

Syllabus of Change of Subject/Discipline for seeking admission in

M.Sc. Microbiology programme

Syllabus is based on Three Years B.Sc. Microbiology of Goa University

PAPER CODE	TITLE
SEMESTER I	
MIC101	Microbiology and Biochemistry I
MIG101	Introduction and Scope of Microbiology
SEMESTER II	
MIC102	Microbiology and Biochemistry II
MIG102	Industrial and Food Microbiology
SEMESTER III	
MIC 103	Environmental Microbiology
MIS 101	Food and Dairy Microbiology
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MIC 104	Molecular Biology
MIS 102	Instrumentation and Techniques
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MIC 105	Medical Microbiology
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MIC 107	Microbial Genetics
MID 101	Applied Microbiology
MID 102	Microbial Physiology
MID 103	Biostatistics and Bioinformatics
SEMESTER VI	
MIC 108	Immunology
MIC 109	Agricultural Microbiology
MIC 110	Genetic Engineering
MID 104	Cell Biology
MID 105	Virology
MID 106	Haematology and Clinical Biochemistry

MIC 101: MICROBIOLOGY AND BIOCHEMISTRY – I

Unit 1 History of Development and Scope of Microbiology

Development of microbiology as a discipline, Spontaneous generation *vs.* biogenesis. Contributions of Leeuwenhoek, Pasteur, Koch, Lister, 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 Beijerinck, Winogradsky, Waksman.

Establishment of fields of medical microbiology and immunology through the work of Ehrlich, Metchnikoff, Jenner. An overview of Scope of Microbiology.

Unit 2 Cell organization

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, Gram staining mechanism, lipopolysaccharide (LPS).

Cell Membrane: Structure, function and chemical composition of bacterial cellular membrane.

Endospore: Structure, formation, stages of sporulation.

Unit 3 Bacteriological techniques

Pure culture isolation: Streaking, serial dilution and plating methods; cultivation, maintenance and preservation of pure cultures; cultivation of anaerobic bacteria.

Unit 4 Microscopy and Principles of staining

Bright Field Microscope, mordants, fixatives and decolorisers, definition of dyes, chromogen, chromophore and auxochrome group, types of staining – Gram staining, monochrome staining and negative staining.

Unit 5 Growth and nutrition

Nutritional requirements in bacteria and nutritional categories.

Culture media: components of media, natural and synthetic media, chemically defined media, complex media, selective, differential.

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

Chemical methods of microbial control: types of disinfectants.

Unit 6 Macromolecules

Carbohydrates

Families of monosaccharides: aldoses and ketoses, trioses, tetroses, pentoses, and hexoses. Furanose and pyranose forms of glucose and fructose, Haworth projection formulae for glucose; chair and boat forms of glucose.

Disaccharides; concept of reducing and non-reducing sugars, Haworth projections of maltose, lactose and sucrose.

Polysaccharides, storage polysaccharides, starch and glycogen. Structural Polysaccharides, cellulose, peptidoglycan.

Lipids: Definition and major classes of storage and structural lipids. Storage lipids. Fatty acids: structure and functions. Essential fatty acids. Triacyl glycerols structure, Structural lipids. Phosphoglycerides: Building blocks, General structure.

Proteins: Amino acids, the building blocks of proteins. General formula of amino acid and concept of zwitterion. Protein structure: Primary, secondary, tertiary and quaternary structures.

Nucleic acids: Structure of nucleotides, DNA and RNA; brief concept of central dogma of molecular biology.

Unit 7 Enzymes

Classification of enzymes. Apoenzyme, coenzyme, prosthetic group, cofactors. Structure of enzyme.

Mechanism of action of enzymes: active site, activation energy, transition state complex.

Multienzyme complex: pyruvate dehydrogenase; Isozyme: lactate dehydrogenase.

Unit 8 Practical

Microbiology Good Laboratory Practices (GLP) and Biosafety. To study the principle and applications of important instruments (biological safety cabinets, autoclave, incubator, BOD incubator, hot air oven, light microscope, pH meter) used in the microbiology laboratory. Preparation of culture media for bacterial cultivation; synthetic media, Complex media-Nutrient agar, MacConkey agar. Simple staining, negative, Gram staining. Isolation of pure cultures of bacteria by streaking method. Estimation of CFU count by spread plate method/pour plate method. Motility by hanging drop method. Qualitative/Quantitative tests for carbohydrates, reducing sugars, non-reducing sugars. Qualitative/Quantitative tests for lipids and proteins.

SUGGESTED READING (Latest editions)

- Tortora GJ, Funke BR and Case CL. Microbiology: An Introduction. Pearson Education
- Madigan MT, Martinko JM, Dunlap PV and Clark DP. Brock Biology of Microorganisms. Pearson International Edition
- Wiley JM, Sherwood LM and Woolverton CJ. Prescott's Microbiology. McGrawHill International
- Atlas RM. Principles of Microbiology. W.M.T.Brown Publishers.
- Pelczar MJ, Chan ECS and Krieg NR. Microbiology. McGraw Hill Book Company.
- Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. General Microbiology. McMillan
- Cappucino J and Sherman N. Microbiology: A Laboratory Manual. Pearson Education Limited
- Salle A.J. Fundamental Principles of Bacteriology. Tata McGraw-Hill Education
- Modi H.A, Elementary Microbiology Vol I, Fundamentals of Microbiology
- Nelson DL and Cox MM. Lehninger Principles of Biochemistry. W.H. Freeman and Company.
- Voet, D. and Voet J.G. Biochemistry. John Wiley and Sons.
- Conn E and Stumpf P. Outlines of biochemistry. John Wiley and Sons.

MIG101: INTRODUCTION AND SCOPE OF MICROBIOLOGY

Unit 1 History of Development of Microbiology

Development of microbiology as a discipline, Spontaneous generation vs. biogenesis. Contributions of Leeuwenhoek, Pasteur, Koch, Lister, Fleming.

Role of microorganisms in fermentation, Germ theory of disease, Development of various microbiological techniques, Golden era of microbiology, Developments in the field of soil microbiology: Contributions of Beijerinck, Winogradsky, Waksman. Establishment of fields of medical microbiology and immunology through the works of Ehrlich, Metchnikoff, Jenner.

Unit 2 Diversity of Microorganisms

Systems of classification: Binomial nomenclature, Whittaker's five kingdom and Carl Woese's three Domain classification systems and their utility.

General characteristics of different groups: Acellular microorganisms (viruses, viroids), cellular microorganisms (Prokarya: Archaea and Eubacteria; Eukarya : Algae, fungi and protozoa) and prions - giving definitions and citing examples.

Unit 3 Microscopy

Bright Field Microscope, Electron Microscope.

Principle of stains and staining techniques (Gram staining, monochrome staining, negative staining).

Unit 4 Sterilization

Autoclave (moist heat), hot air oven (dry heat), Tyndallization, membrane filtration.

Unit 5 Microbes in Human Health & Environment

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

Environmental microbiology: Definitions and examples of important microbial interactions – mutualism, commensalism, parasitism.

Application of microorganisms: bio-pesticides, bio-fertilizers, biodegradation, bio-deterioration and bioremediation (e.g. hydrocarbons in oil spills).

Unit 6 Industrial Microbiology

Definition of fermentation, primary and secondary metabolites, types of fermentations and fermenters, microbes producing important industrial products through fermentation. Biofuels.

Unit 7 Food and Dairy Microbiology

Microorganisms as food (SCP), microorganisms in food fermentations (dairy and non-dairy based fermented food products) and probiotics. Microorganisms in food spoilage and food borne infections.

Unit 8: Ecology and Ecosystems

Concept of ecosystem: Types. Structure and function of ecosystems. Trophic levels: Primary and secondary production. Energy flow: ecological pyramids (pyramid of numbers, pyramid of energy, pyramid of biomass), food chains and food webs. Community structure: succession, trophic structure - zonation and stratification.

Unit 9: Soil Microbiology

Soil as a habitat for microorganisms. Microorganisms in soil and their significance: bacteria, fungi, algae, protozoa, rhizosphere and rhizoplane. Biogeochemical cycles: C, N and role of microorganisms.

SUGGESTED READING (Latest editions)

- ◆ Tortora GJ, Funke BR and Case CL. Microbiology: An Introduction. Pearson Education
- ◆ Madigan MT, Martinko JM, Dunlap PV and Clark DP. Brock Biology of Microorganisms. Pearson International Edition
- ◆ Cappucino J and Sherman N. Microbiology: A Laboratory Manual. Pearson Education Limited
- ◆ Wiley JM, Sherwood LM and Woolverton CJ. Prescott's Microbiology. McGraw Hill International.
- ◆ Atlas RM. Principles of Microbiology. W.M.T. Brown Publishers.
- ◆ Pelczar MJ, Chan ECS and Krieg NR. Microbiology. McGraw Hill Book Company.
- ◆ Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. General Microbiology. McMillan.
- ◆ Odum E. Fundamentals of Ecology. Belmont CA: Thomson Brooks/Cole.
- ◆ Coyne M. Soil Microbiology. Cengage Learning, Inc.
- ◆ Rao NS Subba. Soil Microorganisms and Plant Growth. Oxford and IBH Publishing Co, Pvt. Ltd.
- ◆ Alexander M. Introduction to Soil Microbiology. Krieger Publishing Company.

SEMESTER - II

MIC 102 : MICROBIOLOGY AND BIOCHEMISTRY – II

Unit 1 Introduction to protozoa, fungi, algae and viruses

Discovery, nature, definition and general properties.

Unit 2 Microbial Growth and Effect of Environment on Microbial Growth

Definitions of growth, measurement of microbial growth, Batch culture, Continuous culture, generation time and specific growth rate.

Microbial growth in response to environment - temperature (psychrophiles, psychrotrophs, mesophiles, thermophiles, thermodurics), pH (acidophiles, alkaliphiles), solute and water activity (halophiles, xerophiles, osmophiles), oxygen (aerobes, anaerobes, microaerophilic, facultative aerobes, facultative anaerobes), hydrostatic pressure (barophiles).

Microbial growth in response to nutrition and energy – autotroph/phototroph, heterotroph; photoorganoheterotroph, chemolithotroph: chemolithoautotroph, chemolithoheterotroph, chemoheterotroph, photolithoautotroph.

Unit 3 Nutrient uptake and transport

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

Unit 4 Chemoheterotrophic Metabolism – Aerobic respiration

Concept of aerobic and anaerobic respiration, fermentation. Sugar degradation pathways: EMP, ED, Pentose phosphate pathway, TCA cycle and its amphibolic nature. Electron transport chain: components of respiratory chain.

Unit 5 Chemoheterotrophic Metabolism- Anaerobic respiration and fermentation

Fermentation - Alcohol fermentation and Pasteur effect; lactate fermentation (homofermentative and heterofermentative pathways), concept of linear and branched fermentation pathways.

Unit 6 Eukaryotic Cell Structure and functions

Eukaryotic cell organelles: nucleus, endoplasmic reticulum, golgi apparatus, mitochondria, chloroplast, lysosomes, peroxisomes, protein sorting and transport, cytoskeleton and cell movement, the plasma membrane. Signal transduction – Receptors involved in signal transduction, extracellular matrix and cell interactions. Introduction to cell signalling: components of various signalling pathways, downstream effects of signalling on cell adhesion, cellular differentiation, cell cycle and apoptosis. Stem cells and their applications.

Unit 7 Practical

Study and plot the growth curve of *E. coli* by turbidometric and standard plate count methods. Calculations of generation time and specific growth rate of bacteria from the graph plotted with the given data. Effect of temperature, pH and salt on growth of *E. coli*. Demonstration of alcoholic fermentation. Demonstration of the thermal death time and decimal reduction time of *E. coli*. Isolation and enumeration of bacteriophages (PFU) from water/sewage sample using double agar layer technique. Study of permanent slides of protozoans. Study of morphological characteristics of fungi. Study of morphological characteristics of algae. Study of the structure of cell organelles through electron micrographs. Cytochemical staining of DNA (Feulgen stain).

SUGGESTED READING (Latest Editions)

- Alberts B, Johnson A, Lewis J, Raff M, Roberts K, Walter P. Molecular Biology of The Cell. Garland science, Taylor and Francis group.
- Carter J and Saunders V. Virology: Principles and Applications. John Wiley and Sons.

- Cooper GM and Hausman RE. The Cell: A Molecular Approach. ASM Press and Sunderland, Washington, D.C., Sinauer Associates, MA.
- De Robertis EDP and De Robertis EMF. Cell and Molecular Biology. Lipincott Williams and Wilkins, Philadelphia.
- Dimmock NJ, Easton AL and Leppard KN. Introduction to Modern Virology. Blackwell Publishing Ltd.
- Flint SJ, Enquist LW, Krug RM, Racaniello VR and Skalka AM. Principles of Virology, Molecular biology, Pathogenesis and Control. ASM press Washington DC.
- Gottschalk G. Bacterial Metabolism. Springer Verlag
- Levy JA, Conrat HF and Owens RA. Virology. Prentice Hall publication, New Jersey.
- Lodish H, Berk A, Kaise C, Krieger M, Scott M, Bretscher A, Ploegh H and Matsudaira P. Molecular cell biology .W. H. Francis and company, New York.
- Madigan MT and Martinko JM. Brock Biology of Microorganisms. Prentice Hall International Inc.
- Moat AG and Foster JW. Microbial Physiology. John Wiley and Sons
- Reddy SR and Reddy SM. Microbial Physiology. Scientific Publishers India.
- Stanier RY, Ingrahm JI, Wheelis ML and Painter PR. General Microbiology. McMillan Press.
- Verma PS and Agarwal PK. Genetics, Molecular biology, Evolution and Ecology. S. Chand.
- Wagner EK and Hewlett MJ. Basic Virology. Blackwell Publishing.
- Willey JM, Sherwood LM and Woolverton CJ. Prescott's Microbiology. McGraw Hill Higher Education.

MIG102: INDUSTRIAL AND FOOD MICROBIOLOGY

Unit 1 Introduction to Industrial Microbiology

Brief history and developments in industrial microbiology. Types of fermentation processes - solid state, batch, continuous. Types of fermenters – laboratory, pilot-scale and industrial-scale fermenters.

Unit 2 Maintenance of sterility

Sterilization of equipment: Batch and continuous. Sterilization of production media: Batch and continuous. Sterilization of air: filtration, heat, electrostatic precipitation, UV light and chemical agents.

Unit 3 Isolation of industrially important strains and Study of Fermentation Media

Primary and secondary screening. Preservation and maintenance of industrial strains. Components of fermentation media - molasses, corn steep liquor, whey and yeast extract.

Unit 4 Microbial fermentation processes

Downstream processing - filtration, centrifugation, cell disruption, solvent extraction. Microbial production of industrial products - Vitamin B₁₂ and Penicillin. Industrial applications of the enzymes – amylases, pectinases and proteases.

Unit 5 Food as a substrate for microbial growth

Intrinsic and extrinsic parameters affecting microbial growth in food. Microbial spoilage of food - milk, eggs and canned foods.

Unit 6 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 7 Microbiology of milk

Sources of microorganisms in milk. Microbiological examination of milk: SPC and Breed's smear, advantages and disadvantages. Grading of milk by dye reduction test: MBRT and Resazurin test. Pasteurization of milk: LTH, HTST, UHT and efficacy of pasteurization - Phosphatase test.

Unit 8 Dairy products, probiotics and Food-borne Diseases

Butter, Fermented dairy product – cheese and yogurt. Probiotics definition, examples and benefits. Food intoxication by *Clostridium botulinum* and *Staphylococcus aureus*. Food infections by *Salmonella* and *Listeria*.

SUGGESTED READING (Latest editions)

- Crueger, W. and Crueger, A. Biotechnology: A textbook of Industrial Microbiology. Panima Publishing Company, New Delhi.
- Patel, A.H. Industrial Microbiology. MacMillan India Limited Publishing Company Ltd. New Delhi, India.
- Tortora, G.J., Funke, B.R. and Case, C.L. Microbiology: An introduction. Pearson Education.
- Willey, J.M., Sherwood, L.M. and Woolverton, C.J. Prescott, Harley and Klein's Microbiology. McGraw Hill Higher education.
- Casida, L.E. Industrial Microbiology. Wiley Eastern Limited.
- Stanbury, P.F., Whitaker, A. and Hall, S.J. Principles of Fermentation Technology. Elsevier Science Ltd.
- Adams, M.R and Moss, M.O. Food Microbiology. New Age International (P) Limited Publishers, New Delhi, India.
- Banwart, J.M. Basic Food Microbiology. CBS Publishers and Distributors, Delhi, India.
- Frazier, W.C. and Westhoff, D.C. Food Microbiology. Tata McGraw-Hill Publishing Company Ltd, New Delhi, India.

- Jay, J.M., Loessner, M.J. and Golden, D.A. Modern Food Microbiology. CBS Publishers and Distributors, Delhi, India.

SEMESTER – III
MIC 103: ENVIRONMENTAL MICROBIOLOGY

Unit 1 Microorganisms and their Habitats

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

Unit 2 Microbial Interactions

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 Waste Management

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 4 Microbial Bio-remediation

Microbial remediation of common pesticides, organic (hydrocarbons, oil spills) and inorganic matter (metals).

Unit 5 Water Potability

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.

Unit 6 Practical

Analysis of soil - pH, moisture content, water holding capacity. Isolation of microbes (bacteria and fungi) from soil (28°C and 55°C). Assessment of microbiological quality of air. Assessment of potability of water by MPN, routine analysis – presumptive, confirmed, completed tests; detection of faecal streptococci and clostridia. Determination of BOD of sewage. Isolation of bioluminescent bacteria from sea food. Isolation of *Rhizobium* from root nodules.

SUGGESTED READING (Latest editions)

- Atlas RM and Bartha R. Microbial Ecology: Fundamentals and Applications. Benjamin Cummings Science Publishing, USA.
- Madigan MT, Martinko JM, Dunlap PV and Clark DP. Brock Biology of Microorganisms. Pearson International Edition
- Maier RM, Pepper IL and Gerba CP. Environmental Microbiology. Academic Press.
- Okafor, N. Environmental Microbiology of Aquatic and Waste systems. Springer, New York.
- Singh A, Kuhad, RC and Ward OP. Advances in Applied Bioremediation. Springer-Verlag, Berlin Hedeilberg
- Barton LL and Northup DE. Microbial Ecology. Wiley Blackwell, USA
- Campbell RE. Microbial Ecology. Blackwell Scientific Publication, Oxford, England.
- Coyne MS. Soil Microbiology: An Exploratory Approach. Delmar Thomson Learning.
- Lynch JM and Hobbie JE. Microorganisms in Action: Concepts and Application in Microbial Ecology. Blackwell Scientific Publication, U.K.
- Martin A. An Introduction to Soil Microbiology. John Wiley and Sons Inc. New York and London.

- SubbaRao NS. Soil Microbiology. Oxford and IBH Publishing Co. New Delhi.
- Willey JM, Sherwood LM and Woolverton CJ. Prescott's Microbiology. McGraw Hill Higher Education.

MIS 101: FOOD AND DAIRY MICROBIOLOGY

Unit 1 Food as a substrate for microorganism

Intrinsic and extrinsic factors that affect spoilage of food. Principles and spoilage of vegetables, fruits, meat, eggs, milk and butter, bread, canned foods.

Unit 2 Principles and methods of food preservation

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

Unit 3 Fermented foods

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

Unit 4 Food borne diseases (causative agents, foods involved, symptoms and preventive measures)

Food poisoning: Toxins of *Staphylococcus aureus*, *Clostridium botulinum* and mycotoxins.
Food infections: *Bacillus cereus*, *Vibrio parahaemolyticus*, pathogenic *Escherichia coli*, Salmonellosis, Shigellosis, *Yersinia enterocolitica*, *Listeria monocytogenes* and *Campylobacter jejuni*.

Unit 5 Food sanitation and control

Indices of food sanitary quality and sanitizers, methods of detection of food-borne pathogens, HACCP.

Unit 6 Practical

MBRT of milk samples and their standard plate count. Alkaline phosphatase test to check the efficiency of pasteurization of milk. Isolation of spoilage microorganisms from spoiled vegetables/ fruits/ bread. Preparation of Yogurt/ Dahi/ Sanna.

SUGGESTED READING (Latest editions)

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

SEMESTER – IV
MIC 104 : MOLECULAR BIOLOGY

Unit 1 Nucleic acids

DNA: Watson – Crick model of DNA; Prokaryotic DNA (Circular DNA, Supercoiled, Palindromic), Plasmids; Eukaryotic DNA (Repetitive sequences, split genes, nucleosomes), mitochondrial and chloroplast DNA; Guanine quadruplex (G4) DNA.

RNA: mRNA, rRNA, tRNA, non-coding RNA, micro RNA and Si RNA.

Unit 2 Replication of DNA

Modes of replication - Conservative, semi conservative (Meselson - Stahl experiment) and dispersive; Processes and enzymes involved in replication; Inhibitors of replication; Models of replication in prokaryotes and eukaryotes - Rolling circle model/sigma, theta and linear. Differences between prokaryotic and eukaryotic replication process.

Unit 3 Transcription

Initiation, Elongation, Termination; post transcriptional modification - RNA splicing (Ribozyme), Reverse transcriptase and its implication, Inhibitors of transcription. Concept of operon. Differences between prokaryotic and eukaryotic transcription process.

Unit 4 Translation

Concept of genetic code, Properties: codon / anticodon, Wobble hypothesis, start and stop codons; Ribosomes as sites of protein biosynthesis; amino acid activation and specificity; Initiation, Elongation, Termination; post translational processing and modification; Inhibitors of protein synthesis. Differences between prokaryotic and eukaryotic translation process.

Unit 5 Practical

Study of different types of DNA and RNA using micrographs. Extraction of genomic DNA, quantitative estimation (A_{260}) and estimation of purity ($A_{260/280}$). Estimations: DNA by Diphenylamine method; RNA by Orcinol method; Protein by Folin-Lowry method. Effect of replication inhibitor on bacterial growth. Effect of transcription inhibitor on bacterial growth. Effect of protein synthesis inhibitor on bacterial growth

SUGGESTED READING (Latest editions)

- Frobisher M, Fundamentals of Microbiology, W. B. Saunders Co, Philadelphia.
- Pelczar MJ, Chan ECS and Krieg NR. Microbiology. McGraw Hill Book Company. Willey JM, Sherwood LM, and Woolverton CJ. Prescott's Microbiology. McGraw Hill Higher Education.
- Stanier RY, Ingrahm JI, Wheelis ML and Painter PR. General Microbiology. McMillan Press.
- Tymoczko JL, Berg JM and Stryer L. Biochemistry, W.H. Freeman and Company
- Nelson DL and Cox MM. Lehninger Principles of Biochemistry, W.H. Freeman and Company.
- Goodenough U, Genetics, Holt, Rinehart & Winston of Canada Ltd.
- Gardner EJ, Simmons MJ, Snustad DP. Principles of Genetics. Wiley-India.
- Maloy SR, Cronan JE and Friefelder D. Microbial Genetics, Jones and Barlett Publishers.
- Strickberger M, Microbial Genetics, Prentice Hall India Learning Private Limited
- Goldstein ES, Lewin's Genes, Jones and Bartlett Publishers.
- E-books / Journals.

MIS 102: INSTRUMENTATION AND BIOTECHNIQUES

Unit 1 Microscopy

Phase contrast, Fluorescence, Confocal and Electron (Scanning and Transmission) Microscopy; Micrometry.

Unit 2 pH and Buffers

pH Meter: Principle, calibration and application. Buffers and buffering capacity.

Unit 3 Spectroscopy

Principle of UV-Vis and IR spectroscopy and their application in analysis of biomolecules.

Unit 4 Chromatography

Principles and applications: Paper, Thin layer, Si gel Column, HPLC, Reverse phase, Gel filtration, Ion exchange and Affinity Chromatography.

Unit 5 Electrophoresis

Principle and applications: Native polyacrylamide gel electrophoresis, SDS- polyacrylamide gel electrophoresis, and Agarose gel electrophoresis.

Unit 6 Centrifugation

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

Unit 7 Practical

Measurement of bacterial and yeast cell by micrometry. Preparation of buffer. Determination of λ_{\max} and extinction coefficient of a given sample. Separation of mixture of sugars/amino acids by paper and thin layer chromatography. Silica gel column chromatography. Separation of proteins by Polyacrylamide Gel Electrophoresis (PAGE). Centrifugation of bacterial and yeast cultures as a function of speed and time.

SUGGESTED READING (Latest editions)

- Wilson K and Walker J. Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press.
- Nelson DL and Cox MM. Lehninger Principles of Biochemistry, W. H. Freeman and Company.
- Willey MJ, Sherwood LM and Woolverton C J. Prescott, Harley and Klein's Microbiology. McGraw Hill.
- Karp G. Cell and Molecular Biology: Concepts and Experiments. John Wiley and Sons. Inc.
- De Robertis EDP and De Robertis EMF. Cell and Molecular Biology. Lipincott Williams and Wilkins, Philadelphia.
- Cooper GM and Hausman RE. The Cell: A Molecular Approach. ASM Press and Sunderland, Washington D.C.
- Nigam A and Ayyagari A. Lab Manual in Biochemistry, Immunology and Biotechnology. Tata McGraw Hill.

Semester V
MIC 105 : MEDICAL MICROBIOLOGY

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

Normal microflora of the human body: Importance of normal microflora; normal microflora of skin, throat, gastrointestinal tract, genito - urinary tract

Host pathogen interaction: Pathogen, Invasion, Infection, Pathogenicity, Virulence, Virulence factors (Pili, fimbriae, flagella, capsule, glycocalyx, adhesins, enzymes, chelators (siderophores), endotoxin, exotoxin)

Toxigenicity, Carriers and their types, Opportunistic infections, Nosocomial infections. Transmission of infection, Pathophysiological effects of LPS.

Unit 2 Sample collection, transport and diagnosis

Sample types and collection, transport and culturing from clinical samples.

Principle and methodology of different diagnostic techniques - ELISA, Immunofluorescence, Agglutination based tests, Complement fixation, PCR, DNA probes and Microarray.

Unit 3 Bacterial diseases

List of diseases of various organ systems and their causative agents. The following diseases in detail with mode of transmission, pathogenesis, symptoms, chemotherapy and prophylaxis:

Respiratory Diseases: Pneumonia (*Streptococcus pneumoniae*), Influenza (*Haemophilus influenzae*), Tuberculosis (*Mycobacterium tuberculosis*).

Gastrointestinal Diseases: Bacterial diarrhea (*Escherichia coli*), typhoid (*Salmonella typhi*), Cholera (*Vibrio cholerae*), bacterial dysentery (*Shigella dysenteriae*).

Skin infections- *Staphylococcus aureus*, *Vibrio parahaemolyticus*

Genito-Urinary Tract Infections: Syphilis (*Treponema pallidum*), UTI (*E. coli* and *Proteus vulgaris*)

Unit 4 Viral diseases

List of diseases of various organ systems and their causative agents. The following diseases in detail with mode of transmission, pathogenesis, symptoms, chemotherapy and prophylaxis.

Polio, Hepatitis (A, B, C, D and E), Rabies, Dengue, AIDS.

Unit 5 Protozoan diseases

List of diseases of various organ systems and their causative agents. The following diseases in detail with mode of transmission, pathogenesis, symptoms, chemotherapy and prophylaxis.

Malaria, Amoebic dysentery

Unit 6 Fungal diseases

List of diseases of various organ systems and their causative agents. The following diseases in detail with mode of transmission, pathogenesis, symptoms, chemotherapy and prophylaxis. Cutaneous mycoses: Athlete's foot (*Tinea pedis*). Opportunistic mycoses: Candidiasis (*Candida albicans*)

Unit 7 Practical

Study of composition and use of important differential media for identification of bacteria: EMBAgar, McConkey's agar, SS agar, Mannitol salt agar, Deoxycholate citrate agar, TCBS agar.

Identification of bacteria (*E. coli*, *Klebsiella*, *Salmonella*, *Proteus*, *Staphylococcus*, *Vibrio*) using laboratory strains on the basis of cultural, morphological and biochemical characteristics: IMViC, TSI, nitrate reduction, urease production, catalase, oxidase, HL, PPA, motility tests.

Study of bacterial flora of skin by swab method. Study of symptoms of the diseases with the help of photographs: Polio, TB, Candidiasis, Dermatomycoses (ringworm).

Study of various stages of malarial parasite in RBCs using permanent mounts.

Suggested readings (Latest Edition)

1. Kanungo R. (Editor) Ananthanarayan and Paniker's Textbook of Microbiology. University Press.
2. Brooks G.F., Carroll K.C., Butel J.S., Morse S.A. and Mietzner, T.A. Jawetz, Melnick and Adelberg's Medical Microbiology. McGraw Hill Publication.

3. Goering R., Dockrell H., Zuckerman M. and Wakelin D. Mims' Medical Microbiology. Elsevier.
4. Willey JM, Sherwood LM, and Woolverton CJ. Prescott, Harley and Klein's Microbiology. McGraw Hill Higher Education.
5. Madigan MT, Martinko JM, Dunlap PV and Clark DP. Brock Biology of Microorganisms. Pearson International Edition.

MIC 106: INDUSTRIAL MICROBIOLOGY

Unit 1: Isolation of industrially important microbial strains and fermentation media.

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 2: Types of fermentation processes, bio-reactors and measurement of fermentation parameters

Solid-state and liquid-state (stationary and submerged) fermentations

Batch, fed-batch (baker's yeast) and continuous fermentations (ethanol). Kinetics of batch, fed-batch and continuous fermentations

Components of a typical bio-reactor, Types of bioreactors-Laboratory, pilot-scale and production fermenters, constantly stirred tank and air-lift fermenters

Monitoring and control of fermentation parameters - pH, temperature, dissolved oxygen, foaming and aeration

Unit 3: Down-stream processing

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

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

Citric acid, Ethanol, Penicillin, Vitamin B₁₂, Enzymes (amylase and β -galactosidase)

Unit 5: PRACTICAL

Study of different parts of fermenter.

Microbial fermentations for the production and estimation of: (a) Enzymes: Amylase, (b) Organic acid: Citric acid, (c) Alcohol: Ethanol, (d) Antibiotic: Penicillin

Bioassay of Penicillin and Vitamin B₁₂

Suggested readings (Latest Edition)

1. Patel A.H. Industrial Microbiology. Macmillan India Limited.
2. Okafor N. Modern Industrial Microbiology and Biotechnology. Bios Scientific Publishers Limited. USA.
3. Waites M.J., Morgan N.L., Rockey J.S. and Higton G. Industrial Microbiology: An Introduction. Wiley – Blackwell
4. Glaze A.N. and Nikaido H. Microbial Biotechnology: Fundamentals of Applied Microbiology. W.H. Freeman and Company.
5. Casida LE. Industrial Microbiology. Wiley Eastern Limited.
6. Crueger W and Crueger A. Biotechnology: A textbook of Industrial Microbiology. Panima Publishing Co. New Delhi.
7. Stanbury PF, Whitaker A and Hall SJ. Principles of Fermentation Technology. Elsevier Science Ltd.

MIC 107 : MICROBIAL GENETICS

Unit 1: Gene expression and regulation

General Structure of Operon : Structural and regulatory genes

Induction and repression; catabolite repression.

Positive and negative regulation of lac operon.

Structure and regulation: Trp operon.

Unit 2: Gene transfer mechanisms

Transformation: Griffith's experiment; Avery, MacLeod and McCarty's experiment, Factors affecting transformation, Competence factor, Steps in transformation.

Transduction: Davis' U-Tube experiment. Lytic and lysogenic cycles. Generalized, Specialized, Complete and Abortive Transduction.

Conjugation: Gene transfer by F+ strains, Hfr donor, F-prime state. Chromosome mapping.

Unit 3: Mutations

Spontaneous Mutations: Concept of spontaneous mutations and mechanisms. Principle, methodology and significance of replica plating and fluctuation test. Auxotrophs, Complementation Test.

Types of mutations: Point mutations: base pair substitution, tautomerism (transitions, transversions). Frame shift (slippage). Missense, nonsense, silent, conditional, suppressor (intragenic, extragenic). Large deletions, site directed mutagenesis.

Induced mutations: Physical /chemical mutagens. Teratogenicity testing – Ames test. DNA damage and repair mechanisms (light/dark repair).

Unit 4: Molecular recombination and molecular taxonomy

General features of recombination, types of recombination. Models for reciprocal and non-reciprocal recombination – Fox and Holliday's model, evidence for Fox and Holliday's model. Rec A and Rec BCD complex. rRNA and molecular taxonomy.

Unit 5: PRACTICAL

Preparation of competent cells for transformation. Bacterial transformation. Bacterial conjugation. Replica plate technique. UV Survival curve with effect of dark repair mechanism.

Suggested readings (Latest Edition)

1. Pelczar, M.J., Chan, E.C.S. and Krieg, N.R. Microbiology. McGraw Hill Book Company.
2. Gardner, E.J., Simmons, M.J. and Snustad, D.P. Principles of Genetics. Wiley-India.
2. Stanier, R.Y. General Microbiology. Macmillan Publishers.
3. Wiley, J.M., Sherwood, L.M. and Woolverton, C.J. Prescott's Microbiology. McGraw Hill International.
4. Stryer, L. Biochemistry. W H Freeman and Company.
5. Primrose, S.B., Twyman, R.M. and Old, R.W. Principles of Gene Manipulation. Wiley-Blackwell.
6. Nelson, D.L. and Cox, M.M. Lehninger Principles of Biochemistry. W H Freeman.
7. Sambrook, J. and Russell, D. Molecular Cloning: A Laboratory Manual. Cold Spring Harbor Laboratory Press.

MID 101: APPLIED MICROBIOLOGY

Unit 1: Nutraceuticals

Probiotics, Prebiotics, Synbiotics, PUFA, Antioxidants, Vitamins, Polyphenols, SCP, Applications.

Unit 2: Biosensors

Definition, Components, Basic Characteristics, Elements, Principles, Applications. Detailed study of glucose and BOD sensor.

Unit 3: Bioplastics

Definition, Properties, types and composition, synthesis, microorganisms involved in biodegradation, uses, Environmental impact.

Unit 4: Applications of Microbes in Biotransformation

Definition, types of microbial transformations/bioconversions (oxidation, reduction, hydrolysis, condensation, isomerisation, formation of C=C double bonds).

Screening and enrichment of organisms, biocatalysts and techniques, biotransformation of hydrocarbons and heavy metals.

Unit 5: Immobilisation methods and Applications

Introduction, preparation of immobilised enzymes, support matrix. Methods of immobilisation (adsorption, covalent bonds, entrapment, copolymerisation, encapsulation), advantages and disadvantages, applications.

Unit 6: RNAi

Definition, RNA silencing, mechanism, applications (therapeutics and agriculture)

Unit 7: Intellectual Property Rights (IPR)

Introduction, types of IPR, copyrights, trademark, patents, types of patents, process of patent application.

Unit 8: Nanotechnology

Definition of nanoparticles, types, characterization and properties.

Applications - drug delivery systems, bioremediation, antifouling, degradation of xenobiotics and fiber retting.

Unit 9: Omics

Metabolomics, metagenomics, transcriptomics, proteomics.

Unit 10: PRACTICAL

Estimation of Ascorbic acid by colorimetric/titration method.

Isolation of Probiotic bacteria from curd.

Isolation of Polyhydroxybutyrate producing bacteria from mangrove ecosystems

Isolation of hydrocarbon degrading bacteria by inverted plate method.

Immobilisation of cells by calcium alginate method.

Synthesis of zinc nanoparticles.

Suggested readings (Latest Edition)

1. Ratledge, C and Kristiansen, B. Basic Biotechnology, Cambridge University Press.
2. Demain, A. L and Davies, J. E. Manual of Industrial Microbiology and Biotechnology, ASM Press.
3. Swartz, J. R. Advances in Escherichia coli production of therapeutic proteins. Current Opinion in Biotechnology, 12, 195–201.
4. Prescott, Harley and Klein's Microbiology by Willey JM, Sherwood LM, Woolverton CJ, Mc Graw Hill Publishers.
5. Gupta PK Elements of Biotechnology Rastogi Publications,
6. Glazer AN and Nikaido H Microbial Biotechnology, Cambridge University Press
7. Glick BR, Pasternak JJ, and Patten CL Molecular Biotechnology, ASM Press

8. Stanbury PF, Whitaker A, Hall SJ Principles of Fermentation Technology, Elsevier Science
9. Crueger W, Crueger, A Biotechnology: A text Book of Industrial Microbiology Sinauer associates, Inc.
10. Shukla, RP and Mishra, RS.Nutraceuticals Food Processing Technology: Innovative Scientific Research Hardcover, Bharti Publications.
11. Dubey, RC. A Textbook of Biotechnology, S. Chand & Co. Pvt. Ltd., New Delhi.

MID 102: MICROBIAL PHYSIOLOGY

Unit 1: Bioenergetics and Electron transport chain

Definitions of Gibb's Free Energy, Standard free energy change and equilibrium constant, Coupled reactions and additive nature of standard free energy change, Energy rich compounds: Phosphoenolpyruvate, 1,3- Bisphosphoglycerate, Thioesters, ATP.

ATP as a high energy system, ATP hydrolysis and other high energy phosphate compounds, utilization of ATP in chemical work, ETC and oxidative phosphorylation, substrate level phosphorylation

Unit 2: Chemoheterotrophic Carbohydrate Metabolism

Catabolism: Glyoxylate cycle (Amphibolic pathway, Anaplerotic reactions), glycogenolysis.

Anabolism: Gluconeogenesis, Biosynthesis of glycogen and peptidoglycan

Unit 3: Chemoheterotrophic Lipid Metabolism

Catabolism: Beta oxidation, Omega-oxidation

Anabolism: Biosynthesis of saturated fatty acids and poly beta-hydroxybutyric acid

Unit 4: Chemoheterotrophic Protein Metabolism

Catabolism: Digestion of proteins and peptides, Amino acid oxidation, Transamination, Deamination, Decarboxylation, Stickland reaction.

Unit 5: Chemolithotrophic and Phototrophic Metabolism

Definition and reaction of hydrogen oxidation and methanogenesis. Introduction to phototrophic metabolism - groups of phototrophic microorganisms, anoxygenic v/s oxygenic photosynthesis with reference to photosynthesis in green bacteria, purple bacteria and cyanobacteria

Anaerobic respiration: Dissimilatory nitrate reduction (denitrification, nitrate/nitrite and nitrate/ammonia respiration, fermentative nitrate reduction)

Unit 6: PRACTICAL

IMViC tests, Fermentation - Sugars, HL test , Estimation of lactic acid/acetic acid , Staining of PHB granules, Quantitative estimation of total sugars by Phenol sulphuric acid method, Quantitative estimation of reducing sugars by DNSA and Nelson- Somogyi methods, Detection of Nitrification

Suggested readings (Latest Edition)

1. Berg JM, Tymoczko JL and Stryer L. Biochemistry, W.H. Freeman and Company.
2. Pawar and Dagainawala General Microbiology Volume I. Himalaya Publishing House
3. Murray RK, Mayes PA, Granner DK and Rodwell VW. Harper's Biochemistry. Prentiss Hall International Editions.
4. Jayaraman J. Laboratory Manual in Biochemistry. New Age International (P). Ltd. Publishers
5. Plummer David T. An Introduction to Practical Biochemistry. Tata McGraw Hill Publishers
6. Stanier RY, Ingraham JI, Wheelis ML and Painter PR. General Microbiology. McMillan Press.
7. Willey JM, Sherwood LM, and Woolverton CJ. Prescott's Microbiology. McGraw Hill Higher Education.
8. Moat AG and Foster JW. Microbial Physiology. John Wiley & Sons
9. Nelson DL and Cox MM. Lehninger Principles of Biochemistry. W.H. Freeman and Company.
10. Voet, D. and Voet J.G. Biochemistry. John Wiley and Sons
11. Conn E and Stumpf P. Outlines of biochemistry. John Wiley and Sons.

MID 103: BIostatISTICS AND BIOINFORMATICS

Unit 1: Biostatistics

Data type: Discrete and continuous data type; nominal, ordinal, interval, ratio data type and scale.

Measures of central tendency, Correlation and Regression:

Measure of central tendency - Mean, Mode and Median. Correlation types and characteristics. Linear regression.

Statistical methods: Scope of statistics: utility and misuse.

Principles of statistical analysis of biological data. Sampling parameters.

Difference between sample and Population, Sampling Errors

Sampling Distributions, Standard Error, Testing of Hypothesis, Level of Significance and Degree of Freedom.

Normal distribution, Fitting of Distributions, Large Sample Test based on

Normal Distribution, Small sample test based on t-test, Z- test and F-test;

Confidence Interval; Distribution-free test - Chi-square test.

Unit 2: Bioinformatics

Introduction to Bioinformatics and Biological Databases:

Biological databases - type of biological database for nucleic acid, genome, protein sequence.

Database for structure of biomolecules. Mode of data storage - File formats - FASTA, Genbank and Uniprot

Sequence Alignments, Phylogeny and Phylogenetic trees:

Local and Global Sequence alignment, pairwise and multiple sequence alignment.

Scoring an alignment

Protein Structure Predictions:

Hierarchy of protein structure - primary, secondary and tertiary structures, modeling

Structural Classes, Motifs, Folds and Domains

Unit 3: PRACTICAL

Mean, Median, Mode from grouped and ungrouped Data set

Standard Deviation and Coefficient of Variation

Correlation

Regression

Finding area under the curve using normal probability

Testing of Hypothesis- Normal Distribution, t-test and Chi-Square-test

Confidence Interval

Search of nucleic acid sequence database (GenBank), alignment and construction of phylogenetic tree

Deducing 3D structure of proteins using primary sequence.

Suggested readings (Latest Edition)

1. Rastogi S.C., Mendiratta N. and Rastogi P. Bioinformatics: methods and applications, genomics, proteomics and drug discovery, Prentice Hall India Publication
2. Batschelet E: Introduction to Mathematics for Life Scientists, Springer Verlag, Narosa Publishing House, New Delhi
3. Pradeep and Sinha Preeti. Foundations of Computing, BPB Publications
4. Danial W Biostatistics: A foundation for Analysis in Health Sciences, John Wiley and Sons Inc.
5. Primrose and Twyman. Principles of Genome Analysis & Genomics. Blackwell

Semester VI

MIC 108: IMMUNOLOGY

Unit 1: Introduction of Immunology

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

Structure, Functions and Properties of: Immune Cells – Stem cell, T cell, B cell, NK cell, Macrophage, Neutrophil, Eosinophil, Basophil, Mast cell, Dendritic cell

Structure, Functions and Properties of Immune Organs – Bone Marrow, Thymus, Lymph Node, Spleen, GALT, MALT, CALT.

Unit 3: Antigens and Antibodies

Characteristics of an antigen (Foreignness, Molecular size and Heterogeneity); Haptens; Epitopes (T & B cell epitopes); T-dependent and T-independent antigens; Adjuvants

Antibodies: Structure, Types, Functions and Properties of antibodies; Antigenic determinants on antibodies (Isotypic, allotypic, idiotypic); Monoclonal and Chimeric antibodies.

Unit 4: Major Histocompatibility Complex

Structure and Functions of MHC I & II molecules

Antigen processing and presentation. (Cytosolic and Endocytic pathways).

Unit 5: Complement System

Components of the Complement system; Activation pathways (Classical, Alternative and Lectin pathways)

Biological consequences of complement Activation.

Unit 6: Generation of Immune Response

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 7: Immunological Disorders and Tumor Immunity

Types of Autoimmunity (Rheumatoid arthritis) and Hypersensitivity (I-V).

Unit 8: Immunological Techniques

Principles of Precipitation, Agglutination, Immunodiffusion, Immunoelectrophoresis, ELISA, Western blotting, Immunofluorescence, Immunoelectron microscopy.

Unit 9: Immunohaematology

ABO blood group system, haemolytic disease of newborn.

Unit 10: PRACTICAL

Identification of human blood groups.

Total Leukocyte Count of a blood sample.

Total RBC count of a blood sample.

Differential Leukocyte Count (Leishman/Giemsa) of a blood sample.

Preparation of serum and plasma from blood.

Immunodiffusion by Ouchterlony method.

VDRL test and WIDAL test (qualitative).

Suggested readings (Latest Edition)

1. Delves P, Martin S, Burton D, Roitt IM. Roitt's Essential Immunology. Wiley-Blackwell Scientific Publication, Oxford.

2. Goldsby RA, Kindt TJ, Osborne BA. Kuby's Immunology. W.H. Freeman and Company, New York.

3. Murphy K, Travers P, Walport M. Janeway's Immunobiology. Garland Science Publishers, New York.

4. Peakman M, and Vergani D. Basic and Clinical Immunology. Churchill Livingstone Publishers, Edinberg.
5. Richard C and Geiffrey S. Immunology. Wiley Blackwell Publication.

MIC 109: Agricultural Microbiology

Unit 1: Soil as microenvironment

Organic matter decomposition – humus formation Rhizosphere and endophytic microflora and their role

R:S ratio, Microbivory, Microbial associations in phytosphere: rhizosphere – phyllosphere – spermosphere.

Degradation of cellulose, hemicelluloses, lignin and pectin in soils

Unit 2: Plant Microbe Interaction

Plant diseases

Mode of entry of pathogens, disease symptoms

Bacterial diseases

Crown gall, Citrus cancer, Black rot

Viral diseases, virioids

TMV, Tomato leaf curl, Potato spindle tuber

Fungal diseases

Late blight of potato - *Phytophthora infestans*, Loose smut of wheat - *Ustilagonuda*, Rice blight - *Magnaporthagriseae*, Wilt - *Fusarium*

Control of plant diseases

Principles and practices, cultural practices, chemical methods, biological methods and genetic engineering for disease resistant plants.

Beneficial associations

Rhizobium (Nitrogenase, Nodulation, Hydrogenase)

Azolla

Frankia (infection process, nodulation)

Mycorrhiza (Types- ecto/endo, mechanism of symbiosis)

Phytostimulation and Bioinsecticides

Plant Growth Promoting Bacteria (PGPB)

Microorganisms in soil, Root exudation, Effect of PGPB on plants, Root microbiome, PGPB :Direct (Nitrogen fixation, Psolubilisation, IAA producers, ammonia producers, ethylene (ACC deaminase) and indirect (Siderophores, HCN)

Biopesticides -Introduction, types (bacterial- *Bacillus thuringiensis*, viral -NPV, fungal - *Trichoderma*, *Metarhizium*), mode of action, genes involved, factors influencing their action and target pests.

Unit 3: Biofertilizers

Biofertilizers – definition, importance

Types

i) Nitrogen fixing – *Azotobacter*, *Rhizobium*, Azolla, Frankia, Cyanobacteria and *Azospirillum*.

ii) Phosphate solubilizing Microorganisms.

iii) Vesicular Arbuscular Mycorrhiza (VAM)

Biochemistry of symbiotic and non- symbiotic nitrogen fixation, Phosphate solubilisation and Potassium mobilization

Application methods

Steps in mass production of bacterial biofertilizers, quality guidelines for biofertilizers. Methods of preparation and application – liquid and carrier based, Mass production of blue green algae, Azolla and mycorrhiza. Plant response to biofertilizers.

Unit 4: Genetically Modified Crops

Definition, Advantages, social and environmental aspects, Bt crops, Golden rice, salinity tolerance, cold temperature

Unit 5: PRACTICAL

Study of soil profile, Study of microflora of different types of soils, Isolation of plant growth promoting bacteria: (a) nitrogen fixers - symbiotic and non-symbiotic), (b) PSB's and KSB, (c) IAA producers, (d) siderophores producers, Formulation of biofertilizers, Effect of biofertilizers on seedlings of *Vignaradiata*.

Suggested readings (Latest Edition)

1. Agrios GN. Plant Pathology. Academic press, San Diego,
2. Singh RS. Plant Diseases Management. Oxford & IBH, New Delhi.
3. Glick BR, Pasternak JJ, and Patten CL Molecular Biotechnology ASM Press
4. Atlas RM and Bartha R. Microbial Ecology: Fundamentals & Applications. Benjamin/Cummings Science Publishing, USA
5. Maier RM, Pepper IL and Gerba CP. Environmental Microbiology. Academic Press
6. Barton LL & Northup DE Microbial Ecology. Wiley Blackwell, USA
7. Campbell RE. Microbial Ecology. Blackwell Scientific Publication, Oxford, England.
8. Coyne MS. Soil Microbiology: An Exploratory Approach. Delmar Thomson Learning.
9. Altman A Agriculture Biotechnology, Marcel decker Inc.
10. Mahendra K. Rai Hand Book of Microbial Biofertilizers, The Haworth Press, Inc. New York
11. Reddy, S.M. *etal.* Bioinoculants for Sustainable Agriculture and Forestry, Scientific Publishers
12. Saleem F and Shakoori AR. Development of Bioinsecticide, Lap Lambert Academic Publishing.
13. Rangaswamy G. Diseases of crop plants in India
14. Glick B.R. Beneficial Plant Bacterial Interactions, Springer.

MIC 110: GENETIC ENGINEERING

Unit 1: Introduction to genetic engineering

Milestones in genetic engineering

Unit 2: Tools and strategies: Restriction endonucleases: Type I, II, III. Mode of action, nomenclature and applications of Type II restriction enzymes in genetic engineering. Restriction and modification.

Unit 3: DNA modifying enzymes and their applications: DNA polymerases, Klenow fragment, kinases and phosphatases, terminal deoxynucleotidyl transferase, DNA ligases, S1 nuclease, and RNAase H. Use of linkers and adapters. Synthesis of cDNA, sticky end and blunt end cloning.

Unit 4: Cloning and Expression vectors: Plasmids, pBR and pUC series, Ti plasmid based vector; Bacteriophage, lambda and M13 based vectors; cosmids; phagemids, Bacterial Artificial Chromosomes (BACs); Yeast Artificial Chromosomes (YACs). Shuttle vectors, Expression vectors (Fusion and Pure proteins), *E. coli* lac promoter based vector, Yeast Episomal Plasmids (YEPs), Mammalian vector (SV40).

Unit 5: Methods in molecular cloning

DNA, RNA and Protein Analysis - agarose gel electrophoresis, PAGE - 1D/2D gel analysis, concept of nucleic acid probes, Northern, Southern, Western and Immuno-blotting techniques and protein sequencing.

DNA amplification and DNA sequencing - PCR, Sanger's method, Maxam and Gilbert's method, Shot gun sequencing.

Transformation, Transduction and Screening

Chemical methods, electroporation, shotgun method, virus mediated gene delivery; *Agrobacterium* mediated gene delivery, selection methods of transformed bacterial cells (antibiotic resistance markers and Blue white screening).

Colony hybridization and Plaque hybridization. Chromosome walking and chromosome jumping.

Unit 6: Applications of recombinant DNA technology

Unit 7: Products of rDNA technology: Human therapeutic significance – insulin, antisense molecules. Gene therapy, RNAi, recombinant vaccines. Agricultural significance – Bt transgenic: cotton, brinjal.

Unit 8: PRACTICAL

Restriction enzyme digestion of DNA and analysis by agarose gel electrophoresis.

Ligation of DNA fragments and analysis by agarose gel electrophoresis.

Interpretation of sequencing gel electropherograms and sequence analysis.

Native PAGE.

Demonstration of Immuno-blotting technique

Demonstration of PCR

Demonstration of Gel-Doc

Screening of transformed cells (blue-white screening method)

Suggested readings (Latest Edition)

1. Sambrook J and Russell D. Molecular Cloning: A Laboratory Manual. Cold Spring Harbor Laboratory Press.
2. Freifelder D. Microbial Genetics. Jones and Bartlett Publishers.
3. Gardner EJ, Simmons MJ, Snustad DP. Principles of Genetics. Wiley India.
4. Stryer L. Biochemistry. W H Freeman and Company.
5. Krebs JE, Goldstein ES, Kilpatrick ST. Lewin's Genes. Jones and Bartlett Publishers.
6. Glick BR, Pasternak JJ, and Patten CL. Molecular Biotechnology ASM Press.
7. Dubey RC, A Textbook of Biotechnology. S. Chand & Co. Ltd.
8. Mathur SK, Purohit SS, Biotechnology. Fundamentals and Applications. Agro Botanica.
9. Brown TA. Gene Cloning and DNA Analysis: An Introduction. Wiley Publication.

Students will be able to handle microorganisms for isolation and amplification of DNA and transform host cells.

MID 104: CELL BIOLOGY

Unit 1: Cell to cell interactions.

Eukaryotic cell membrane, Extra cellular matrix and cell matrix interactions, cell surface protrusions, Types of cellular junctions - adhesion junctions, tight junctions, gap junctions, and plasmodesmata.

Unit 2: Protein Sorting and Transport

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

Unit 3: Cell Signalling

Cyclic GMP and MAP kinase pathway, chemotaxis and phototaxis, quorum sensing: CFTR, Calmodulin.

Unit 4: Cell Cycle

Regulation of eukaryotic cell cycle, mitosis and meiosis. Cell death and apoptosis.

Unit 5: Development of cancer, causes and types

Introduction to cancer, Oncogenes, Tumor suppressor genes, Properties and development of cancer cells (activation of cell division), Symptoms, Causes, Risk factors, Classification (benign and malignant), Different types (Carcinoma, Sarcoma, Leukemia, Lymphoma and Myeloma), Stages of cancer (Histological classification).

Unit 6: PRACTICAL

Study of stages of mitosis.

Study of stages of meiosis.

Study of gap junctions through electron micrographs.

Identification and study of cancer cells by photomicrographs.

Demonstration of quorum sensing (Swarming by *Proteus*).

Demonstration of positive and negative chemotaxis (Effect of attractants and repellants on *E.coli*).

Demonstration of apoptosis and necrosis

Suggested readings (Latest Edition)

1. Hardin J, Bertoni G and Kleinsmith LJ. Becker's World of the Cell. Pearson.
2. Karp G. Cell and Molecular Biology: Concepts and Experiments. John Wiley & Sons. Inc.
3. De Robertis, EDP and De Robertis EMF. Cell and Molecular Biology. Lipincott Williams and Wilkins, Philadelphia.
4. Cooper, G.M. and Hausman, R.E. The Cell: A Molecular Approach. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
5. Lodish H., Berk A., Kaiser C., Krieger M., Scott M., Bretscher A., Ploegh H., Matsudaira P., Molecular cell biology .W H Francis and company, New York.
6. Alberts B., Johnson A., Lewis J., Raff M., Roberts K., Walter P., Molecular Biology of The Cell Garland science, Taylor and Francis group.
7. Adler J. Chemotaxis in Bacteria .Annual Reviews of Biochemistry. 44:341-356.

MID 105: VIROLOGY

Unit 1: Nature and Properties of Viruses

Introduction: Discovery of viruses, nature and definition of viruses, general properties, concept of viroids, virusoids, satellite viruses and Prions.

Structure of Viruses: Capsid symmetry, enveloped and non-enveloped viruses, Isolation, purification and cultivation of viruses.

Viral taxonomy: Molecular classification and nomenclature of different groups of viruses.

Unit 2: Bacteriophages

Diversity, Classification of bacteriophage on the basis of structure, one step multiplication curve

Lytic and lysogenic phages (lambda phage) concept of early and late proteins

Regulation of transcription in lambda phage.

Unit 3: Viruses and Cancer

Introduction to oncogenic viruses

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

Unit 4: Prevention & control of viral diseases

Antiviral compounds and their mode of action

Interferon and their mode of action

General principles of viral vaccination

Unit 5: PRACTICALS

Study of the structure of important animal viruses (rhabdo, influenza, hepatitis B and retroviruses) using electron micrographs, Study of the structure of important plant viruses (caulimo, Gemini, tobacco mosaic virus) using electron micrographs, Study of the structure of important bacterial viruses (T4, λ) using electron micrograph, Determination of phage titre from water/sewage sample, Study of cytopathic effects of viruses using photographs

Suggested readings (Latest Edition)

1. Dimmock, NJ, Easton, AL, Leppard, KN. Introduction to Modern Virology. Blackwell Publishing Ltd.
2. Carter J and Saunders V. Virology: Principles and Applications. John Wiley and Sons.
3. Flint SJ, Enquist, LW, Krug, RM, Racaniello, VR, Skalka, AM. Principles of Virology, Molecular biology, Pathogenesis and Control. ASM press Washington DC.
4. Levy JA, Conrat HF, Owens RA. Virology. Prentice Hall publication, New Jersey.
5. Wagner EK, Hewlett MJ. Basic Virology. Blackwell Publishing.

MID 106: Haematology and Clinical Biochemistry

Unit 1: Haematology

Overview of blood circulatory system of humans, Blood, plasma, serum - definition, Blood components and their functions, Buffering system – role of proteins, carbonate system and other ions in buffering, deviations in pH and their impact, Haematopoiesis-erythropoiesis, leukopoiesis and thrombopoiesis.

Structure and function of erythrocytes, Hemoglobin- structure, function, synthesis, metabolism of iron, abnormal erythrocytes and haemoglobins, types of Hbs and its derivatives (carboxy Hb and met Hb, sickle cell Hb).

Structure and function of different types of leucocytes.

Structure and function of thrombocytes.

Unit 2: Blood counts

Collection of blood - methods, skin puncture and venipuncture; type and use of Anticoagulants, handling and processing of blood samples, disposal of samples.

Determination of hemoglobin- significance, principle and method.

Blood cell counts – RBC count and Total leucocyte count by Haemocytometer, differential leucocyte count, total platelet count, determination of haematocrit –micro haematocrit and macro haematocrit method, Erythrocyte sedimentation rate (ESR) - Westergren's and Wintrobe's method. Overview of automated methods of blood analysis.

Unit 3: Hemostasis and coagulation

Mechanism of blood coagulation – intrinsic and extrinsic pathways, routine coagulation tests – bleeding time, clotting time.

Unit 4: Hematological diseases

Anaemia - Introduction and etiological classification, types of anaemias – iron deficiency, aplastic anaemia, megaloblastic anaemia, sideroblastic anaemia, pernicious anaemia.

Thalassemia – alpha and beta – underlying causes, clinical features, diagnosis and treatment

Leukemia - introduction, types of leukemia - Acute myelogenous leukemia (AML), Chronic lymphocytic leukemia (CLL), Acute lymphoblastic leukemia (ALL).

Unit 5: Immunohaematology

Blood groups – Introduction and history of blood grouping, classification of different types of blood groups, ABO and sub groups, antigen (structure and composition) and antibodies (definition and role of natural Abs). ABO blood grouping techniques, Inheritance of the ABO blood groups, Rh blood group – definition, structure, importance, incomplete antibodies. Other blood group systems and their significance, Cross matching.

Blood transfusion- collection of blood from donor, Blood transfusion reactions. Blood banks and their role.

Unit 6: Clinical Biochemistry

Carbohydrate metabolism: Clinical aspects of Regulation of Blood sugar and Diabetes, Diabetic profile test.

Protein metabolism: starvation, and protein energy malnutrition, blood urea.

Lipid metabolism: Clinical aspects of lipid profile- HDL, LDL, VLDL, cholesterol, triglycerides. Atherosclerosis.

Unit 7: PRACTICAL

Total RBC count by Haemocytometer, Total WBC count by Haemocytometer, Differential leucocyte count, Determination of Packed cell volume by Macro- hematocrit method, Determination of ESR by Westergren/Wintrobe method, Determination of platelet count, Screening for sickle cell anemia, Determination of bleeding time, Determination of blood clotting time, Qualitative test for ABO grouping by slide method, Determination of Rho (D) typing by slide method, Cross matching by saline tube method, Fasting and post prandial blood sugar determination using glucometer, Total serum protein determination, Determination of serum total cholesterol

Suggested readings (Latest Edition)

1. Godkar, P. B. and Godkar, D. P., Textbook of Medical Lab Technology, Bhalani Publishing House, India.

2. Maheshwari, N., Clinical Pathology, Hematology and Blood Banking (for DMLT students), Jaypee Brothers Medical Publishers.
3. Kabra, M. P. and Kabra, A., Practical Human Anatomy and Physiology, Pharmamedix India Publication Pvt. Ltd.
4. Deb, A. C., Fundamentals of Biochemistry, New Central Book Agency, Kolkata.
5. Sood, R., Textbook of Medical Laboratory Technology, Jaypee Brothers Medical Publishers.
6. Chatterjee, M.N. and Shinde, R., Textbook of Medical Biochemistry, JP Medical Limited.
7. Bain, B., Bates, I., Laffan, M. and Lewis, S., Dacie and Lewis Practical Haematology, Churchill Livingstone.
8. Makroo, R. N., Compendium of Transfusion Medicine, Career Publication.