOTAL HOURS: 60

CREDITS: 2

1. Preparation of different media: Nutrient agar, McConkey agar, EMB agar.
2. Preparation of Czapekdox Agar slant/plate for fungal cultivation.
3. Sterilization of medium using Autoclave and assessment for sterility
4. Inoculation of fungi (*Penicillium*, *Aspergillus*) in Czapekdox medium
5. Study of *Spirogyra* and *Chlamydomonas*, *Volvox* using temporary Mounts
6. Study of the following protozoans using permanent mounts/photographs: *Amoeba*, *Entamoeba*, *Paramecium* and *Plasmodium*
7. Estimation of CFU count by spread plate method/pour plate method.
8. Isolation of pure cultures of bacteria by streaking method.
9. Study and plot the growth curve of *E. coli* by turbidometric method.
10. Calculations of generation time and specific growth rate of bacteria from the graph plotted with the given data

SUGGESTED READINGS

1. Atlas RM. (1997). Principles of Microbiology. 2nd edition. W M. 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. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9th edition Pearson Education.
7. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.
8. Cappuccino 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

SEMESTER –III

DS-3T: BIOCHEMISTRY (THEORY)

TOTAL HOURS: 45

CREDITS: 3

Unit 1 Bioenergetics

No. of Hours:

06

First and second laws of Thermodynamics. Definitions of Gibb's Free Energy, enthalpy, and Entropy and mathematical relationship among them, Standard free energy change and equilibrium constant Coupled reactions and additive nature of standard free energy change, Standard Free Energy Change of coupled reactions, Energy rich compounds: Phosphoenolpyruvate, 1,3-Bisphosphoglycerate, Thioesters, ATP, Numerical problems on calculations of Standard Free Energy Change and Equilibrium Constant

Unit 2 Carbohydrates

No. of Hours:

10

Families of monosaccharides: aldoses and ketoses, trioses, tetroses, pentoses, and hexoses. Stereo isomerism of monosaccharides, epimers, Mutarotation and anomers of glucose. Furanose and pyranose forms of glucose and fructose, Haworth projection formulae for glucose; chair and boat forms of glucose, Sugar derivatives, glucosamine, galactosamine, muramic acid, N- acetyl neuraminic acid, Disaccharides; concept of reducing and nonreducing sugars, occurrence and Haworth projections of maltose, lactose, and sucrose, Polysaccharides, storage polysaccharides, starch and glycogen. Structural Polysaccharides, cellulose, peptidoglycan and chitin

Unit 3 Lipids

No. of Hours:

08

Definition and major classes of storage and structural lipids. Storage lipids. Fatty acids structure and functions. Essential fatty acids. Triacyl glycerols structure, functions and properties. Saponification Structural lipids. Phosphoglycerides: Building blocks, General structure, functions and properties. Structure of phosphatidylethanolamine and phosphatidylcholine, Sphingolipids.

Unit 4 Proteins

No. of Hours:

10

Functions of proteins, Primary structures of proteins: Amino acids, the building blocks of proteins. General formula of amino acid and concept of zwitterion. Concept of pH and buffers, Titration curve of amino acid and its Significance, Classification, biochemical structure and notation of standard protein amino acids Ninhydrin reaction.

Secondary structure of proteins: Peptide unit and its salient features. The alpha helix, the beta pleated sheet and their occurrence in proteins,

Tertiary and quaternary structures of proteins. Forces holding the polypeptide together. Human haemoglobin structure, Quaternary structures of proteins

Unit 5. Enzymes

No. of Hours:

11

Structure of enzyme: Apoenzyme and cofactors, prosthetic group-TPP, coenzyme NAD, metal cofactors, Classification of enzymes, Mechanism of action of enzymes: active site, transition state complex and activation energy. Lock and key hypothesis, and Induced Fit hypothesis. Significance of hyperbolic, double reciprocal plots of enzyme activity, K_m , and allosteric mechanism Definitions of terms – enzyme unit, specific activity and turnover number, Multienzyme complex :pyruvate dehydrogenase; isozyme: lactate dehydrogenase, Effect of pH and temperature on enzyme activity. Enzyme inhibition: competitive- sulfa drugs; non-competitive-heavy metal salts

DS- 3P: BIOCHEMISTRY (PRACTICALS)

TOTAL HOURS: 60

CREDITS:

2

1. Preparation of buffers and numerical problems to explain the concepts
2. Qualitative/Quantitative tests for carbohydrates, reducing sugars, non reducing sugars
3. Qualitative/Quantitative tests for proteins: Biuret & Lowry's method
4. Formol titration of glycine
5. Study of enzyme kinetics – calculation of V_{max} , K_m , K_{cat} values
6. Study effect of temperature, pH and Heavy metals on enzyme activity

SUGGESTED READING

1. Campbell, MK (2012) Biochemistry, 7th ed., Published by Cengage Learning
2. Campbell, PN and Smith AD (2011) Biochemistry Illustrated, 4th ed., Published by Churchill Livingstone
3. Tymoczko JL, Berg JM and Stryer L (2012) Biochemistry: A short course, 2nd ed., W.H.Freeman
4. Berg JM, Tymoczko JL and Stryer L (2011) Biochemistry, W.H.Freeman and Company
5. Nelson DL and Cox MM (2008) Lehninger Principles of Biochemistry, 5th Edition., W.H. Freeman and Company,
6. Willey MJ, Sherwood, LM & Woolverton C J (2013) Prescott, Harley and Klein's Microbiology by. 9th Ed., McGrawHill
7. Voet,D. and Voet J.G (2004) Biochemistry 3rd edition, John Wiley and Sons,

SE 3: Microbial Diagnosis & Public Health

TOTAL HOURS: 45

CREDITS:

3

Unit 1 Importance of Diagnosis of Diseases

No of Hours:

8

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

Unit 2 Collection of Clinical Samples

No of Hours:

6

How to collect clinical samples (oral cavity, throat, skin, Blood, CSF, urine and faeces) and precautions required. Method of transport of clinical samples to laboratory and storage.

Unit 3 Direct Microscopic Examination and Culture

No of Hours:

10

Examination of sample by staining - Gram stain, Ziehl-Neelson staining for tuberculosis, Giemsa-stain for malaria, Preparation and use of culture media - Blood agar, Chocolate agar, Lowenstein-Jensen medium, MacConkey agar, Distinct colony properties of various bacterial pathogens.

Unit 4: Serological and Molecular Methods

No of Hours:

8

Serological Methods - Agglutination, ELISA, immunofluorescence, Nucleic acid based methods - PCR, Nucleic acid probes

Unit 5: Kits for Rapid Detection of Pathogens

No of Hours:

5

Typhoid, Dengue and HIV, Swine flu

Unit 6: Testing for Antibiotic Sensitivity in Bacteria

No of Hours:

8

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.

SEMESTER IV

DS 4T: MICROBIAL PHYSIOLOGY AND METABOLISM (THEORY)

TOTAL HOURS: 45

CREDITS: 3

Unit 1 Nutrient uptake and Transport

No. of Hours:

05

Passive and facilitated diffusion Primary and secondary active transport, concept of uniport, symport and antiport Group translocation Iron uptake

Unit 2 Chemoheterotrophic Metabolism - Aerobic Respiration

No. of Hours:

15

Concept of aerobic respiration, anaerobic respiration and fermentation Sugar degradation pathways i.e. EMP, ED, Pentose phosphate pathway TCA cycle Electron transport chain: components of respiratory chain, comparison of mitochondrial and bacterial ETC, electron transport phosphorylation, uncouplers and inhibitors

Unit 3 Chemoheterotrophic Metabolism- Anaerobic respiration and fermentation

No. of Hours: 08

Anaerobic respiration with special reference to dissimilatory nitrate reduction (Denitrification; nitrate /nitrite and nitrate/ammonia respiration; fermentative nitrate reduction) Fermentation - Alcohol fermentation and Pasteur effect; Lactate fermentation (homofermentative and heterofermentative pathways), concept of mixed acid fermentation.

Unit 4 Chemolithotrophic and Phototrophic Metabolism

No. of Hours:

14

Introduction to aerobic and anaerobic chemolithotrophy with an example each. Hydrogen oxidation (definition and reaction) and methanogenesis (definition and reaction), Introduction to phototrophic

metabolism - groups of phototrophic microorganisms, anoxygenic vs. oxygenic photosynthesis with reference to photosynthesis in green bacteria, purple bacteria and cyanobacteria

Unit 5 Nitrogen Metabolism - an overview

No. of Hours: 03

Introduction to biological nitrogen fixation Ammonia assimilation, Assimilatory nitrate reduction, dissimilatory nitrate reduction, denitrification

DS 4P: MICROBIAL PHYSIOLOGY AND METABOLISM (PRACTICAL)

TOTAL HOURS: 60

CREDITS:

2

1. Effect of temperature on growth of *E. coli*
2. Effect of pH on growth of *E. coli*
3. Effect of carbon and nitrogen sources on growth of *E.coli*
4. Effect of salt on growth of *E. coli*
5. Demonstration of alcoholic fermentation

SUGGESTED READINGS

1. Madigan MT, and Martinko JM (2014). Brock Biology of Microorganisms. 14th edition. Prentice Hall International Inc.
2. Moat AG and Foster JW. (2002). Microbial Physiology. 4th edition. John Wiley & Sons
3. Reddy SR and Reddy SM. (2005). Microbial Physiology. Scientific Publishers India
4. Gottschalk G. (1986). Bacterial Metabolism. 2nd edition. Springer Verlag
5. Stanier RY, Ingrahm JI, Wheelis ML and Painter PR. (1987). General Microbiology. 5th edition, McMillan Press.
6. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill HigherEducation.

DS 5T: ENVIRONMENTAL MICROBIOLOGY (THEORY)

TOTAL HOURS: 45

CREDITS:

3

Unit 1 Microorganisms and their Habitats

No. of Hours:

12

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:

8

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
Phosphorus cycle: Phosphate immobilization and solubilisation. Sulphur cycle: Microbes involved in sulphur cycle.

Unit 4 Waste Management

No. of Hours:

8

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:

5

Principles and degradation of common pesticides, organic (hydrocarbons, oil spills) and inorganic (metals) matter, biosurfactants

Unit 6 Water Potability

No. of Hours:

6

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

DS 5P: ENVIRONMENTAL MICROBIOLOGY (PRACTICAL)

TOTAL HOURS: 60

CREDITS: 2.

1. Isolation of microbes (bacteria & fungi) from soil.
2. Isolation of microbes from rhizosphere and phyllosphere.
3. Assessment of microbiological quality of water.
4. Determination of BOD of waste water sample.
5. Study of amylase production by soil bacteria (qualitative).

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. Subba Rao NS. (1999). Soil Microbiology. 4th edition. Oxford & IBH Publishing Co., New Delhi.
9. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.

DS 6T: FOOD & DAIRY MICROBIOLOGY (THEORY)

TOTAL HOURS: 45

CREDITS:

3

Unit 1 Foods as a substrate for microorganisms

No. of Hours:

4

Intrinsic and extrinsic factors that affect growth and survival of microbes in foods, natural flora and source of contamination of foods in general.

Unit 2 Microbial spoilage of various foods

No. of Hours: 5

Principles, Spoilage of vegetables, fruits, meat, eggs, milk and butter, bread, canned Foods

Unit 3 Principles and methods of food preservation

No. of Hours:

10

Principles, physical methods of food preservation: temperature (low, high, canning, drying), irradiation, hydrostatic pressure, high voltage pulse, microwave processing and aseptic packaging, chemical methods of food preservation: salt, sugar, organic acids, SO₂, nitrite and nitrates, ethylene oxide, antibiotics and bacteriocins

Unit 4 Fermented foods

No. of Hours:

12

Dairy starter cultures, fermented dairy products: yogurt, acidophilus milk, kumiss, kefir, dahi and cheese, other fermented foods: dosa, sauerkraut, soy sauce and tampeh, Probiotics: Health benefits, types of microorganisms used, probiotic foods available in market.

Unit 5 Food borne diseases (causative agents, foods involved, symptoms and preventive measures)

No. of Hours:

10

Food intoxications: *Staphylococcus aureus*, *Clostridium botulinum* and mycotoxins; Food infections: *Bacillus cereus*, *Vibrio parahaemolyticus*, *Escherichia coli*, Salmonellosis, Shigellosis, *Yersinia enterocolitica*, *Listeria monocytogenes* and *Campylobacter jejuni*

Unit 6 Food sanitation and control

No. of Hours:

4

HACCP, Indices of food sanitary quality and sanitizers

DS 6P: FOOD & DAIRY MICROBIOLOGY (PRACTICAL)

TOTAL HOURS: 60

CREDITS:

2

1. MBRT of milk samples and their standard plate count.
2. Alkaline phosphatase test to check the efficiency of pasteurization of milk.
3. Isolation of any food borne bacteria from food products.
4. Isolation of spoilage microorganisms from spoiled vegetables/fruits.
5. Isolation of spoilage microorganisms from bread.

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.

DS 7T: MEDICAL MICROBIOLOGY (THEORY)

TOTAL HOURS: 45
3

CREDITS:

Unit 1 Normal microflora of the human body and host pathogen interaction

No. of Hours:08

Normal microflora of the human body: Importance of normal microflora, normal microflora of skin, throat, gastrointestinal tract, urogenital tract

Host pathogen interaction: Definitions - Infection, Invasion, Pathogen, Pathogenicity,

Virulence, Toxigenicity, Carriers and their types, Opportunistic infections, Nosocomial infections.

Transmission of infection, Pathophysiologic effects of LPS

Unit 2 Sample collection, transport and diagnosis

No. of Hours: 03

Collection, transport and culturing of clinical samples, principles of different diagnostic tests (ELISA, Immunofluorescence, Agglutination based tests, Complement fixation, PCR, DNA probes).

Unit 3 Bacterial diseases

No. of Hours:

12

List of diseases of various organ systems and their causative agents. The following diseases with Symptoms, mode of transmission, prophylaxis and control

Respiratory Diseases: *Haemophilus influenzae*, *Mycobacterium tuberculosis*

Gastrointestinal Diseases: *Escherichia coli*, *Salmonella typhi*, *Vibrio cholerae*, *Helicobacter pylori*

Others: *Staphylococcus aureus*, *Bacillus anthracis*, *Clostridiumtetani*

Unit 4 Viral diseases

No. of Hours:

10

List of diseases of various organ systems and their causative agents. The following diseases with Symptoms, mode of transmission, prophylaxis and control

Polio, Hepatitis, Rabies, Dengue, AIDS, Influenza with brief description of swine

flu, Ebola, Chikungunya, Japanese Encephalitis

Unit 5 Protozoan diseases

No. of Hours:

03

List of diseases of various organ systems and their causative agents. The following diseases with Symptoms, mode of transmission, prophylaxis and control

Malaria, Kala-azar

Unit 6 Fungal diseases**No. of Hours:****03**

Brief description of each of the following types of mycoses and one representative disease to be studied with respect to transmission, symptoms and prevention

Cutaneous mycoses: Tinea pedis (Athlete's foot) Systemic mycoses: Histoplasmosis

Opportunistic mycoses: Candidiasis

Unit 7 Antimicrobial agents: General characteristics & mode of action**No. of Hours:****06**

Antibacterial agents: Five modes of action with one example each: Inhibitor of nucleic acid synthesis; Inhibitor of cell wall synthesis; Inhibitor of cell membrane function; Inhibitor of protein synthesis; Inhibitor of metabolism Antifungal agents: Mechanism of action of Amphotericin B, Griseofulvin, Antibiotic resistance, MDR, XDR, MRSA, NDM-1

DS 7P: MEDICAL MICROBIOLOGY (PRACTICAL)**TOTAL HOURS: 60****CREDITS:****2**

1. Identify bacteria (any three of *E. coli*, *Staphylococcus*, *Bacillus*) using laboratory strains on the basis of cultural, morphological and biochemical characteristics: IMViC, TSI, nitrate reduction, urease production and catalase tests
2. Antibacterial sensitivity test by agar cup assay
3. Antibacterial sensitivity test by Kirby-Bauer method
4. Determination of minimal inhibitory concentration (MIC) of an antibiotic.

SUGGESTED READING

1. Ananthanarayan R. and Paniker C.K.J. (2009) Textbook of Microbiology. 8th edition, University Press Publication
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. Goering R., Dockrell H., Zuckerman M. and Wakelin D. (2007) Mims' Medical Microbiology. 4th edition. Elsevier
4. Willey JM, Sherwood LM, and Woolverton CJ. (2013) Prescott, Harley and Klein's Microbiology. 9th edition. McGraw Hill Higher Education
5. Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2014). Brock Biology of Microorganisms. 14th edition. Pearson International Edition

SEMESTER V**DS 8T: MICROBIAL GENETICS (THEORY)****TOTAL HOURS: 45****CREDITS:****3****Unit 1 Genome Organization, Mutation & DNA repair****No. of Hours:****16**

Genome organization: *E. coli*, Mutations and mutagenesis: Definition and types of Mutations; Physical and chemical mutagens; Molecular basis of mutations; Functional mutants (loss and gain of function mutants); Uses of mutations Reversion and suppression: True revertants; Intra- and inter-genic suppression; Ames test; Mutator genes, Repair: phoreactivation, NER, SOS, mismatch.

Unit 2 Plasmids

No. of Hours:

08

Types of plasmids – F plasmid, R Plasmids, colicinogenic plasmids, Ti plasmids, linear plasmids, yeast- 2 μ plasmid, Plasmid replication and partitioning, Host range, plasmid-incompatibility, plasmid amplification, Regulation of copy number, curing of plasmids

Unit 3 Mechanisms of Genetic Exchange

No. of Hours:

15

Transformation - Discovery, mechanism of natural competence Conjugation - Discovery, mechanism, Hfr and F' strains, Interrupted mating technique and time of entry mapping Transduction - Generalized transduction, specialized transduction, LFT & HFT lysates, Mapping by recombination and co-transduction of markers

Unit 4 Transposable elements

No. of Hours:

06

Prokaryotic transposable elements – Insertion Sequences, composite and noncomposite transposons, Replicative and Non replicative transposition, Uses of transposons and transposition

DS 8P: MICROBIAL GENETICS (PRACTICAL)

TOTAL HOURS: 60

CREDITS:

2

1. Preparation of Master and Replica Plates
2. Effect of ultraviolet (UV) light exposure on bacterial survival
3. Isolation of Plasmid DNA from *E.coli*
4. Study different conformations of plasmid DNA through Agaraose gel electrophoresis.
5. Bacterial Conjugation

SUGGESTED READING

1. Klug WS, Cummings MR, Spencer, C, Palladino, M (2011). Concepts of Genetics, 10th Ed., Benjamin Cummings
2. Krebs J, Goldstein E, Kilpatrick S (2013). Lewin's Essential Genes, 3rd Ed., Jones and Bartlett Learning
3. Pierce BA (2011) Genetics: A Conceptual Approach, 4th Ed., Macmillan Higher Education Learning
4. Watson JD, Baker TA, Bell SP et al. (2008) Molecular Biology of the Gene, 6th Ed., Benjamin Cummings
5. Gardner EJ, Simmons MJ, Snustad DP (2008). Principles of Genetics. 8th Ed. Wiley- India
6. Russell PJ. (2009). *i* Genetics- A Molecular Approach. 3rd Ed, Benjamin Cummings
7. Sambrook J and Russell DW. (2001). Molecular Cloning: A Laboratory Manual. 4th Edition, Cold Spring Harbour Laboratory press.
8. Maloy SR, Cronan JE and Friefelder D(2004) Microbial Genetics 2nd EDITION., Jones and Barlett Publishers

DS 9T: VIROLOGY AND CANCER BIOLOGY (THEORY)

TOTAL HOURS: 45

CREDITS: 3

Unit 1 Nature and Properties of Viruses:**No. of Hours: 08**

Introduction: Discovery of viruses, nature and definition of viruses, general properties,

Structure of Viruses: Capsid symmetry, enveloped and non-enveloped viruses Isolation, %.
Viral taxonomy: Classification and nomenclature of different groups of viruses: Baltimore classification, ICTV classification

Unit 2 Bacteriophages & phage genetics:**No. of Hours: 08**

Diversity, classification, one step multiplication curve, lytic and lysogenic phages (λ phage) concept of early and late proteins, regulation of transcription in λ phage

Unit 3 Viral Transmission, Salient features of viral nucleic acids and Replication No.of Hours: 18

Modes of viral transmission: Persistent, non-persistent, vertical and horizontal

Salient features of viral Nucleic acid : Unusual bases (TMV, T4 phage), overlapping genes (X174, Hepatitis B virus), alternate splicing (HIV), terminal redundancy (T4 phage), terminal cohesive ends (lambda phage), partial double stranded genomes (Hepatitis B), long terminal repeats (retrovirus), segmented (Influenza virus), and non-segmented genomes (picornavirus), capping and tailing (TMV), Viral multiplication and replication strategies, Viral Assembly, maturation and release (Adeno virus and influenza virus as example)

Unit 4 Viruses and Cancer**No. of Hours: 05**

Introduction to oncogenic viruses Types of oncogenic DNA and RNA viruses: Concepts of oncogenes and proto-oncogenes

Unit 5 Prevention & control of viral diseases**No. of Hours: 06**

Antiviral compounds and their mode of action Interferon and their mode of action General principles of viral vaccination, Mechanism of action of Amantadine, Acyclovir, Azidothymidine

DS-9P: VIROLOGY AND CANCER BIOLOGY (PRACTICAL)**TOTAL HOURS: 60****CREDITS: 2**

1. Plaque assay of bacteriophages from standard teaching kit
2. Isolation and enumeration of bacteriophages (PFU) from water/sewage/cow dung sample using double agar layer technique (demonstration only)

SUGGESTED READING

1. Dimmock, NJ, Easton, AL, Leppard, KN (2007). Introduction to Modern Virology. 6th edition, Blackwell Publishing Ltd.

DS-10T: CELL BIOLOGY (THEORY)**TOTAL HOURS: 45****CREDITS: 3****Unit 1 Structure and organization of Eukaryotic Cell No. of Hours: 12**

Cell Organization– Eukaryotic (Plant and animal cells) Cell Wall: Eukaryotic cell wall,

Extra cellular matrix and cell matrix interactions,

Cell-Cell Interactions - adhesion junctions, tight junctions, gap junctions, and plasmodesmata (only structural aspects)

Mitochondria, chloroplasts and peroxisomes

Cytoskeleton: Structure and organization of actin filaments, association of actin filaments with plasma membrane, cell surface protrusions, intermediate filaments, microtubules

Unit 2 Nucleus**No. of Hours: 05**

Nuclear envelope, nuclear pore complex and nuclear lamina Chromatin – Molecular organization, Nucleolus

Unit 3 Basics of Protein Sorting and Transport**No. of Hours: 10**

Ribosomes, Endoplasmic Reticulum – Structure, targeting and insertion of proteins in the ER, smooth ER, export of proteins to Golgi Apparatus – Organization, protein glycosylation, protein sorting and export from Golgi Apparatus, Lysosomes

Unit 4 Introduction to Cell Signaling **No. of Hours: 10**

Signaling molecules and their receptors Function of cell surface receptors Pathways of intra-cellular receptors – Cyclic AMP pathway, cyclic GMP

Unit 5 Cell Cycle **No. of Hours: 08**

Eukaryotic cell cycle and its regulation, Mitosis and Meiosis Development of cancer, causes and types Programmed cell death.

DS-10P: CELL BIOLOGY (PRACTICAL)

TOTAL HOURS: 60

CREDITS: 2

1. Study a representative plant (*Allium cepa* or any other suitable plant material) and animal (squamous epithelial cells) cell by microscopy.
2. Cytochemical staining of DNA – Feulgen
3. Demonstration of the presence of mitochondria in striated muscle cells/ cheek epithelial cell using vital stain Janus Green B
4. Study of different stages of Mitosis.
5. Study of different stages of Meiosis.

SUGGESTED READING

1. Hardin J, Bertoni G and Kleinsmith LJ. (2010). Becker's World of the Cell. 8th edition. Pearson.
2. Karp G. (2010) Cell and Molecular Biology: Concepts and Experiments. 6th edition. John Wiley & Sons. Inc.
3. De Robertis, EDP and De Robertis EMF. (2006). Cell and Molecular Biology. 8th edition. Lipincott Williams and Wilkins, Philadelphia.
4. Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. 5th Edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.

DS-11T: MOLECULAR BIOLOGY (THEORY)

TOTAL HOURS: 45

CREDITS: 3

Unit 1 Structures of DNA and RNA / Genetic Material

No. of Hours: 09

DNA Structure: Miescher to Watson and Crick- historic perspective, DNA structure, Salient features of double helix, Types of DNA, Types of genetic material, denaturation and renaturation, cot curves. DNA topology - linking number, topoisomerases; Organization of DNA Prokaryotes, Viruses, Eukaryotes. RNA Structure, Organelle DNA -- mitochondria and chloroplast DNA.

Unit 2 Replication of DNA (Prokaryotes and Eukaryotes)

No. of Hours: 09

Bidirectional and unidirectional replication, semi-conservative, semi discontinuous replication Mechanism of DNA replication: Enzymes and proteins involved in DNA replication –DNA polymerases, DNA ligase, primase, telomerase – for replication of linear ends, various models of DNA replication including rolling circle, D- loop (mitochondrial), (theta) mode of replication and other accessory proteins.

Unit 3 Transcription

No. of Hours: 06

Transcription in prokaryotes: Definition, difference from replication, promoter - concept and strength of promoter RNA polymerase and the transcription unit Transcription in Eukaryotes: RNA polymerases, general Transcription factors (outline only)

Unit 4 Basic concept of Post-Transcriptional Processing

No. of Hours: 05

Split genes, concept of introns and exons, RNA splicing, spliceosome machinery, concept of alternative splicing, Polyadenylation and capping, Processing of rRNA, RNA interference: si RNA, miRNA and its significance

Unit 5 Translation

No. of Hours: 06

Prokaryotic Translational machinery, charging of tRNA, aminoacyl tRNA synthetases, Mechanisms of initiation, elongation and termination of polypeptides. Fidelity of translation, Inhibitors of protein synthesis in prokaryotes. Difference between eukaryotic and prokaryotic translation

Unit 6 Regulation of gene Expression

No. of Hours: 10

Principles of transcriptional regulation, regulation at initiation with examples from lac and trp operons, Sporulation in Bacillus, Changes in Chromatin Structure - DNA methylation and Histone Acetylation mechanisms.

Ds-11P: MOLECULAR BIOLOGY (PRACTICAL)

TOTAL HOURS: 60

CREDITS: 2

1. Estimation of DNA using colorimeter (diphenylamine reagent) or UV spectrophotometer (A260 measurement)
2. Estimation of RNA using colorimeter (orcinol reagent) or UV spectrophotometer (A260 measurement)
3. Isolation of genomic DNA from E. coli
4. Determination of Purity of isolated DNA
5. Resolution and visualization of DNA by Agarose Gel Electrophoresis.
6. Resolution and visualization of proteins by Polyacrylamide Gel Electrophoresis (SDS-PAGE): Demonstration only.

SUGGESTED READINGS

Watson JD, Baker TA, Bell SP, Gann A, Levine M and Losick R (2008) Molecular Biology of the Gene, 6th edition, Cold Spring Harbour Lab. Press, Pearson Publication

2. Becker WM, Kleinsmith LJ, Hardin J and Bertoni GP (2009) The World of the Cell, 7th edition, Pearson Benjamin Cummings Publishing, San Francisco

3. De Robertis EDP and De Robertis EMF (2006) Cell and Molecular Biology, 8th edition. Lippincott Williams and Wilkins, Philadelphia

4. Karp G (2010) Cell and Molecular Biology: Concepts and Experiments, 6th edition, John Wiley & Sons. Inc.

5. Sambrook J and Russell DW. (2001). Molecular Cloning: A Laboratory Manual. 4th Edition, Cold Spring Harbour Laboratory press.

6. Krebs J, Goldstein E, Kilpatrick S (2013). Lewin's Essential Genes, 3rd Ed., Jones and Bartlett Learning

7. Gardner EJ, Simmons MJ, Snustad DP (2008). Principles of Genetics. 8th Ed. Wiley-India

SEMESTER –VI

DS-12T: INDUSTRIAL MICROBIOLOGY (THEORY)

TOTAL HOURS: 45

CREDITS: 3

Unit 1 Introduction to industrial microbiology

No. of Hours: 02

Brief history and developments in industrial microbiology

Unit 2 Isolation of industrially important microbial strains and fermentation media No. of Hours: 08

Sources of industrially important microbes and methods for their isolation, preservation and maintenance of industrial strains, strain improvement, Crude and synthetic media; molasses, corn- steep liquor, sulphite waste liquor, whey, yeast extract and protein hydrolysates

Unit 3 Types of fermentation processes, bio-reactors and measurement of fermentation parameters

No. of Hours: 10

Types of fermentation processes - Solid-state and liquid-state (stationary and submerged) fermentations; batch, fed-batch (e.g. baker's yeast) and continuous fermentations Components of a typical bio-reactor, Types of bioreactors-Laboratories, pilot- scale and production fermenters, constantly stirred tank and air-lift fermenters, Measurement and control of fermentation parameters - pH, temperature, dissolved oxygen, foaming and aeration

Unit 4 Down-stream processing

No. of Hours: 05

Cell disruption, filtration, centrifugation, solvent extraction, precipitation, lyophilization and spray drying.

Unit 5 Microbial production of industrial products (micro-organisms involved, media, fermentation conditions, downstream processing and uses)

No. of Hours: 15

Citric acid, ethanol, penicillin, glutamic acid, Vitamin B12, Enzymes (amylase, protease, lipase) Wine, beer

Unit 6 Enzyme immobilization

No. of Hours: 05

Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes (glucose isomerase and penicillin acylase)

DS-12P: INDUSTRIAL MICROBIOLOGY (PRACTICAL)

TOTAL HOURS: 60

CREDITS: 2

1. Microbial fermentations for the production and estimation (qualitative and quantitative) of-(a)
Enzymes: Amylase

(b) Organic acid: Citric acid/Lactic acid

(c) Alcohol: Ethanol

1. A visit to any industry to see industrial fermentation and other downstream processing operations.

SUGGESTED READINGS

1. Patel A.H. (1996). Industrial Microbiology. 1st edition, Macmillan India Limited
2. Okafor N. (2007). Modern Industrial Microbiology and Biotechnology. 1st edition. Bios Scientific Publishers Limited. USA
3. Waites M.J., Morgan N.L., Rockey J.S. and Higton G. (2001). Industrial Microbiology: An Introduction. 1st edition. Wiley – Blackwell
4. Glaze A.N. and Nikaido H. (1995). Microbial Biotechnology: Fundamentals of Applied Microbiology. 1st edition. W.H. Freeman and Company
5. Casida LE. (1991). Industrial Microbiology. 1st edition. Wiley Eastern Limited.
6. Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd edition. Panima Publishing Co. New Delhi.

DS-13T: IMMUNOLOGY (THEORY)

TOTAL HOURS: 45

CREDITS: 3

Unit 1 Introduction

No. of Hours: 03

Concept of Innate and Adaptive immunity; Contributions of following scientists to the development of field of immunology - Edward Jenner, Karl Landsteiner, Robert Koch, Paul Ehrlich, Elie Metchnikoff, Peter Medawar, MacFarlane Burnet, Neils K Jerne, Rodney Porter and Susumu Tonegawa

Unit 2 Immune Cells and Organs

No. of Hours: 05

Structure, Functions and Properties of: Immune Cells – Stem cell, T cell, B cell, NK cell, Macrophage, Neutrophil, Eosinophil, Basophil, Mast cell, Dendritic cell; and Function of Immune Organs – Bone Marrow, Thymus, Lymph Node, Spleen

Unit 3 Antigens	No. of Hours: 04
Characteristics of an antigen (Foreignness, Molecular size and Heterogeneity); Haptens; Epitopes (T&B cell epitopes); T-dependent and T-independent antigens; Adjuvants	
Unit 4 Antibodies	No. of Hours: 05
Structure, Types, Functions and Properties of antibodies; Antigenic determinants on antibodies (Isotypic, allotypic, idiotypic); Monoclonal and Chimeric antibodies	
Unit 5 Major Histocompatibility Complex	No. of Hours: 04
Structure and Functions of MHC I & II molecules; Antigen processing and presentation (Cytosolic and Endocytic pathways)	
Unit 6 Complement System	No. of Hours: 03
Components of the Complement system; Activation pathways (Classical, Alternative and Lectin pathways); Biological consequences of complement Activation.	
Unit 7 Generation of Immune Response	No. of Hours: 08
Primary and Secondary Immune Response; Generation of Humoral Immune Response (Plasma and Memory cells); Generation of Cell Mediated Immune Response (Self MHC restriction, T cell activation, Co- stimulatory signals); Killing Mechanisms by CTL and NK cells, Introduction to tolerance	
Unit 8 Immunological Disorders and Tumor Immunity	No. of Hours: 08
Types of Autoimmunity and Hypersensitivity with examples; Immunodeficiencies - Animal models (Nude and SCID mice), tumor antigens	
Unit 9 Immunological Techniques	No. of Hours: 05
Principles of Precipitation, Agglutination, Immunodiffusion, Immunoelectrophoresis, ELISA, ELISPOT, Western blotting, Immunofluorescence, Flow cytometry	

DS-13P: IMMUNOLOGY (PRACTICAL)

TOTAL HOURS: 60

CREDITS: 2

1. Identification of human blood groups.
2. Single Radial Immuno Diffusion
3. Immunodiffusion by Ouchterlony method.
4. DOT ELISA (Demonstration)
5. Immunoelectrophoresis.

SUGGESTED READINGS

1. Abbas AK, Lichtman AH, Pillai S. (2007). Cellular and Molecular Immunology. 6th edition Saunders Publication, Philadelphia.
2. Delves P, Martin S, Burton D, Roitt IM. (2006). Roitt's Essential Immunology. 11th edition Wiley-Blackwell Scientific Publication, Oxford.
3. Goldsby RA, Kindt TJ, Osborne BA. (2007). Kuby's Immunology. 6th edition W.H. Freeman and Company, New York.
4. Murphy K, Travers P, Walport M. (2008). Janeway's Immunobiology. 7th edition Garland Science Publishers, New York.

DS-14T: RECOMBINANT DNA TECHNOLOGY (THEORY)

TOTAL HOURS: 45

CREDITS: 3

Unit 1 Introduction to Genetic Engineering

No. of Hours: 02

Milestones in genetic engineering and biotechnology.

Unit 2 Molecular Cloning- Tools and Strategies

No. of Hours: 16

Restriction modification systems: Types I, II and III. Mode of action, nomenclature, 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 Cloning Vectors: Definition and Properties Plasmid vectors: pBR and pUC series Bacteriophage lambda and M13 based vectors Cosmids, BACs, YACs Use of linkers and adaptors Expression vectors: *E.coli* lac and T7 promoter-based vectors, yeast YIp, YEp and YCp vectors, Baculovirus based vectors, mammalian SV40-based expression vectors

Unit 3 Methods in Molecular Cloning

No. of Hours: 12

Transformation of DNA: Chemical method, Electroporation, Gene delivery: Microinjection, electroporation, biolistic method (gene gun), liposome and viral mediated delivery, *Agrobacterium* - mediated delivery DNA, RNA and Protein analysis: Agarose gel electrophoresis, Southern - and Northern - blotting techniques, dot blot, DNA microarray analysis, SDS-PAGE and Western blotting.

Unit 4 DNA Amplification and DNA sequencing

No. of Hours:

5

PCR: Basics of PCR, RT-PCR, Real-Time PCR Sanger's method of DNA Sequencing: traditional and automated sequencing Primer walking and shotgun sequencing

Unit 5 Construction and Screening of Genomic & cDNA libraries

No. of Hours: 5

Genomic and cDNA libraries: Preparation and uses, Screening of libraries: Colony hybridization and colony PCR, Chromosome walking and chromosome jumping

Unit 6 Applications of Recombinant DNA Technology

No. of Hours:

5

Products of recombinant DNA technology: Products of human therapeutic interest - insulin, hGH, Bt transgenic - cotton, brinjal, Gene therapy, recombinant vaccines and site directed mutagenesis

DS 14P: RECOMBINANT DNA TECHNOLOGY (PRACTICAL)

TOTAL HOURS: 60

CREDITS:

2

1. Preparation of competent cells for transformation
2. Bacterial Transformation and calculation of transformation efficiency.
3. Digestion of DNA using restriction enzymes and analysis by agarose gel electrophoresis
4. Ligation of DNA fragments
5. Cloning of DNA insert and Blue white screening of recombinants.

SUGGESTED READING

1. Brown TA. (2010). Gene Cloning and DNA Analysis. 6th edition. Blackwell Publishing, Oxford, U.K.
2. Clark DP and Pazdernik 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. (2008). Prescott, Harley and Klein's Microbiology. 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.

DS-15T: MICROBES IN SUSTAINABLE AGRICULTURE AND DEVELOPMENT (THEORY)

TOTAL HOURS: 45

CREDITS: 3

Unit 1 Soil Microbiology

No of Hours: 06

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

No of Hours: 06

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

Unit 3 Microbial Control of Soil Borne Plant Pathogens

No of Hours: 08

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

Unit 4 Biofertilization, Phytostimulation, Bioinsecticides

No of Hours: 10

Plant growth promoting bacteria, biofertilizers – symbiotic (Bradyrhizobium, Rhizobium, Frankia), Non-Symbiotic (Azospirillum, Azotobacter, Mycorrhizae), Phosphate solubilizers.

Unit 5 Secondary Agriculture Biotechnology

No of Hours: 09

Biomanure, biogas, biofuels – general concepts and advantages

Unit 6 Genetically Modified crops

No of Hours: 06

Bt crops, golden rice, transgenic animals, advantages, social and environmental aspects.

DS-15P: MICROBES IN SUSTAINABLE AGRICULTURE AND DEVELOPMENT (PRACTICAL)

TOTAL HOURS: 60

CREDITS: 2

1. Study of microflora of rhizospheric soils
2. Isolation and characterization of phosphate solubilizing bacteria from soil
3. Isolation and characterization of Nitrogen fixing bacteria from soil
4. Isolation of Rhizobium from root nodules
5. Soil dehydrogenase assay

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

SEMESTER –VII

DS-16T: EUKARYOTIC GENETICS (THEORY)

TOTAL HOURS: 45

CREDITS: 3

Unit 1 Introduction to Genetics

No. of Hours: 3

Historical development, Model organisms in genetic analyses and experimentation: Escherichia coli, Saccharomyces cerevisiae, Drosophila melanogaster, Arabidopsis thaliana

Unit 2 Mendelian Principles

No. of Hours: 10

Mendel's Laws: Dominance, segregation, independent assortment, deviation from Mendelian inheritance, Rediscovery of Mendel's principles, Chromosome theory of inheritance: Allele, multiple alleles, pseudoallele, complementation tests, Extensions of Mendelian genetics: Allelic interactions, concept of dominance, recessiveness, Incomplete dominance and co-dominance, Multiple alleles, Epistasis, penetrance and expressivity

Unit 3 Linkage and Crossing over

No. of Hours: 5

Linkage and recombination of genes, Cytological basis of crossing over, Crossing over at four-strand stage, Molecular mechanism of crossing over.

Unit 4 Extra-Chromosomal Inheritance

No. of Hours: 6

Extra nuclear inheritance in bacteria: Plasmid and episome, Organelle heredity – Chloroplast, Mitochondria,

Unit 5 Characteristics of Chromosomes

No. of Hours: 6

Structural organization of chromosomes - centromeres, telomeres and repetitive DNA, Packaging DNA molecules into chromosomes, Concept of euchromatin and heterochromatin, Chromosome banding, Giant chromosomes: Polytene and lamp brush chromosomes,

Unit 6 Recombination

No. of Hours: 5

Homologous and non-homologous recombination, including transposition, site-specific recombination.

Unit 7 Human genetics

No. of Hours: 10

Pedigree analysis, lod score for linkage testing, karyotypes, Variations in chromosome structure: Deletion, duplication, inversion and translocation, Variation in chromosomal number and structural abnormalities - Klinefelter syndrome, Turner syndrome, Down syndrome.

DS-16P: EUKARYOTIC GENETICS (PRACTICAL)

TOTAL HOURS: 60

CREDITS: 2

1. Chi-Square Analysis of Mendelian monohybrid/dihybrid cross
2. Study of polytene chromosomes using temporary mounts of salivary glands of Chironomus / Drosophila larvae
3. Study of pedigree analysis: problems

SUGGESTED READING

1. Gardner EJ, Simmons MJ, Snustad DP (2008). Principles of Genetics. 8th Ed. Wiley-India
2. Snustad DP, Simmons MJ (2011). Principles of Genetics. 6th Ed. John Wiley and Sons Inc.
3. Weaver RF, Hedrick PW (1997). Genetics. 3rd Ed. McGraw-Hill Education
4. WS, Cummings MR, Spencer CA, Palladino M (2012). Concepts of Genetics. 10th Ed. Benjamin Cummings
5. Griffith AJF, Wessler SR, Lewontin RC, Carroll SB. (2007). Introduction to Genetic Analysis. 9th Ed. W.H. Freeman and Co., New York

6. Hartl DL, Jones EW (2009). Genetics: Analysis of Genes and Genomes. 7th Ed, Jones and Bartlett Publishers
7. Russell PJ. (2009). i Genetics - A Molecular Approach. 3rd Ed, Benjamin Cummings

DS-17T: BIOPHYSICAL TECHNIQUES IN RESEARCH (THEORY)

TOTAL HOURS: 45

CREDITS: 3

Unit 1 Microscopy

No. of Hours: 08

Brightfield and darkfield microscopy, Fluorescence Microscopy, Phase contrast Microscopy, Confocal Microscopy, Electron Microscopy (Scanning and Transmission Electron Microscopy).

Unit 2 Chromatography

No. of Hours: 12

Principles and applications of paper chromatography (including Descending and 2-D), Thin layer chromatography. Column packing and fraction collection, Gel filtration chromatography, ion- exchange chromatography and affinity chromatography, GLC, HPLC.

Unit 3 Electrophoresis

No. of Hours: 10

Principle and applications of native polyacrylamide gel electrophoresis, SDS- polyacrylamide gel electrophoresis, 2D gel electrophoresis, Isoelectric focusing, Zymogram preparation and Agarose gel electrophoresis.

Unit 4 Spectrophotometry

No. of Hours: 08

Principle and use of study of absorption spectra of biomolecules, Analysis of biomolecules using UV and visible range, Colorimetry and turbidometry

Unit 5 Centrifugation

No. of Hours: 07

Preparative and analytical centrifugation, fixed angle and swinging bucket rotors. RCF and sedimentation coefficient, differential centrifugation, density gradient centrifugation and ultracentrifugation

DS-17P: BIOPHYSICAL TECHNIQUES IN RESEARCH (PRACTICAL)

TOTAL HOURS: 60

CREDITS: 2

1. Separation of amino acid mixtures by thin layer chromatography.
2. Separation of protein mixtures by any form of chromatography.
3. Separation of protein mixtures by Polyacrylamide Gel Electrophoresis (PAGE).
4. Determination of λ_{max} for an unknown sample and calculation of extinction coefficient.
5. Separation of components of a given mixture using a laboratory scale centrifuge.

SUGGESTED READINGS

1. Wilson K and Walker J. (2010). Principles and Techniques of Biochemistry and Molecular Biology. 7th Ed., Cambridge University Press.
2. Nelson DL and Cox MM. (2008). Lehninger Principles of Biochemistry, 5th Ed., W.H. Freeman and Company.
3. Willey MJ, Sherwood LM & Woolverton C J. (2013). Prescott, Harley and Klein's Microbiology. 9th Ed., McGraw Hill.
4. Karp G. (2010) Cell and Molecular Biology: Concepts and Experiments. 6th edition. John Wiley & Sons. Inc.
5. De Robertis EDP and De Robertis EMF. (2006). Cell and Molecular Biology. 8th edition. Lipincott Williams and Wilkins, Philadelphia.

6.Cooper G.M. and Hausman R.E. (2009). The Cell: A Molecular Approach. 5th Edition. ASM Press &Sunderland, Washington D.C., Sinauer Associates, MA.

7.Nigam A and Ayyagari A. 2007. Lab Manual in Biochemistry, Immunology and Biotechnology. Tata McGraw Hill.

SEMESTER –VIII

DS18T: BIOMATHEMATICS AND BIOSTATISTICS (THEORY)

TOTAL HOURS: 45

CREDITS: 3

Unit 1 Biomathematics

No of Hours: 23

Reaction Kinetics: Zero order, first order, second order kinetics with examples; Michaelis- Menten equation; Coupled reactions, Application in fermentation technique; Mathematical expression in batch culture, continuous culture, steady state condition, logarithm: Application in Henderson-Hasselbatch equation, problems related to buffer solution, Free energy: Mathematical expression and related problems, Differentiation and Integration: Radioactive decay, Half-life, problems related to radioactivity, Decimal reduction time: mathematical expression and related problems

Unit 2 Biostatistics

No of Hours: 22

Measures of central tendency, Measures of dispersion; skewness, kurtosis; Elementary Probability and basic laws; Discrete and Continuous Random variable, Mathematical Expectation; Curve Fitting; Correlation and Regression. Emphasis on examples from Biological Sciences; Poisson and Normal distribution

Statistical methods: Principles of statistical analysis of biological data. Sampling parameters. Difference between sample and Population, Sampling Errors: Standard Error, Testing of Hypothesis, Level of Significance and Degree of Freedom; t-test, Z- test and F test; Confidence Interval; Chi-square test

DS-18P: BIOMATHEMATICS AND BIOSTATISTICS (PRACTICAL)

TOTAL HOURS: 60

CREDITS: 2

1. Mean, Median, Mode from grouped and ungrouped Data set
2. Determination of Standard Deviation and standard error in laboratory experiment data
3. Graphical representation of Standard Deviation and standard error
4. Testing of Hypothesis- Normal Distribution, t-test and Chi-Square-test
5. Determination of Confidence Interval by MPN test of water sample

DS 19T: BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS (THEORY)

TOTAL HOURS: 45

CREDITS: 3

Unit 1

No of Hours:

14

Concept of IPR, Designs, trademarks, trade secrets, domain names, geographical indications, copyright, Evolution of patent laws, history of Indian patent system, Agreements and Treaties: GATT, TRIPS Agreements; Role of Madrid Agreement; Hague Agreement; WIPO Treaties; Budapest Treaty on international recognition of the deposit of microorganisms; UPOV & Brene conventions; Patent Co-operation Treaty (PCT); Indian Patent Act 1970 & recent amendments. Classification of patents in India,

Unit 2

No of Hours:

10

classification of patents by WIPO, categories of patent, special patents, patenting biological products, Patentable inventions in India and abroad, non patentable inventions in India and abroad, Rights of patent holder and co-owners, transfer of patent rights, limitations of patent rights, Patent and economy, patent management, patent growth, patenting of life forms, biodiversity and IPR, Study of famous case study between Diamond and Chakraborty

Unit 3
08

No of Hours:

Overview of biosafety, risk assessment, Cartagena Protocol on Biosafety, capacity building, GMOs Transgenic technology, future opportunities and challenges, Regulatory measures for biosafety, biosafety guidelines in India evolved by DBT.

Unit 4
08

No of Hours:

Prevention of food adulteration act, food and safety standard bill and seed policy, rules for the manufacture and storage of hazardous, biosafety management, Some of the products development from RDT and their biosafety issues, biosafety and Gene therapy, ecological safety assessment of recombinant organisms

Unit 5
05

No of Hours:

Bioethics and its scope, different approaches to ethics, biological weapons and their social and ethical implications, Importance of good laboratory practices, general good laboratory practices

DS 19P: BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS (PRACTICAL)

TOTAL HOURS: 60

CREDITS:

2

Standardization of contamination free environment in laboratory practices. Biochemical and Microbiological analysis of Foods. Food adulteration and its Testing / Analysis

Suggested Reading

1. Bare Act, 2007. Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., New Delhi.
2. Goel D & Prashar S (2013). IPR, Biosafety and Bioethics. Pearson

DS 20T: GENOME BIOLOGY (THEORY)

TOTAL HOURS: 45

CREDITS:

3

Unit 1 Evolution of Bacterial Genomes

No. of Hours:

09

Basic concept of bacterial genome evolution, Horizontal gene transfer (HGT), Evolution of bacterial virulence - Genomic islands, Pathogenicity islands (PAI) and their characteristics

Unit 2 Metagenomics

No. of Hours:

12

Development of metagenomics, Understanding bacterial diversity using metagenomic approach. Basic knowledge of viral metagenome, metatranscriptomics, metaproteomics and metabolomics.

Unit 3 Molecular Basis of Host-Microbe Interactions

No. of Hours:

12

Virulence factors of pathogens: enzymes, toxins (host specific and non specific) growth regulators, virulence factors in viruses (replicase, coat protein, silencing suppressors) in disease development.

Biofilms: types of microorganisms, molecular aspects and significance in environment, health care, virulence and antimicrobial resistance.

Unit 4 Systems and Synthetic Biology

No. of Hours:

12

Networking in biological systems: Quorum sensing in bacteria, Co-ordinated regulation of bacterial virulence factors. Introduction and implications of synthetic biology with respect to bacteria and viruses

DS 20P: GENOME BIOLOGY (PRACTICAL)

TOTAL HOURS: 60

CREDITS:

2

1. Extraction and purification genomic DNA from *E.coli* using phenol chloroform method.
2. Performing PCR amplification by using suitable DNA
3. Isolation of antibiotic resistant bacteria from soil and study of multiple antibiotic resistance, using at least three(3) antibiotics.

SUGGESTED READING

1. Fraser CM, Read TD and Nelson KE. Microbial Genomes, 2004, Humana Press
2. Miller RV and Day MJ. Microbial Evolution- Gene establishment, survival and exchange, 2004, ASM Press
3. Bull AT. Microbial Diversity and Bioprospecting, 2004, ASM Press
4. Sangdun C. Introduction to Systems Biology, 2007, Humana Press
5. Klipp E, Liebermeister W. Systems Biology – A Textbook, 2009, Wiley
6. Caetano-Anolles G. Evolutionary Genomics and Systems Biology, 2010, John Wiley and Sons
7. Madigan MT, Martink JM, Dunlap PV and Clark DP (2014) Brook's Biology of Microorganisms, 14th edition, Pearson-Benjamin Cummings
8. Wilson BA, Salyers AA Whitt DD and Winkler ME (2011) Bacterial Pathogenesis- A molecular Approach, 3rd edition, ASM Press

DS 21T BIOINFORMATICS (THEORY)

TOTAL HOURS: 45

CREDITS:

3

Unit 1 Introduction to Bioinformatics and Biological Databases

No. of Hours:

10

Biological databases - nucleic acid, genome, protein sequence and structure, gene expression databases, Database of metabolic pathways, Mode of data storage - File formats - FASTA, Genbank and Uniprot, Data submission & retrieval from NCBI, EMBL, DDBJ, Uniprot, PDB

Unit 2 Sequence Alignments, Phylogeny and Phylogenetic trees

No. of Hours:

15

Local and Global Sequence alignment, pairwise and multiple sequence alignment. Scoring an alignment, scoring matrices, PAM & BLOSUM series of matrices Types of phylogenetic trees, Different approaches of phylogenetic tree construction - UPGMA, Neighbour joining, Maximum Parsimony, Maximum likelihood

Unit 3 Genome organization and analysis**No. of Hours:****10**

Diversity of Genomes: Viral, prokaryotic & eukaryotic genomes Genome, transcriptome, proteome, 2-D gel electrophoresis, MalDI Toff spectroscopy Major features of completed genomes: *E.coli*, *S.cerevisiae*, *Arabidopsis*

Unit 4 Protein Structure Predictions**No. of Hours:****10**

Hierarchy of protein structure - primary, secondary and tertiary structures, modelling Structural Classes, Motifs, Folds and Domains
Protein structure prediction in presence and absence of structure template
Energy minimizations and evaluation by Ramachandran plot
Protein structure and rational drug design

DS 21: BIOINFORMATICS (PRACTICAL)**TOTAL HOURS: 60****CREDITS:****2**

1. Introduction to different operating systems - UNIX, LINUX and Windows
2. Introduction to bioinformatics databases (any three): NCBI/PDB/DDBJ, Uniprot, PDB
3. Sequence retrieval using BLAST
4. Sequence alignment & phylogenetic analysis using clustalW & phylip
5. Picking out a given gene from genomes using Genscan or other softwares (promoter region identification, repeat in genome, ORF prediction). Gene finding tools (Glimmer, GENSCAN), Primer designing, Genscan/Genetool
6. Protein structure prediction: primary structure analysis, secondary structure prediction using psipred, homology modeling using Swissmodel. Molecular visualization using jmol, Protein structure model evaluation (PROCHECK)
7. Prediction of different features of a functional gene

SUGGESTED READING

1. Saxena Sanjay (2003) A First Course in Computers, Vikas Publishing House
2. Pradeep and Sinha Preeti (2007) Foundations of Computing, 4th ed., BPB Publications
3. Lesk M.A.(2008) Introduction to Bioinformatics . Oxford Publication, 3rd International Student Edition
4. Rastogi S.C., Mendiratta N. and Rastogi P. (2007) Bioinformatics: methods and applications, genomics, proteomics and drug discovery, 2nd ed. Prentice Hall India Publication
5. Primrose and Twyman (2003) Principles of Genome Analysis & Genomics. Blackwell

MINOR COURSE

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. 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.

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.

SEMESTER III

MA 3T: Industrial & Food Microbiology (Theory)

TOTAL HOURS: 45

CREDITS: 3

Unit 1 Industrial Strains and Fermentation Medium

No. of Hours: 8

Primary and secondary screening, Preservation and maintenance of industrial strains
Ingredients used in fermentation medium - molasses, corn steep liquor, whey & Yeast extract

Unit 2 Microbial fermentation processes

No. of Hours: 10

Fermentor: General design of a bioreactor, general idea of Downstream processing, Microbial production of industrial products - citric acid, ethanol and penicillin.
Industrial production and uses of the enzymes - amylases, proteases

Unit 3 Food as a substrate for microbial growth

No. of Hours: 8

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

Unit 4 Food preservation

No. of Hours: 8

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

Unit 5 Dairy products, probiotics and Food-borne Diseases

No. of Hours: 11

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*

MA-3: INDUSTRIAL AND FOOD MICROBIOLOGY (PRACTICAL)

TOTAL HOURS: 60

CREDITS: 2

1. Microbial fermentation for the production of amylase
2. Determination of the microbiological quality of milk sample by MBRT

3. Isolation of fungi from spoilt bread/fruits/vegetables
4. Preparation of Yogurt/Dahi

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.

SEMESTER IV

MA 4: MEDICAL MICROBIOLOGY (THEORY)

TOTAL HOURS: 45

CREDITS: 3

Unit 1 Normal microflora of the human body and host pathogen interaction No. of Hours: 12

Normal microflora of the human body: Importance of normal microflora, normal microflora of skin, throat, gastrointestinal tract, urogenital tract

Host pathogen interaction: Definitions - Infection, Invasion, Pathogen, Pathogenicity, Virulence, Toxigenicity, Carriers and their types, Opportunistic infections, Nosocomial infections.

Transmission of infection,

Unit 2 Sample collection, transport and diagnosis

No. of Hours: 6

Collection, transport and culturing of clinical samples and their identification characteristics.

Unit 3 Bacterial diseases

No. of Hours: 5

List of diseases of various organ systems and their causative agents.

Unit 4 Viral diseases

No. of Hours: 5

List of diseases of various organ systems and their causative agents.

Unit 5 Protozoan diseases

No. of Hours: 4

List of diseases of various organ systems and their causative agents.

Unit 6 Fungal diseases

No. of Hours: 4

Brief description of various types of mycoses.

Unit 7 Antimicrobial agents: General characteristics and mode of action

No. of Hours: 9

Antibacterial agents: Five modes of action with one example each: Inhibitor of nucleic acid synthesis;

Inhibitor of cell wall synthesis; Inhibitor of cell membrane function; Inhibitor of protein synthesis;

Inhibitor of metabolism, Antifungal agents: Mechanism of action of Amphotericin B, Griseofulvin

Antiviral agents: Mechanism of action of Amantadine, Acyclovir, Azidothymidine.

MA 4: MEDICAL MICROBIOLOGY (PRACTICAL)

TOTAL HOURS: 60

CREDITS: 2

1. Study of composition and use of important differential media for identification of bacteria: EMB Agar, McConkey agar, Mannitol salt agar, Deoxycholate citrate agar, TCBS
2. Study of bacterial flora of skin by swab method

3. Perform antibacterial sensitivity by Kirby-Bauer method

SUGGESTED READING

1. Ananthanarayan R. and Paniker C.K.J. (2009) Textbook of Microbiology. 8th edition, University Press Publication
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. Goering R., Dockrell H., Zuckerman M. and Wakelin D. (2007) Mims' Medical Microbiology. 4th edition. Elsevier
4. Willey JM, Sherwood LM, and Woolverton CJ. (2013) Prescott, Harley and Klein's Microbiology. 9th edition. McGraw Hill Higher Education

SEMESTER V

MA 5: MICROBIAL GENETICS AND MOLECULAR BIOLOGY (THEORY)

TOTAL HOURS: 45

CREDITS:

3

Unit 1 Structures of DNA and RNA / Genetic Material

No. of Hours: 10

DNA structure, Salient features of double helix, Types of DNA, denaturation and renaturation, topoisomerases; Organization of DNA Prokaryotes, Viruses, Eukaryotes. RNA Structure

Unit 2 Replication of DNA

No. of Hours: 6

Bidirectional and unidirectional replication, semi- conservative, semi- discontinuous replication
Mechanism of DNA replication: Enzymes and proteins involved in DNA replication –DNA polymerases, DNA ligase, primase, telomerase – for replication of linear ends

Unit 3 Transcription

No. of Hours: 6

Transcription: Definition, promoter - concept and strength of promoter. Transcriptional Machinery and Mechanism of transcription.

Unit 4 Translation

No. of Hours: 6

Genetic code, Translational machinery, Charging of tRNA, aminoacyl tRNA synthetases, Mechanisms of initiation, elongation and termination of polypeptides.

Unit 5 Mutations

No. of Hours: 9

Mutations and mutagenesis: Definition and types of Mutations; Physical and chemical mutagens; Uses of mutations, DNA repair mechanisms

Unit 6 Plasmids

No. of Hours: 8

Property and function of plasmids, Types of plasmids, Plasmid transfer by conjugation

MA5: MICROBIAL GENETICS AND MOLECULAR BIOLOGY (PRACTICAL)

TOTAL HOURS: 60

CREDITS: 2

1. Study of different types of DNA and RNA using micrographs and model / schematic representations
2. Study of semi-conservative replication of DNA through micrographs / schematic representations
3. Qualitative analysis of DNA using colorimeter (diphenylamine reagent) or UV spectrophotometer (A₂₆₀ measurement)
4. Resolution and visualization of DNA by Agarose Gel Electrophoresis. (Demonstration only)

SUGGESTED READINGS

1. Watson JD, Baker TA, Bell SP, Gann A, Levine M and Losick R (2008) Molecular Biology of the Gene, 6th edition, Cold Spring Harbour Lab. Press, Pearson Publication
2. Becker WM, Kleinsmith LJ, Hardin J and Bertoni GP (2009) The World of the Cell, 7th edition, Pearson Benjamin Cummings Publishing, San Francisco
3. De Robertis EDP and De Robertis EMF (2006) Cell and Molecular Biology, 8th edition. Lippincott

Williams and Wilkins, Philadelphia

4. Karp G (2010) Cell and Molecular Biology: Concepts and Experiments, 6th edition, John Wiley & Sons. Inc.

5. Sambrook J and Russell DW. (2001). Molecular Cloning: A Laboratory Manual. 4th Edition, Cold Spring Harbour Laboratory press.

SEMESTER VI

MA 6: IMMUNOLOGY (Theory)

TOTAL HOURS: 45

CREDITS: 3

Unit 1 Immune Cells and Organs

No. of Hours: 10

Structure, Functions and Properties of: Immune Cells – Stem cell, T cell, B cell, NK cell, Macrophage, Neutrophil, Eosinophil, Basophil, Mast cell, Dendritic cell; and Immune Organs – Bone Marrow, Thymus, Lymph Node, Spleen

Unit 2 Antigens and Antibodies

No. of Hours: 10

Characteristics of an antigen (Foreignness, Molecular size and Heterogeneity); Haptens; Epitopes (T & B cell epitopes), Adjuvants, Structure, Types and Functions of antibodies.

Unit 3 Generation of Immune Response

No. of Hours: 10

Primary and Secondary Immune Response; Generation of Humoral Immune Response (Plasma and Memory cells); Generation of Cell Mediated Immune Response

Unit 4 Immunological Disorders and Tumor Immunity

No. of Hours: 8

Types of Autoimmunity and Hypersensitivity with examples; Immunodeficiencies - Animal models (Nude and SCID mice).

Unit 5 Immunological Techniques

No. of Hours: 7

Principles of Precipitation, Agglutination, Immunodiffusion, Immunoelectrophoresis, ELISA, ELISPOT.

MA-6: IMMUNOLOGY (PRACTICAL)

TOTAL HOURS: 60

CREDITS: 2

1. Identification of human blood groups.
2. To separate serum from the blood sample (demonstration).
3. To perform immunodiffusion by Ouchterlony method.

SEMESTER VII

SM 1 (SPECIAL MINOR): ENVIRONMENTAL BIOTECHNOLOGY (THEORY)

TOTAL HOURS: 45

CREDITS: 3

Unit 1 Soil Microbiology: Soil as Microbial Habitat

No. of Hours: 10

Soil profile and properties, Soil formation, Diversity and distribution of microorganisms in soil. Microbial Activity in Soil and Green House Gases- Carbon dioxide, methane, nitrous oxide, nitric oxide – production and control

Unit 2 Mineralization of Organic & Inorganic Matter in Soil

No. of Hours: 8

Mineralization of cellulose, hemicelluloses, lignocelluloses, lignin and humus, phosphate, nitrate, silica, potassium

Unit 3 Microbial Control of Soil Borne Plant Pathogens**No. of Hours: 7**

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

Unit 4 PGPRs**No. of Hours: 10**

Biofertilization, Phyto-stimulation, Bioinsecticides: 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

Unit 5 Agricultural Biotechnology**No. of Hours: 10**

Biotech feed, Silage, Biomanure, biogas, biofuels – advantages and processing parameters. GM crops: Advantages, social and environmental aspects, Bt crops, golden rice, transgenic animals

SM 1 (SPECIAL MINOR): ENVIRONMENTAL BIOTECHNOLOGY (PRACTICAL)**TOTAL HOURS: 60****CREDITS: 2**

1. Isolation of Nitrogen bacteria from soil.
2. Laboratory scale production of biofertilizers.
3. Isolation and characterization of plant growth promoting bacteria (phosphate solubilizing bacteria).

SUGGESTED READING

1. Eldor A. Paul. Soil Microbiology. Ecology and Biochemistry. VI Edition: Academic Press, (2007).
2. Eugene L. Madsen. Environmental Microbiology: From Genome to Biogeochemistry. I Edition, Wiley-Blackwell Publishing. (2008).
3. Agrios, G.N. Plant pathology. Harcourt Asia Pvt. Ltd. (2000).
4. Buchanan, B.B., Gruissem, W. and Jones, R.L. Biochemistry and Molecular Biology of Plants. I.K. International Pvt. Ltd. (2000).
5. Mehrotra R S and Ashok Agrawal. Plant Pathology. Tata Mc Graw Hill, 6th reprint (2006).
6. K. S. Bilgrami, H. C. Dube. A textbook of modern pathology. 6th Edition, Vani Educational Books

MULTIDISCIPLINARY COURSE (MDC): 3 credits (theory)

[To be completed from a pool of topics in Life Science (for students of OTHER THAN MICROBIOLOGY/BIOLOGICAL SCIENCE)]

BIOREMEDIATION**Unit 1: Microorganism and Metal Pollutants**

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

Unit 2: 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 Heidelberg
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.

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. and DNA ligases, Agarose gel electrophoresis, PCR

Unit 2 Vectors

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

Unit 3 Application of Genetic Engineering and Biotechnology

Products of recombinant DNA technology: Products of human therapeutic interest - insulin, hGH, antisense molecules. Bt transgenic - cotton, brinjal, Gene therapy, recombinant vaccine

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

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 dekker 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