

Kazi Nazrul University

Proposed Structure of B. Sc. 3rd and 4th Semester

Microbiology (Hons.) Syllabus under CBCS pattern.

Yes
Alloy

Semester III

Core Subjects

C-5: Microbial Physiology & Metabolism

C-6: Cell Biology

C-7: Molecular Biology

Generic Electives

GE-3: Microbial Metabolism (3rd Sem)

Skill Enhancement Elective Courses (Any one)

SEC-1: Microbial Quality Control in Food and Pharmaceutical Industries

SEC-2: Microbial Diagnosis in Health Clinics

C-5: MICROBIAL PHYSIOLOGY AND METABOLISM (THEORY)

TOTAL HOURS: 50 FM-50, WRITTEN-40, INTERNAL-10, CREDIT-4

MICROBIAL PHYSIOLOGY & METABOLISM, CREDITS: 4

1. Microbial Growth and Effect of Environment on Microbial Growth

12

Definitions of growth, 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 (psychrophiles, mesophiles, thermophiles, extremophiles), pH (acidophiles, alkaliphiles), solute and water activity (halophiles, xerophiles, osmophilic), Oxygen (aerobic, anaerobic, microaerophilic, facultative aerobe, facultative anaerobe), barophilic. Microbial growth in response to nutrition and energy - Autotroph/Phototroph, Heterotroph, Chemolithoautotroph, Chemolithoheterotroph, Chemoheterotroph, Chemolithotroph, photolithoautotroph, Photoorganoheterotroph.

2. Chemoheterotrophic Metabolism

12

Concept of aerobic and anaerobic respiration. Sugar degradation pathways: 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.

Fermentation- Alcohol fermentation and Pasteur Effect; Lactate fermentation (homofermentative and heterofermentative pathways).

3. Chemolithotrophic and Phototrophic Metabolism

10

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.

4. Nitrogen Metabolism - an overview **6**

Introduction to biological nitrogen fixation, Ammonia assimilation, Assimilatory nitrate reduction, dissimilatory nitrate reduction, denitrification, nodule formation, nod factors and *nif* genes

5. Amino acid metabolism **5**

Concept and reaction of Transamination, Deamination, Transmethylation and decarboxylation. Urea cycle, Amino acid Biosynthesis pathways-Aspartate family of amino acids.

6. Lipid Metabolism **5**

Detailed account of beta-oxidation of even and odd number, saturated and unsaturated fatty acids. Biosynthesis of fatty acid.

C-5: MICROBIAL PHYSIOLOGY AND METABOLISM (PRACTICAL)
TOTAL HOURS: 50 FM-50 CREDITS: 2

Microbial Physiology & Metabolism Lab

1. Study and plot of the growth curve of bacteria by turbidometric methods, determination of generation time and specific growth rate from the plot.
2. Effect of temperature, pH, salt concentration on bacterial growth.
3. Enrichment of microbes- Nitrogen fixer, cellulose decomposer, photosynthetic bacteria.
4. Biochemical tests-Amylase, Catalase, Protease, Indole production, MRVP test, acid gas production, Citrate utilization and nitrate reduction.
5. Determination of the thermal death point of a bacteria.
6. 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 Higher Education.

C-6: CELL BIOLOGY, TOTAL HOURS: 50, CREDITS: 6

FM-50, WRITTEN-40, INTERNAL-10

Cell Biology

1. Structure and organization of Cell 14

Basic idea of Cell Organization – Eukaryotic (Plant and animal cells) and prokaryotic Plasma membrane: Structure and transport (passive and facilitated diffusion, active transport, Group translocation, ionophore). 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). Cytoskeleton: Structure and organization of actin filaments, microtubules. Mitochondria, chloroplasts and peroxisomes

2. Nucleus 4

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

3. Protein Sorting and Transport 12

Ribosomes, Endoplasmic Reticulum – Structure, targeting and insertion of proteins in the ER, protein folding and processing, export of proteins and lipids
Golgi Apparatus – Organization, protein glycosylation, protein sorting and export from Golgi Apparatus. Lysosomes

4. Cell Signalling 8

Basic idea and function of signaling molecules and their receptors.
Pathways of intra-cellular receptors – Cyclic AMP pathway, cyclic GMP and MAP kinase, Integrin pathway

5. Cell Cycle, Cell Death and Cell Renewal 12

Eukaryotic cell cycle and its regulation, Mitosis and Meiosis. Development of cancer, Programmed cell death. Basic idea of Stem cells and pluripotency.

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

C-7: MOLECULAR BIOLOGY

FM-50, Written-40, Internal-10, CREDITS: 6, TOTAL HOURS: 50

Unit 1 Structures of DNA and RNA / Genetic Material

No. of Hours: 10

Structure of DNA (Watson & Crick), Salient features of double helix, RNA structure, denaturation and renaturation, Cot curve, C-value paradox.

Unit 2 Replication of DNA (Prokaryotes and Eukaryotes)

No. of Hours: 12

Semi conservative replication, rolling circle and (theta) mode of replication. Mechanism and steps of prokaryotic DNA replication: Enzymes and proteins involved in DNA replication –DNA polymerases, DNA ligase, primase. Comparison with eukaryotic, replication, basic idea of telomerase.

Unit 3 Transcription and post transcriptional modification

No. of Hours: 12

Transcription: Definition, difference from replication, promoter - concept and strength of promoter, RNA Polymerase and the transcription unit.

Transcription in Eukaryotes: RNA polymerases, general Transcription factors Concept of introns, exons, RNA splicing, alternative splicing, Polyadenylation and capping.

Unit 4 Translation (Prokaryotes and Eukaryotes)

No. of Hours: 8

Translational machinery, Charging of tRNA, aminoacyl tRNA synthetases, Mechanisms of initiation, elongation and termination of polypeptides in prokaryotes and comparison with eukaryotes, Fidelity of translation, Inhibitors of protein synthesis in prokaryotes and eukaryote

Unit 5 Regulation of gene Expression in Prokaryotes and Eukaryotes

No. of Hours: 8

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.

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. th
5. Sambrook J and Russell DW. (2001). Molecular Cloning: A Laboratory Manual. 4 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

GE-3: MICROBIAL METABOLISM (THEORY)

TOTAL HOURS: 60 FM: 50

CREDITS: 4

Unit 1 Microbial Growth and Effect of Environment on Microbial Growth No. of Hours: 12

Definitions of growth, Batch culture, Continuous culture, generation time and specific growth rate Temperature and temperature ranges of growth pH and pH ranges of growth Effect of solute and water activity on growth Effect of oxygen concentration on growth Nutritional categories of microorganisms

Unit 2 Nutrient uptake and Transport

No. of Hours: 10

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

Unit 3 Chemoheterotrophic Metabolism - Aerobic Respiration

No. of Hours: 16

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 4 Chemoheterotrophic Metabolism- Anaerobic respiration and fermentation

No. of Hours: 6

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 linear and branched fermentation pathways

Unit 5 Chemolithotrophic and Phototrophic Metabolism

No. of Hours:10

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 and cyanobacteria

Unit 6 Nitrogen Metabolism - an overview

No. of Hours: 6

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

GE-3: MICROBIAL METABOLISM (PRACTICAL)

SEMESTER –III

TOTAL HOURS: 60 FM: 50

CREDITS: 2

1. Study and plot of the growth curve of bacteria by turbidometric methods, determination of generation time and specific growth rate from the plot.
2. Effect of temperature, pH, salt concentration on bacterial growth.

3. Enrichment of microbes- Nitrogen fixer, cellulose decomposer, photosynthetic bacteria.
4. Biochemical tests-Amylase, Catalase, Protease, Indole production, MRVP test, acid gas production, Citrate utilization and nitrate reduction.
5. Determination of the thermal death point of a bacteria.
6. 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 Higher Education.

SE-1: MICROBIAL QUALITY CONTROL IN FOOD AND PHARMACEUTICAL INDUSTRIES

TOTAL HOURS: 30; CREDITS: 2 FM 50

Unit 1 Microbiological Laboratory and Safe Practices

No. of Hours: 8

Good laboratory practices - Good laboratory practices, Good microbiological practices
 Biosafety cabinets – Working of biosafety cabinets, using protective clothing, specification for BSL-1, BSL-2, BSL-3. Discarding biohazardous waste – Methodology of Disinfection, Autoclaving & Incineration

Unit 2 Determining Microbes in Food / Pharmaceutical Samples

No. of Hours: 10

Culture and microscopic methods - Standard plate count, Most probable numbers, Direct microscopic counts, Biochemical and immunological methods: Limulus lysate test for endotoxin, gel diffusion, sterility testing for pharmaceutical products
 Molecular methods - Nucleic acid probes, PCR based detection, biosensors.

Unit 3 Pathogenic Microorganisms of Importance in Food & Water

No. of Hours: 8

Enrichment culture technique, Detection of specific microorganisms - on XLD agar, Salmonella Shigella Agar, Manitol salt agar, EMB agar, McConkey Agar, Saboraud Agar Ascertaining microbial quality of milk by MBRT, Rapid detection methods of microbiological quality of milk at milk collection centres (COB, 10 min Resazurin assay)

Unit 4 HACCP for Food Safety and Microbial Standards

No. of Hours: 4

Hazard analysis of critical control point (HACCP) - Principles, flow diagrams, limitations Microbial Standards for Different Foods and Water – BIS standards for common foods and drinking water

SUGGESTED READING

1. Harrigan WF (1998) Laboratory Methods in Food Microbiology, 3rd ed. Academic Press
2. Garg N, Garg KL and Mukerji KG (2010) Laboratory Manual of Food Microbiology I K International Publishing House Pvt. Ltd.
3. Jay JM, Loessner MJ, Golden DA (2005) Modern Food Microbiology, 7th edition. Springer
4. Baird RM, Hodges NA and Denyer SP (2005) Handbook of Microbiological Quality control in Pharmaceutical and Medical Devices, Taylor and Francis Inc.

SE-2: MICROBIAL DIAGNOSIS IN HEALTH CLINICS

TOTAL HOURS: 30; CREDITS: 2 FM 50

Unit 1 Importance of Diagnosis of Diseases

No of Hours: 5

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: 5

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: 5

Examination of sample by staining - Gram stain, Ziehl-Neelson staining for tuberculosis, Giemsa-stained thin blood film 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: 5

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: 5

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

Core Subjects

- C- 8: Environmental & Agricultural Microbiology
 C-9: Food & Dairy Microbiology
 C-10: Industrial Microbiology

GE-4: Industrial and Food Microbiology (4th Sem)

Skill Enhancement Elective Courses (Any one)

- SEC-3:** Food Fermentation Techniques
SEC-4: Biofertilizers and Biopesticides

C-8: ENVIRONMENTAL MICROBIOLOGY (THEORY) CREDITS: 4
TOTAL HOURS: 60 FM-50, Written-40, Internal-10

Unit 1 Microorganisms and their Habitats

No. of Hours: 14

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 Microbial succession in decomposition of plant organic matter

Unit 2 Microbial Interactions

No. of Hours: 12

Microbe interactions: Mutualism, synergism, commensalism, competition, amensalism, parasitism, predation Microbe-Plant interaction: Symbiotic and non symbiotic interactions
 Microbe-animal interaction: symbiotic luminescent bacteria

Unit 3 Biogeochemical Cycling

No. of Hours: 12

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: 12

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: 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

C-8: ENVIRONMENTAL MICROBIOLOGY (PRACTICAL)

TOTAL HOURS: 60 FM-50

CREDITS: 2

1. Analysis of soil - pH, moisture content, water holding capacity
2. Isolation of spore formers from soil .
3. Isolation of microbes (bacteria & fungi) from rhizosphere and rhizoplane.
4. Assessment of microbiological quality of water. (MPN)
5. Microbiological examination of water
 - i) Presumptive test
 - ii) Confirmatory test
 - iii) Completed test for coliform
 - iv) IMViC reaction.
6. 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, USA
6. Barton LL & Northup DE (2011). Microbial Ecology. 1st edition, Wiley Blackwell, 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. edition. John Wiley & Sons
9. Martin A. (1977). An Introduction to Soil Microbiology. 2nd 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.

C-9: FOOD AND DAIRY MICROBIOLOGY (THEORY) CREDITS: 4
TOTAL HOURS: 55 FM-50, Written-40, Internal-10

Unit 1 Foods as a substrate for microorganisms **No. of Hours: 8**

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: 10**

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

Unit 3 Principles and methods of food preservation **No. of Hours: 12**

Principles, physical methods of food preservation: temperature (low, high, canning, drying), of food irradiation, microwave processing and aseptic packaging, chemical preservation: salt, sugar, organic acids, SO₂, nitrite and nitrates.

Unit 4 Fermented foods **No. of Hours: 10**

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 preventivemeasures) **No. of Hours: 10**

Food intoxications: *Staphylococcus aureus*, *Clostridium botulinum*, *Escherichia coli*, *Salmonellosis*, *Campylobacter jejuni*

Unit 6 Food sanitation and control **No. of Hours: 5**

HACCP, Indices of food sanitary quality and sanitizers

C-9: FOOD AND DAIRY MICROBIOLOGY (PRACTICAL)
CREDITS: 2; TOTAL HOURS: 50 FM-50.

1. MBRT of milk samples
2. Standard plate count of milk samples.
3. Isolation of spoilage microorganisms from bread and carrot.
4. Cultivation of edible mushroom.

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.
8. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9th edition. Pearson Education.

C-10: INDUSTRIAL MICROBIOLOGY, FM-50, Written-40, Internal-10, Credit-6

1. Isolation of industrially important microbial strains and fermentation media Isolation, preservation and maintenance of industrial strains, strain improvement, Crude and synthetic media; molasses, corn-steep liquor, sulphite waste liquor, whey, yeast extract.
2. **Types of fermentation processes, bio-reactors and measurement of fermentation parameters**

Types of fermentation processes - Solid-state and liquid-state (stationary and submerged) fermentations; batch, fed-batch (eg. baker's yeast) and continuous fermentations Components of a typical bio-reactor, Types of bioreactors-Laboratory, pilot - scale, Measurement and control of fermentation parameters - pH, temperature, dissolved oxygen, foaming and aeration

3. Down-stream processing

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

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

Citric acid, ethanol, penicillin, Vitamin B₁₂. Enzymes (amylase), Wine, beer

5. Enzyme immobilization

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

SUGGESTED READING

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

GE-4: INDUSTRIAL AND FOOD MICROBIOLOGY (THEORY), SEMESTER – IV

TOTAL HOURS: 60; CREDITS: 4

Unit 1 Introduction to Industrial microbiology

No. of Hours: 10

Brief history and developments in 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

Unit 2 Isolation of 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 3 Microbial fermentation processes

No. of Hours: 12

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.

Unit 4 Food as a substrate for microbial growth**No. of Hours: 9**

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

Unit 5 Principles and methods of food preservation and food sanitation No. of Hours: 9

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 6 Dairy products, probiotics and Food-borne Diseases**No. of Hours: 12**

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

**GE-4: INDUSTRIAL AND FOOD MICROBIOLOGY (PRACTICAL),
SEMESTER – IV****TOTAL HOURS: 50; CREDITS: 2**

1. MBRT of milk samples
2. Standard plate count of milk samples.
3. Isolation of spoilage microorganisms from bread and carrot.
4. Cultivation of edible mushroom.
5. Standard plate count of milk samples.

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.
7. Adams MR and Moss MO. (1995). Food Microbiology. 4th edition, New Age International (P) Limited Publishers, New Delhi, India.
8. Banwart JM. (1987). Basic Food Microbiology. 1st edition. CBS Publishers and Distributors, Delhi, India.
9. Frazier WC and Westhoff DC. (1992). Food Microbiology. 3rd edition. Tata McGraw-Hill Publishing Company Ltd, New Delhi, India.
10. Jay JM, Loessner MJ and Golden DA. (2005). Modern Food Microbiology. 7th edition, CBS Publishers and Distributors, Delhi, India.

SEC-3: FOOD FERMENTATION TECHNIQUES

TOTAL HOURS: 30; CREDITS: 2

Unit 1 Fermented Foods **No of Hours: 4**

Definition, types, advantages and health benefits

Unit 2 Milk Based Fermented Foods **No of Hours: 8**

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

Unit 3 Grain Based Fermented Foods **No of Hours: 6**

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

Unit 4 Vegetable Based Fermented Foods **No of Hours: 4**

Pickels, Saeurkraut: Microorganisms and production process

Unit 5 Fermented Meat and Fish **No of Hours: 4**

Types, microorganisms involved, fermentation process

Unit 6 Probiotic Foods **No of Hours: 4**

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

SEC-4: BIOFERTILIZERS AND BIOPESTICIDES

SEMESTER – IV

TOTAL HOURS: 30; CREDITS: 2

Unit 1 Biofertilizers **No of Hours: 10**

General account of the microbes used as biofertilizers for various crop plants and their advantages over chemical fertilizers.

Symbiotic N₂ fixers: *Rhizobium* - Isolation, characteristics, types, inoculum production and field application, legume/pulses plants

Frankia - Isolation, characteristics, Alder, Casurina plants, non-leguminous crop symbiosis.

Cyanobacteria, *Azolla* - Isolation, characterization, mass multiplication, Role in rice cultivation, Crop response, field application.

Unit 2 Non - Symbiotic Nitrogen Fixers **No of Hours: 4**

Free living *Azospirillum*, *Azotobacter* - free isolation, characteristics, mass inoculums, production and field application.

Unit 3 Phosphate Solubilizers

No of Hours: 4

Phosphate solubilizing microbes - Isolation, characterization, mass inoculum production, field application

Unit 4 Mycorrhizal Biofertilizers

No of Hours: 5

Importance of mycorrhizal inoculum, types of mycorrhizae and associated plants, Mass inoculum production of VAM, field applications of Ectomycorrhizae and VAM.

Unit 5 Bioinsecticides

No of Hours: 7

General account of microbes used as bioinsecticides and their advantages over synthetic pesticides, *Bacillus thuringiensis*, production, Field applications, Viruses – cultivation and field applications.

SUGGESTED READINGS

1. Kannaiyan, S. (2003). Bioetchnology of Biofertilizers, CHIPS, Texas.
2. Mahendra K. Rai (2005). Hand book of Microbial biofertilizers, The Haworth Press, Inc. New York.
3. Reddy, S.M. et. al. (2002). Bioinoculants for sustainable agriculture and forestry, Scientific Publishers.
4. Subba Rao N.S (1995) Soil microorganisms and plant growth Oxford and IBH publishing co. Pvt. Ltd. NewDelhi.
5. Saleem F and Shakoori AR (2012) Development of Bioinsecticide, Lap Lambert Academic Publishing GmbH KG
6. Aggarwal SK (2005) Advanced Environmental Biotechnology, APH publication.

