

CHOICE BASED CREDIT SYSTEM COURSE
DETAILS

M.Sc. MICROBIOLOGY



DEPARTMENT OF MICROBIOLOGY
CENTRAL UNIVERSITY OF HARYANA,
MAHENDERGARH, HARYANA

**Central University of Haryana
Master of Science in Microbiology
(Choice-Based Credit System)
Curriculum Structure 2015-17**

Semester	Core/ Elective	Paper Code	Title of the Paper	Max Marks	Credit Hours
I	CC	SIAL MB 01 01 01 C	Principles of Microbiology	100	(4+0)
	CC	SIAL MB 01 01 02 C	Microbial Physiology and Metabolism	100	(4+0)
	GEC	SIAL BC 1 1 02 GE 4004	Principles of Biochemistry	100	(4+0)
	CC	SIAL MB 01 01 03 C	Bacteriology	100	(4+0)
	CC	SIAL MB 01 01 04 C	Practical -I	200	(0+4)
II	CC	SIAL MB 01 02 05 C	Virology	100	(4+0)
	DCEC**	SIAL MB 01 02 01 DCEC	Mycology & Phycology	100	(4+0)
	DCEC**	SIAL MB 01 02 02 DCEC	Plant Pathology	100	(4+0)
	CC	SIAL MB 01 02 06 C	Food and Dairy Microbiology	100	(4+0)
	CC	SIAL MB 01 02 07 C	Microbial Genetics	100	(4+0)
	CC	SIAL MB 01 02 08 C	Practical-II	200	(0+4)
	CC	SIAL MB 01 02 09 C	Seminar	50	(1+0)
III	CC	SIAL MB 01 03 10 C	Medical Microbiology and Immunology	100	(4+0)
	DCEC**	SIAL MB 01 03 03 DCEC	Environmental Microbiology	100	(4+0)
	DCEC**	SIAL MB 01 03 04 DCEC	Soil & Agricultural Microbiology	100	(4+0)
	CC	SIAL MB 01 03 11 C	Industrial Microbiology	100	(4+0)
	GEC	SIAL BC 1 3 04 GE 4004	Molecular Biology	100	(4+0)
	CC	SIAL MB 01 03 12 C	Practical-III	200	(0+4)
IV	GEC	SIAL BT 01 01 02 GE	Biostatistics & Bioinformatics	50	(2+0)
	SEEC	SIAL MB 01 04 01 SEEC	Dissertation	200	(0+22)

CC- Core Course

GEC- Generic Elective Course

*Paper code from other programme(s)

**Choose any one in given semester

Discipline Centric Elective Course (DCEC)-Offered to the students from Microbiology and other Departments

Skill Enhancement Elective Course (SEEC)-Exclusive for Microbiology students

GEC for SEM I and III are offered by Department of Biochemistry and for SEM IV is offered by Department of Biotechnology

Generic Elective Course (GEC)- Offered to students from other Departments by our department

Semester	Core/ Elective	Paper Code	Title of the Paper	Total Credit Hours
I	CC CC	SIAL MB 01 01 01 GEC SIAL MB 01 01 02 GEC	Introduction to Microbiology Microbial Energetics & Biosynthesis	(4) (4)
II	CC	SIAL MB 01 02 03 GEC	Food Microbiology	(4)
III	CC	SIAL MB 01 03 04 GEC	Soil Microbiology	(4)

M.Sc. (Microbiology)
(SEMESTER-I)
SIAL MB 01 01 01 C Principles of Microbiology

Unit I

History of development of Microbiology in 20th century; The spontaneous generation controversy; Germ theory of disease; Microbes and fermentation; Physical and chemical methods of sterilization; Microscopy - light, confocal and electron.

Unit II

Binomial Nomenclature; Haeckel's three kingdom classification; Basic principles and techniques used in bacterial classification; Use of DNA and r-RNA sequencing in classification of microorganisms; Woese's three kingdom classification system and its utility - archaea, eubacteria, eukarya; Organization of prokaryotic and eukaryotic cell in detail; Different groups of acellular microorganisms - viruses, viroids and prions.

Unit III

General features of microorganisms - Bacteria, Algae, Fungi and Protozoa; Classification of bacteria; Bacterial growth and metabolism; Microbes in different environment; Microbes in extreme environment - special features of the thermophilic, methanogenic and halophilic archaea; Photosynthetic bacteria, Cyanobacteria; Microbes in other extreme conditions - deep ocean and space.

Unit IV

Scope of Microbiology; Biogeochemical cycles; Microbial interactions - mutualism, symbiosis, commensalisms, predation, parasitism, amensalism, competition; Bioluminescence; Biodegradation; Biofilms; Cleaning oil spills; Microbes in composting; Biocontrol agents; Bioremediation; Bioleaching; SCP; Microbial enzymes and fermented foods; Human, animals and plant diseases and their causative agents; Aeromicrobiology.

Suggested readings:

1. Atlas RM (1997). Principles of Microbiology, Wm C Brown Publishers, USA.
2. Brock TD (1961). Milestones in Microbiology, Infinity Books.
3. Madigan MT, Martinko JM, Parker J (2015). Brock Biology of Microorganisms, 14th edition, Pearson Education Ltd, Prentice-Hall, Englewood Cliffs, NJ, Inc USA.
4. Pelczar MJ, Chan ECS, Kreig NR (1993). Microbiology: Concepts and Application, 5th edition, Tata McGraw Hill, New Delhi.
5. Stanier RY, Ingraham JL, Wheelis ML, Painter PR (1976). General Microbiology, 4th edition, MacMillan, New Jersey, USA.

M.Sc. (Microbiology)
(SEMESTER-I)
SIAL MB 01 01 02 C Microbial Physiology and Metabolism

Unit I

Nutritional categories of microorganisms based on carbon and energy sources; Metabolite transport - passive and facilitated, primary and secondary active transport, group translocation (phosphotransferase system), symport, antiport and uniport, electrogenic and electroneutral transport, transport of iron; Microbial Growth - Definition balanced and unbalanced growth, growth curve, the mathematics of growth, generation time, specific growth rate, batch and continuous culture, synchronous growth, diauxic growth curve; Effect of physical and chemical factors on growth.

Unit II

Brief account of photosynthetic and accessory pigments - chlorophyll, bacteriochlorophyll, rhodopsin, carotenoids, phycobiliproteins; Autotrophy - oxygenic, anoxygenic photosynthesis; Autotrophic generation of ATP; Fixation of CO₂; Calvin cycle pathway. Chemolithotrophy - Sulphur, iron, hydrogen, nitrogen oxidations, methanogenesis, luminescence.

Unit III

Respiratory metabolism - Embden-Mayer Hoff pathway, Entner Doudroff pathway, Pentose phosphate pathway, Krebs cycle, Branched TCA cycle, Reverse TCA cycle, Glyoxalate pathway, Oxidative and substrate level phosphorylation,, Gluconeogenesis, Pasteur effect; Fermentation of carbohydrates - homo and heterolactic fermentations; Halophiles and ATP synthesis.

Unit IV

Biosynthesis of peptidoglycan, polysaccharides, major amino acids, polyamines, lipids, nucleotides - purines and pyrimidines; Assimilation of nitrogen; Dormancy and germination; Microbial Differentiation, Sporulation and morphogenesis, Cell division cycle in *E. coli* and yeast.

Suggested Readings:

1. Doelle HW (1969). Bacterial Metabolism, Academic Press, USA.
2. Gottschalk G (1979). Bacterial Metabolism, Springer Verlag, New York, USA.
3. Moat AG (1979). Microbial Physiology, John Wiley & Sons, New York, USA.
4. Moat AG, Foster J W, Spector M P (2009). Microbial Physiology, 4th edition, Wiley India Pvt Ltd, Country.
5. Sokatch JR (1969). Bacterial Physiology and Metabolism, Academic Press, USA.

M.Sc. (Microbiology)
(SEMESTER-I)
SIAL MB 01 01 03 C Bacteriology

Unit I

Organization of Bacterial Cell - Structure and function of cell wall, cell membrane, cytoplasm, flagella, endoflagella, fimbriae, glycocalyx, capsule, endospore; Growth and Nutrition - cultivation of aerobic, anaerobic and accessing non-culturable bacteria; Maintenance and preservation of bacterial cultures; Components of media and different types of culture media.

Unit II

Bacterial Classification - Basis of bacterial classification, conventional, molecular and recent approaches to polyphasic bacterial taxonomy; evolutionary chronometers; rRNA oligonucleotide sequencing; signature sequences; and protein sequences; differences between eubacteria and archaeobacteria.

Unit III

Important archaeal groups according to Brock's 2009 and Bergey's Manual of Systematic Bacteriology; Archaeobacteria - General characteristics, phylogenetic overview, genera belonging to Nanoarchaeota (*Nanoarchaeum*), Crenarchaeota (*Sulfolobus*, *Thermoproteus*) and Euryarchaeota [Methanogens (*Methanobacterium*, *Methanocaldococcus*), thermophiles (*Thermococcus*, *Pyrococcus*, *Thermoplasma*) and Halophiles (*Halobacterium*, *Halococcus*)].

Unit IV

Eubacteria – Non-Proteobacteria and Proteobacteria – Morphology, metabolism, ecological significance and economic importance of following groups:

Gram Negative - Non proteobacteria (*Aquifex*, *Thermotoga*, *Deinococcus*, *Thermus*, *Chlorobium*, *Chloroflexus*, *Chlamydiae*, *Spirochaete*), Alpha proteobacteria (*Rickettsia*, *Coxiella*, *Caulobacter*, *Rhizobium*, *Hyphomicrobium*, *Agrobacterium*), Beta proteobacteria (*Neisseria*, *Burkholderia*, *Thiobacillus*), Gamma proteobacteria (*Enterobacteriaceae* family, Purple sulphur bacteria, *Pseudomonas*, *Vibrio*, *Beggiatoa*, *Methylococcus*, *Haemophilus*), Delta proteobacteria (*Bdellovibrio*, *Myxococcus*), Epsilon proteobacteria (*Helicobacter*, *Campylobacter*).

Gram Positive - Low G+C or Firmicutes (*Mycoplasmas*, *Clostridium*, *Heliobacterium*, *Lactobacillus*, *Lactococcus*, *Staphylococcus*, *Streptococcus*, *Leuconostoc*, *Bacillus*), High G+C or Acinetobacteria (*Arthrobacter*, *Bifidobacterium*, *Corynebacterium*, *Frankia*, *Mycobacterium*, *Nocardia*, *Streptomyces*, *Thermomonospora*, *Propionibacterium*, *Cyanobacteria*).

Suggested readings:

1. Atlas RM (1997). Principles of Microbiology, Wm C Brown Publishers, USA.

2. Madigan MT, Martinko JM, Parker J (2015). Brock Biology of Microorganisms, 14th edition, Pearson Education Ltd, Prentice-Hall, Englewood Cliffs, NJ, Inc USA.
3. Pelczar MJ, Chan ECS, Kreig NR (1993). Microbiology: Concepts and Application, 5th edition, Tata McGraw Hill, New Delhi.
4. Stanier RY, Ingraham JL, Wheelis ML, Painter PR (1976). General Microbiology, 4th edition, MacMillan, New Jersey, USA.
5. Vandenmark PV, Batzing BL. The Microbes - An Introduction to their nature and Importance, Benjamin Cummings, San Francisco, USA.
6. Whitman WB, Goodfellow M, Kämpfer P, Busse HJ, Trujillo ME, Ludwig W, Suzuki K (2012). Bergey's Manual of Systematic Bacteriology, 2nd edition, Springer-Verlag, New York.

M.Sc. (Microbiology)
(SEMESTER-I)
SIAL MB 01 01 04 C Practical -I

(Microbiology; Microbial Physiology and Metabolism; Biochemistry; Bacteriology)

Microbiology: Microscopic examination of bacteria, actinomycetes, algae, fungi and protozoa; Differential staining methods; Study of shape and arrangement of bacterial cells; Preparation of microbiological media; Sterilization: Principles and operations; Preparation of specific media for isolation of bacteria, actinomycetes and fungi from natural sources; Sampling and quantification of microorganisms in air, soil and water.

Microbial Physiology and Metabolism: Determination of viable number of bacterial cells in a given sample; Determination of bacterial growth by turbidity measurements (Bacterial growth curve); To study the microscopic measurements; To study the types of growth (synchronous, diauxic, batch); To study the effect of incubation temperature on the growth of microorganisms; To study the lethal effect of temperature; To study the effect of different pH on the growth of microorganisms; To study the effect of salt concentration on the growth of microorganisms; Preparation of selective and differential media for the growth of microorganisms; Fermentation of different carbohydrates.

Biochemistry: Preparation of standard and buffer solutions; Use of simple techniques in laboratory (Spectrophotometry-verification of Beer's law, relation between O.D. and percentage transmission; Centrifugation); Estimation of sugars, Estimation of Proteins by Lowry's method; Estimation of DNA and RNA by diphenylamine and orcinol methods; Determination of enzyme activity and study of enzyme kinetics.

Bacteriology: Methods of isolation, purification and maintenance of bacteria from different environments (air, water, soil, milk and food); Staining of bacteria and actinomycetes; Use of selective media; Enrichment culture technique – isolation of asymbiotic nitrogen fixing bacteria; Isolation of symbiotic nitrogen fixing bacteria from nodules; Morphological, physiological and biochemical characterization of isolated bacterial cultures.

M.Sc. (Microbiology)
(SEMESTER-I)
SIAL MB 01 01 01 GEC Introduction to Microbiology

Unit I

History and Development of various fields of Microbiology in 20th century; The spontaneous generation vs Biogenesis of microorganisms; Microbes - causative agents of disease; Microbes- fermentation and putrefaction; Preparation of microbiological media; Physical and chemical methods of sterilization. Microscopy - Light and Electron Microscopes.

Unit II

Microbial classification - Haeckel's classification- lower and higher protista; Woese's three kingdom classification systems – Archaea, Eubacteria, Eukarya; Organization of archaea, bacteria and eukaryotic cell; Different types of acellular microorganisms- Viruses, viroids and prions.

Unit III

General features and classification of Bacteria, Algae, Fungi and Protozoa; Bacterial growth and metabolism; Photosynthetic bacteria; Photoheterotrophs; Chemolithotrophs and Chemoheterotrophs; Microbes in Extreme Environment – Characteristic features of the thermophilic, methanogenic and halophilic archaea; Microbes in other extreme conditions – Deep ocean, arctic and antarctic region and space.

Unit IV

Scope of Microbiology - Cycle of matter in nature; Microbial interactions – Symbiosis and parasitism; Biodegradation and Bioremediation; Biofilms; Microbes in composting; Biofertilizers and Biopesticides; Microbes and Industry - SCP, microbial enzymes and fermented foods. Human diseases and their causative agents; Vaccines and antibiotics; Phytopathogenic bacteria.

Suggested readings:

1. Brock TD (1961). Milestones in Microbiology, Infinity Books.
2. Madigan MT, Martinko JM, Parker J (2015). Brock Biology of Microorganisms, 14th edition, Pearson Education Ltd, Prentice-Hall, Englewood Cliffs, NJ, Inc USA.
3. Pelczar MJ, Chan ECS, Kreig NR (1993). Microbiology: Concepts and Application, 5th edition, Tata McGraw Hill, New Delhi.
4. Stainier RY, Ingraham JL, Wheelis ML, Painter PR (1976). General Microbiology, 4th edition, MacMillan, New Jersey, USA.

M.Sc. (Microbiology)
(SEMESTER-I)
SIAL MB 01 01 02 GEC Microbial Energetics and Biosynthesis

Unit I

Classification of microorganisms based on carbon and energy sources; Metabolite Transport - Different types and their mechanisms; Microbial Growth - Balanced and Unbalanced growth, salient features of growth curve, generation time, specific growth rate during batch and continuous culture systems; synchronous growth, diauxic growth curve; Effect of chemicals and other environmental factors on growth.

Unit II

Photophosphorylation by bacteria - photosynthetic and accessory pigments; Carbohydrates – anabolism; Autotrophy, oxygenic, anoxygenic photosynthesis – autotrophic generation of ATP; fixation of CO₂, Calvin cycle. Chemolithotrophy - Sulphur, iron, hydrogen, nitrogen oxidations, methanogenesis.

Unit III

Embden-Mayer Hoff pathway, Entner-Doudroff pathway, Pentose phosphate pathway, Glyoxalate pathway, Krebs cycle, Oxidative and substrate level phosphorylation, Reverse TCA cycle, Gluconeogenesis, Pasteur effect; Fermentation of carbohydrates - Homo and heterolactic fermentations by microbes.

Unit IV

Biosynthesis of amino acids, polyamines, nucleotides - purines and pyrimidines; Regulation of microbial metabolism; Assimilation of nitrogen; Biosynthesis of Lipids; Biosynthesis of peptidoglycan and other cell wall polysaccharides; Dormancy and germination; Microbial differentiation; Sporulation and morphogenesis, Cell division cycle in microbes.

Suggested Readings:

6. Doelle HW (1969). Bacterial Metabolism, Academic Press, USA.
7. Gottschalk G (1979). Bacterial Metabolism, Springer Verlag, New York, USA.
8. Moat AG (1979). Microbial Physiology, John Wiley & Sons, New York, USA.
9. Moat AG, Foster J W, Spector M P (2009). Microbial Physiology, 4th edition, Wiley India Pvt Ltd, Country.
10. Sokatch JR (1969). Bacterial Physiology and Metabolism, Academic Press, USA.

M.Sc. (Microbiology)
(SEMESTER-I)
SIAL BC 1 1 02 GE 4004 Biochemistry

Unit I

Scope and Importance of Biochemistry; Fundamental principles governing life; Structure of water; Acid base concept and buffers; pH; Hydrogen bonding; Hydrophobic, Electrostatic and Vander Waal forces; General introduction to physical techniques for determination of structure of biopolymers.

Unit II

Classification, structure and function of carbohydrates; Biomembranes and lipids; Structure and function of amino acids and vitamins; Structure and function of proteins; Types of nucleic acid, their structure and functions.

Unit III

Enzymes: classification, mechanism of action; Factors affecting enzyme action; Immobilized enzymes; Hormones; Thermodynamic principles and biological processes, Bioenergetics.

Unit IV

Metabolism of carbohydrates; Photosynthesis and respiration; Oxidative phosphorylation; Lipids; Proteins and nucleic acids; DNA replication, transcription and translation in prokaryotes and eukaryotes; Recombinant DNA Technology.

Suggested readings:

1. Devlin TM (2010). Textbook of Biochemistry with Clinical Correlations, 7th edition, John Wiley and Sons Inc, USA.
2. Lehninger AL, Nelson DL, Cox MM (2008). Principles of Biochemistry, 5th edition, W. H. Freeman, New York, USA.
3. Mathews CK, van Holde KE, Ahern KG (2000). Biochemistry, 3rd edition, Benjamin Cummings, San Francisco.
4. Robert K, Murray MD, Granner DK, Mayes PA, Rodwell VI Harper's Biochemistry, 29th edition, McGraw-Hill/Appleton and Lange, New York.
5. Shukla P, Pletschke BI (2013). Advances in Enzyme Biotechnology, Springer-Verlag Berlin Heidelberg, Germany.
6. Stryer L (2002), Biochemistry, 5th edition, W.H. Freeman and Co Ltd, New York, USA.

M.Sc. (Microbiology)
(SEMESTER-II)
SIAL MB 01 02 05 C Virology

Unit I

Discovery and general characteristics of viruses; Capsid symmetry; Enveloped and non-enveloped viruses; Isolation, purification and cultivation of viruses; Viral taxonomy - classification and nomenclature of different groups (animal viruses and plant viruses) of viruses; Basic understanding of viroids, virusoids, satellite viruses and prions.

Unit II

Diversity and classification of bacteriophages; One step multiplication curve; Lytic and lysogenic phages (lambda phage); Concept of early and late proteins; Regulation of transcription in lambda phage; Phage therapy.

Unit III

Salient features of viral nucleic acid - Unusual bases (TMV, T4 phage), overlapping genes (ϕ X174, Hepatitis B virus), alternate splicing (HIV), terminal redundancy (T4 phage), terminal cohesive ends (Lambda phage), partial double stranded genomes (Hepatitis B), long terminal repeats (Retrovirus), segmented genomes (Influenza virus), non-segmented genomes (Picornavirus), capping and tailing (TMV); Modes of transmission of plant and animal viruses; Viral multiplication and replication strategies: Interaction of viruses with cellular receptors and entry of viruses; Replication of viruses as per Baltimore classification - assembly, maturation and release of virions.

Unit IV

Disease caused by human, animal and plant viruses – Polio, influenza, rabies, common cold, AIDS, hepatitis, chikungunya, dengue, ebola, foot and mouth disease, blue tongue disease, mad cow disease, bud necrosis, tobacco mosaic disease and cauliflower mosaic disease; Introduction to oncogenic viruses; Types of oncogenic DNA and RNA viruses; Mechanism of disease causation by plant viruses; Antiviral compounds and their mode of action; Interferon and their mode of action; Use of viral vectors in cloning, expression, and gene therapy.

Suggested Reading:

1. Dimmock NJ, Easton AL, Leppard KN (2007). Introduction to Modern Virology, 6th edition, Blackwell Publishing Ltd, UK.
2. Carter J, Saunders V (2007). Virology: Principles and Applications. John Wiley and Sons, New York.
3. Flint SJ, Enquist, LW, Krug, RM, Racaniello, VR, Skalka, AM (2004). Principles of Virology, Molecular biology, Pathogenesis and Control, 2nd edition, ASM press, Washington DC.
4. Wagner EK, Hewlett MJ (2004). Basic Virology, 2nd edition, Blackwell Publishing, UK.
5. Mathews REF (2004). Plant Virology, Hull R. Academic Press, New York.
6. Versteeg J (1985). A Color Atlas of Virology, Wolfe Medical Publication, New York.

M.Sc. (Microbiology)
(SEMESTER-II)
SIAL MB 01 02 01 DCEC Mycology and Phycology

Unit I

Cellular Organization of algal and fungal cells in detail; Fungi - Occurrence and distribution, somatic structure, hyphal growth, nutrition, heterothallism; Recent classification of fungi; Reproduction in fungi - asexual, sexual and parasexual cycle.

Unit II

Life cycle and economic importance of fungal genera representing the following phyla: Chytridiomycota; Blastocladiomycota; Neocallimastigomycota; Microsporidia; Glomeromycota; Ascomycota and Basidiomycota.

Unit III

Algae - occurrence and distribution, thallus structure, characteristics, nutrition, classification and reproduction; Algae as pollution indicators and eutrophication agent; Role of algae in bioremediation; Algae in global warming and environmental sustainability; Cyanobacteria and selected microalgae in agriculture as biofertilizer; Importance of algae in production of algal pigments, biofuels, hydrogen production and important bioactive molecules. Lichens and Mycorrhiza - occurrence, structure, types and importance.

Unit IV

Fungal metabolites and their potential applications in food, agriculture, industry and environment; Fungi as symbionts; Biocontrol agents; Role of fungi in deterioration of biomolecules and biomaterials; Mycotoxins.

Suggested Readings:

1. Alexopolus CJ, Mims CW, Blackwell M (2002). Introductory Mycology, 4th edition, Wiley India Pvt. Ltd, India.
2. Barsanti L, Gualtieri P (2005). Algae, Anatomy, Biochemistry & Biotechnology, CRC press, Taylor & Francis, Florida, USA.
3. Carlile MS, Watkinson SC, and G. Gooday (2001). The Fungi, 2nd edition, Academic Press, New York.
4. Graham LE, Graham JM, Wilcox LW (2009). Algae, 2nd edition, Benjamin Cummings, San Francisco.
5. <http://nt.ars-grin.gov/fungaldatabases/>
6. Landecker ME (1996). Fundamentals of the fungi, 4th edition, Benjamin Cummings, San Francisco.
7. Moore D, Robson GD, Anthony P, Trinci J (2011). 21st Century Guidebook to Fungi, Cambridge University Press, UK.
8. Sumbali G (2005). The Fungi, 2nd edition, Narosa Publishing India House, India.
9. The Index Fungorum- <http://www.indexfungorum.org/>.

M.Sc. (Microbiology)
(SEMESTER-II)
SIAL MB 01 02 02 DCEC Plant Pathology

Unit-I

Introduction and history of plant pathology; Definitions and concepts of plant diseases; Biotic and abiotic factors responsible for plant diseases; Interaction of microorganisms with plants and their effect on plant growth.

Unit-II

Growth, reproduction, survival and dispersal of important plant pathogens; Production of various enzymes, toxins and other metabolites by pathogens for causing disease; Role of environment and host nutrition on disease development; Diseases of some important cereals, vegetables and crops - Crown gall, downy mildew; Symptoms of important viral diseases and their control.

Unit-III

Host parasite interactions - recognition and infection, symptomatology, disease development- role of enzymes, toxins, growth regulators; defense strategies, oxidative burst; Phenolics, phytoalexins, PR proteins, elicitors and their effects on host plants

Unit-IV

Plant disease resistance – Pathogen Associated Molecular patterns, Pattern Recognition Receptors, PTI, Effectors, ETI, ‘R’ genes; Mechanism of genetic variation in pathogens; Disease control in plants - physical, chemical methods; Use of biocontrol agents - bacteria and fungi; Molecular markers for disease resistance in plants; Transgenic approach for plant protection - applications and constraints.

Suggested Readings

1. Agrios GN (2005). Plant Pathology, 5th edition, Academic Press, New York.
2. Dickinson M (2003). Molecular Plant Pathology, BIOS Scientific Publishers, London.
3. Mukerji KG, Garg KL (1988). Biocontrol of Plant Diseases (Vol. I) CRC Press, Inc., Boca Raton, Florida, USA.
4. Sigeo DC (1993). Bacterial Plant Pathology, Cell and Molecular aspects, Cambridge University Press, UK.
5. Upadhyay RK, Mukherjee KG (1997). Toxins in Plant Disease Development and Evolving Biotechnology. Oxford & IBH.

M.Sc. (Microbiology)
(SEMESTER-II)
SIAL MB 01 02 06 C Food & Dairy Microbiology

Unit I

Natural flora and source of contamination of foods; Intrinsic and extrinsic factors that affect growth and survival of microbes in foods; Microbial spoilage of vegetables, fruits, meat, eggs, milk, bread, butter, and canned foods.

Unit II

Principles of food preservation; Physical methods of food preservation - temperature (low, high, canning, and drying), irradiation, hydrostatic pressure, high voltage pulse, microwave processing and aseptic packaging; Chemical methods of food preservation - salt, sugar, organic acids, SO₂, nitrite and nitrates, ethylene oxide, antibiotics and bacteriocins; Food sanitation - HACCP, indices of food sanitary quality and sanitizers.

Unit III

Fermented foods - Dairy starter cultures and fermented dairy products (yogurt, acidophilus milk, curd, kefir, kumiss, cheese, dosa, sauerkraut, soy sauce and tempeh); Probiotics and prebiotics - Health benefits, types of microorganisms used, probiotic foods available in the Indian market.

Unit IV

Food-borne diseases (causative agents, foods involved, symptoms and preventive measures) - Food intoxications caused by *Staphylococcus aureus*, *Clostridium botulinum* and mycotoxins; Food infections caused by *Bacillus cereus*, *Vibrio parahaemolyticus*, *Escherichia coli*, *Salmonella*, *Shigella*, *Yersinia enterocolitica*, *Listeria monocytogenes* and *Campylobacter jejuni*; Conventional and recent methods for detection of food-borne pathogens.

Suggested Readings

1. Frazier WC, Westhoff DC (1992). Food Microbiology, 3rd edition, Tata McGraw-Hill Publishing Company Ltd, New Delhi, India.
2. Gould GW (1995). New Methods of Food Preservation, Blackie Academic and Professional, London, UK.
3. Jay JM, Loessner MJ, Golden DA (2005). Modern Food Microbiology, 7th edition, CBS Publishers and Distributors, Delhi, India.
4. Lund BM, Baird Parker AC, Gould GW (2000). The Microbiological Safety and Quality of Foods. Vol. 1-2, ASPEN Publication, Gaithersburg, MD.
5. Tortora GJ, Funke BR, Case CL (2008). Microbiology: An Introduction, 9th edition, Pearson Education, New York, USA.

M.Sc. (Microbiology)
(SEMESTER-II)
SIAL MB 01 02 07 C Microbial Genetics

Unit I

Mendel's work on transmission of traits; Genetic variation; Prokaryotic, eukaryotic and viral genome - Structure and Functions; Extrachromosomal DNA; Mitosis and meiosis; Linkage and crossing over; Molecular mechanism of crossing over; Structure, classification and replication of plasmids.

Unit II

Molecular basis of mutations - Induced *versus* spontaneous mutations; Gene mapping by recombination and complementation; Fine gene structure analysis; Cloning genes by complementation and marker rescue; DNA repair mechanisms; Mutation and microbial evolution.

Unit III

Gene transfer in bacteria - conjugation, transformation and transduction; Regulation of gene transfer by conjugation; Mapping the bacterial genomes using Hfr strains; Transfer systems in gram positive bacteria; Ti plasmid and applications; Transformation - molecular basis of natural transformation; Transduction- Generalized *versus* specialized transduction; Mapping bacterial genes by transduction; Tetrad analysis in fungi; Positive and negative gene regulation and attenuation in different operons; Riboswitches.

Unit IV

Genes involved in the lytic and lysogenic cycle of lambda phage; Replication and packaging of filamentous phages M13; Benzer's experiments to construct phage genetic linkage maps; Transposons and gene regulation; Yeast Ty-1 transposon; Methods of gene cloning and sequencing; Genome transplantation (Synthetic genome).

Suggested Reading

1. Birge EA (1981). Bacterial and Bacteriophage Genetics, Springer Verlag, Germany.
2. Gardner JE, Simmons MJ, Snustad DP (1991). Principles of Genetics, John Wiley & Sons, New York, USA.
3. Klug WS, Cummings MR (2012). Concepts of Genetics 10th edition, Benjamin Cummings, San Francisco.
4. Lewin B (2008). Gene, Vol IX, John Wiley & Sons, New York, USA.
5. Maloy A, Friedfelder D (1994). Microbial Genetics, Narosa Publishing house, New Delhi, India.
6. Snyder L, Chapness W (2013). Molecular Genetics of Bacteria, 4th edition, ASM Press, USA.
7. Watson JD, Hopkins NH, Roberts JW, Steitz JA, Weiner AM (1987). Molecular Biology of the Gene, 4th edition, Benjamin Cummings, San Francisco.

M.Sc. (Microbiology)
(SEMESTER-II)
SIAL MB 01 02 08 C Practical- II

(Virology; Mycology & Phycology; Plant Pathology; Food and Dairy Micro; Microbial Genetics)

Virology: Study of virus architecture using electron microphotographs of TMV, poliovirus and adenovirus; Study of virus architecture using models of TMV and any virus having icosahedral symmetry; Discussion as to how animal viruses are cultivated in various media like embryonated eggs and cell cultures; Study of the cytopathic effects of viruses using electron microphotographs; Bacteriophage assay using the plaque technique; Salient symptoms of viral diseases using colored slides – small pox, chicken pox, herpes, foot and mouth disease of cattle, genital warts, tobacco mosaic, tomato leaf curl; Good laboratory practices while handling the viruses in the laboratory.

Mycology and phycology: Isolation and identification of fungi from different environmental samples; Study yeast dimorphism; Isolation and identification of algae from different habitats; Growth of algae under lab conditions; Study of nutritional requirement of mycelial fungi and yeasts; Cultivation of fungi in submerged and solid state; Production of enzymes, organic acids and other metabolites by fungi; Collection and study of basidiomycetous fungi.

Plant pathology: Isolation, characterization and frequency of occurrence of fungi present in cultivated plants; Isolation and characterization of bacteria and fungi present on different diseased/infected plant samples; To study occurrence of disease by inoculation with bacterial or fungal pathogens; Measuring plant disease intensity under controlled conditions; Isolation of bacteria from infected vegetables and fruits; Biochemical and physiological tests for detection of pathogens in fruits and vegetables; Study of soil borne pathogens.

Food microbiology: Isolation of lactic acid bacteria (LAB) from curd or milk sample; Detection of number of bacteria in milk by SPC; Determination of quality of milk sample by methylene blue reductase test (MBRT); Microbiological examination of different food samples; Production of Sauerkraut by microorganisms; Determination of antibacterial activity of lactic acid bacteria using agar well diffusion method; Statutory, recommended and supplementary tests for microbiological analysis of various foods - Baby foods, canned foods, milk and dairy products, eggs, meat, vegetables, fruits, cereals, surfaces, containers and water.

Microbial genetics: Inactivation of microorganisms by different mutagens; Production, isolation and characterization of mutants; Isolation and characterization of plasmids; Transformation of *E.coli* using isolated plasmid DNA.

M.Sc. (Microbiology)
(SEMESTER-II)
SIAL MB 01 02 03 GEC Food Microbiology

Unit I

Food and Microorganisms- Historical developments, Microorganisms important in food - Molds, yeast and bacteria - general characteristics, classification and importance; Factors affecting growth of microorganisms - Nutrient content, inhibitory substances and cell structures.

Unit II

Spoilage of different foods - Microorganisms associated with plants, soil, animals, water and air; Chemical composition of various foods and their spoilage- Vegetables, fruits, cereals, sugar and its products, milk and its products, meat and meat products, poultry, fish and sea foods. Principles of Food preservation - Types of preservation methods used – Physical, Chemical and Biological.

Unit III

Food fermentation - Production methods of bread, cheese, fermented vegetables and dairy products; Production of vinegar, wine, beer and oriental fermented foods on industrial scale, Microbes as a single cell protein (quorn and pruteen); Production of Mushroom and some indigenous Indian fermented foods.

Unit IV

Food borne infections and intoxications - Bacterial and non-bacterial infection - *Brucella*, *Bacillus*, *Clostridium*, *Escherichia*, *Salmonella*, *Shigella*, *Staphylococcus*, *Vibrio*, *Yersinia*, fungi, viruses, nematodes and emerging food-borne pathogens; Foodborne outbreaks; Laboratory testing procedures and preventive measures; Food sanitation in manufacture and retail trade.

Suggested Readings:

1. Adams MR, Moss MO (2005). Food Microbiology, 2nd edition, Royal Society of Chemistry Publication, Cambridge.
2. Frazier WC, Westhoff DC (2007). Food Microbiology, Tata McGraw Hill Publishing Company Ltd, New Delhi.
3. George J Banwart (1989). Basic Food Microbiology, AVI publication, New Delhi.
4. Jay JM (2008). Modern Food Microbiology, 6th edition, Aspen Publishers, Inc, Gaithersburg, Maryland.
5. Pepler HJ, Perlman D (1979). Microbial Technology, 2nd edition, Academic Press, USA.
6. Ray B (2005). Fundamental Food Microbiology, 3rd edition, CRC Press, New York, USA.

M.Sc. (Microbiology)
(SEMESTER-III)
SIAL MB 01 03 10 C Medical Microbiology & Immunology

Unit 1

Normal microflora of the human body and its importance: normal microflora of skin, throat and gastrointestinal tract; Collection, transport and culturing of clinical samples (sputum, urine, blood, stools) for microbiological analysis; Human microbiome.

Unit II

Causative agents, symptoms, mode of transmission and control of diseases caused by *Staphylococcus aureus*, *Streptococcus pyogenes*, *Haemophilus influenzae*, *Mycobacterium tuberculosis*, *Escherichia coli*, *Salmonella typhi*, *Vibrio cholerae*, *Helicobacter pylori*, *Bacillus anthracis*, *Clostridium tetani*, *Treponema pallidum* and TORCH group of pathogens; Causative agents, symptoms, mode of transmission and control of diseases dermatomycoses, histoplasmosis, candidiasis, malaria and kala-azar; Mechanism of action of various antimicrobial agents - inhibitors of nucleic acid synthesis, cell wall synthesis, cell membrane function and protein synthesis.

Unit III

Concept of innate and adaptive immunity; active and passive immunity; humoral and cell-mediated immunity; Structure, characteristics and functions of T cell, B cell, NK cell, Macrophage, Neutrophil, Eosinophil, Basophil, Mast cell and Dendritic cell; Immune Organs – Bone Marrow, Thymus, Lymph node, Spleen, GALT and MALT; Characteristics of an antigen (Foreignness, Molecular size and Heterogeneity); Haptens ; Epitopes (T and B cell epitopes); T-dependent and T-independent antigens; Adjuvants; Types and properties of antibodies; VDJ rearrangements; Monoclonal antibodies; Principles of Precipitation, Agglutination, Immunodiffusion, Immuno-electrophoresis, Immunofluorescence, ELISA, ELISPOT and Western blotting.

Unit IV

Organization of MHC locus (Mice and Human); Structure and functions of MHC I and II molecules; Antigen processing and presentation (cytosolic and endocytic pathways); Components of the complement system; Activation pathways (classical, alternative); Biological consequences of complement activation, 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, autoimmunity, hypersensitivity and immune deficiencies; Characteristics of tumours antigens and immune response to tumour antigens.

Suggested Reading:

1. Ananthanarayan R, Paniker CKJ (2009). Textbook of Microbiology, 8th edition, University Press Publication, India.

2. Brooks GF, Carroll KC, Butel JS, Morse SA, Mietzner TA (2010). Jawetz, Melnick and Adelberg's Medical Microbiology, 25th edition, McGraw Hill Publication,
3. Abbas AK, Lichtman AH, Pillai S (2007). Cellular and Molecular Immunology, 6th edition, Saunders Publication, Philadelphia.
4. Goldsby RA, Kindt TJ, Osborne BA, Kuby J (2007). Immunology, 6th edition, W.H. Freeman and company, New York, USA.
5. Murphy K, Travers P, Walport M (2008). Janeway's Immunobiology, Garland Science Publishers, 7th edition, New York, USA.
6. Willey JM, Sherwood LM, Woolverton CJ (2008). Prescott, Harley and Klein's Microbiology, 7th edition, McGraw Hill Higher Education, USA.

M.Sc. (Microbiology)
(SEMESTER-III)
SIAL MB 01 03 03 DCEC Environmental Microbiology

Unit-I

Introduction and scope of environmental microbiology; An overview of microbial activities in microbial niches in biosphere; Microbiology of water, air and environment in relation to human, animal and plant health and their activities.

Unit-II

Microbiology of natural waters; Environmental pollution – beneficial and deleterious role of microorganisms; Microflora of various soil types, rhizosphere and phyllosphere; Remedial measures of specialized habitats by using microorganisms - water bodies, mangroves, coral reefs and mined area; Brief account of microbial interactions; Biofertilizers and vesicular mycorrhizae (VAM); Microorganism in extreme environments.

Unit-III:

Microbial technology in waste treatment; Solid and liquid wastes characterization - physical, chemical and biological; Aerobic, anaerobic, primary, secondary and tertiary treatments - trickling filters, activated sludge, oxidation ponds *etc*; Utilization of solid wastes for production of food (SCP, mushroom, yeast), fuel (ethanol, methane) and fertilizer (composting); Waste management and resource recovery in metal, petroleum and bioenergy fields; Biofuels and biorefineries.

Unit-IV:

Value addition in fossil fuels and coal gas by use of microorganisms; Microbial interaction in rumen and gastrointestinal tract; Biodeterioration and bioremediation by microorganisms; Biotransformation of xenobiotic compounds.

Suggested Readings

1. Arnold E, Maier RM, Pepper IL, Gerba CP (2009). Environmental microbiology, 2nd edition, Academic Press, USA.
2. Atlas RM, Bartha R (1998). Microbial Ecology: Fundamentals and Applications, 4th editions, Benjamin Cummings, San Francisco.
3. Baker KH, Herson DS (1994). Bioremediation, McGraw Hill Inc., New York.
4. Campbell R (1983). Microbial ecology, Blackwell Scientific Publications, London, UK.
5. Maier RM, Pepper IL, Gerba CP (2000). Environmental microbiology, Academic Press. USA.
6. Ralph MA (1997). Environmental microbiology, John Wiley and Sons Inc., New York, USA.

M.Sc. (Microbiology)
(SEMESTER-III)
SIAL MB 01 03 04 DCEC Soil and Agriculture Microbiology

Unit – I

History of Development of soil microbiology; Soil microbiota and their interactions; Unculturable soil microbiota; Soil microbial ecology; Microorganisms in soil fertility; Influence of soil and environmental factors on microflora; Microbial population in manure and composts; Soil amendments and microbial dynamics.

Unit – II

Microorganisms in biogeochemical cycles; Microbial transformations of carbon, nitrogen, phosphorus, sulphur, iron and manganese; Biodegradation of pesticides and other organic wastes; Production of biogas; Production of manure using organic waste; Methods to improve soil structure and soil health by microorganisms.

Unit – III

Interrelationships between plants and microorganisms – Rhizosphere (Quantitative and qualitative studies – R:S ratio), Rhizoplane, spermosphere, phyllosphere microorganisms; Nitrogen fixation by soil bacteria - symbiotic, non-symbiotic, associative symbiotic and endophytic organisms, process of nitrogen fixation; Molecular biology of Nitrogen fixation; PGPR (plant growth promoting rhizobacteria), siderophore producers and biocontrol agents.

Unit –IV

Biofertilizers – Mycorrhizal inoculants, Mass cultivation of microbial inoculants; Green manuring; Microbial products and plant health; Microbial Pesticides: development and their significance.

Suggested readings:

1. Alexander M (1985). Introduction to Soil Microbiology, 3rd edition, Wiley Eastern, New Delhi.
2. Atlas RM, Bartha R (1998). Microbial Ecology: Fundamentals and Applications, 4th editions, Benjamin Cummings, San Francisco.
3. Paul EA (2007). Soil Microbiology, Ecology and Biochemistry, 3rd edition, Academic Press, New York, USA.
4. Sylvia D, Fuhrmann J, Hartel P, Zuberer D (2005). Principles and Applications of Soil Microbiology, 2nd edition, Pearson Education, USA.
5. van Elsas JD, Trevors JT, Wellington EMH (1997). Modern Soil Microbiology. Marcel Dekker, New York, USA.

M.Sc. (Microbiology)
(SEMESTER-III)
SIAL MB 01 03 11 C Industrial Microbiology

Unit I

Introduction and scope of industrial microbiology; Biology of industrially important microbes (metabolic pathways and control mechanisms); Isolation and selection of industrially important microorganisms; Genetic improvement of microbes by using classical and r-DNA techniques; Preservation and maintenance of microbial cultures.

Unit II

Microbial substrates - Media formulation, optimization of media; Cell growth kinetics - Kinetics of substrate utilization, biomass production and product formation in batch, fed batch and continuous cultivations; Types of fermentation processes - solid state, static and submerged fermentations; Design of laboratory bioreactor; Types of bioreactor - Stirred tank reactor, bubble column reactor, Airlift reactor, Packed bed reactor and Fluidized bed reactors; Scale-up principles; Downstream processes; Fermentation economics.

Unit III

Types of microbial products; Production of biomass: Baker's Yeast, mushrooms, single cell proteins, biopesticides and biofertilizers; Production of primary metabolites: Ethanol, organic acids, amino acids, vitamins; industrial enzymes and bioplastics

Unit IV

Production of secondary metabolites: Antibiotics (penicillin, cephalosporins, streptomycin), pigments, Microbial transformation, Production of metabolites of non-microbial origin like Insulin, Interleukins and growth hormones using rDNA technology. Development of designer microbes for food, energy and health care products.

Suggested readings:

1. Casida LE (1968). Industrial Microbiology, New Age Publishers, New Delhi.
2. Crueger W, Crueger A (1991). Biotechnology. A Textbook of Industrial Microbiology, 2nd edition, Sinauer Associates, USA.
3. Shuler ML, F Kargi (2004). Bioprocess Engineering - Basic Concepts, 2nd edition, Prentice Hall, New Jersey, USA.
4. Stanbury PF, A. Whitaker SJ (1999). Principles of Fermentation Technology, 2nd edition, Butterworth-Heinemann, UK.

M.Sc. (Microbiology)
(SEMESTER-III)
SIAL BC 1 3 04 GE 4004 Molecular Biology

Unit I

History of molecular biology; Nucleic acids as hereditary material; Structure of nucleic acid; Secondary and tertiary structure of nucleic acids; Types of RNA - rRNA, tRNA and mRNA; structure of ribosomes; Nucleases; Restriction and modification; DNA replication and DNA polymerases of *E.coli*. DNA sequencing

Unit II

Transcription; RNA polymerases; Types of promoters; Reverse transcriptase and RNA replicase; Genetic code; Translation; Gene regulation at transcriptional and translational level; Operon - positive and negative control; Attenuation; Molecular mechanism of mutation; Mechanism of DNA repair.

Unit III

Molecular organization of eukaryotic genome - Structure of genomes, chromatin; Types of DNA polymerases, DNA replication; Types of RNA polymerases - Transcription, structure of primary transcript; Ribozyme, RNA processing and alternate splicing; Structure of ribosomes and translation in eukaryotes; Development and differentiation; Molecular evolution.

Unit IV

Cell division cycle - Check points in cell cycle; apoptosis and its pathways; Oncogenes - Retroviruses, Tumor suppressor p53, Telomere shortening, *Ras* oncogenes; Oncoproteins and gene expression; Genetic instability and cancer.

Suggested readings:

1. Alberts B, Bray D, Lewis J, Raff M, Roberts K, Watson JD (1989). Molecular Biology of the Cell, 2nd edition, Garland Publishing, New York, USA.
2. Brown TA (2003). Genomes, 2nd edition, John Wiley and Sons Inc, New York, USA.
3. Lewin B (2009). Gene, Vol X, John Wiley & Sons, New York, USA.
4. Lodish H, Berk A, Zipursky S, Matsudaira P, Baltimore D, Darnell JE (1999). Molecular Cell Biology, 4th edition, W.H. Freeman and Company, USA.
5. Watson JD, Hopkins NH, Roberts JW, Steitz JA, Weiner AM (1987). Molecular Biology of the Gene, 4th edition, Benjamin Cummings, San Francisco.

M.Sc. (Microbiology)
(SEMESTER-III)
SIAL MB 01 03 12 C Practical III

(Medical Microbiology & Immunology; Environmental Microbiology; Soil & Agricultural Microbiology; Industrial Microbiology and Molecular Biology)

Medical microbiology and Immunology: Study composition, preparation and use of common selective differential media commonly used in medical microbiology – MacConkey agar, EMB agar, Hektoen enteric agar, Deoxycholate citrate agar (DCA); Staining techniques used in medical microbiology - Gram's staining and Ziehl-Neelsen staining for acid fast bacilli (AFB); Study resident microflora of the skin; Widal test; Antibiotic susceptibility testing using Kirby-Bauer method; Determine minimal inhibitory concentration (MIC) of an antibiotic using double dilution technique or E-test strips. **Immunology:** Determine total leucocyte count (TLC) of a given blood sample; Determine differential leucocyte count (DLC) of the blood sample, study cell morphology in blood; Identification of human blood groups - ABO and Rh factor; Immunodiffusion by Ouchterlony method; Immunoelectrophoresis; Dot-ELISA; Demonstration of Western blotting.

Environmental microbiology: Screening for microorganisms from soils and industrial effluents; Analysis of natural waters, waste waters and organic waste in relation to water pollution; Quality control tests for water; Waste treatment and anaerobic digestion; Demonstration of waste water treatment processes such as activated sludge biofilters and fluidized bed process; Isolation and screening of thermotolerant microbes from environmental samples for hydrolytic enzymes; Metagenomic analysis of any environmental sample and study the microbial diversity; Bioremediation of effluents from alcohol and textile industry using microbial cultures; To study dye and industrial effluent treatment by the microbial cultures.

Soil & agricultural microbiology: Determination of soil microbial population; Isolation of different bacterial and fungal organisms important in recycling of C, N, P, S in soil; Soil microbial biomass; Decomposition studies in soil, Soil enzymes; Measurement of important soil microbial processes such as ammonification, nitrification, N₂ fixation, S oxidation, P solubilization and mineralization of other micro nutrients; Study of rhizosphere microflora effect on plant growth.

Industrial microbiology: Isolation of industrially important microorganism from different sources using specific substrates; Design and formulation of media for microbial fermentations; Growth curve studies and determination of yield coefficient of *Saccharomyces cerevisiae* on various substrates; To study the design of fermenter and its working; To study the various methods of biomass production and its measurement; Production of ethanol using sugar by yeast isolate; Vinegar production using immobilized bacterial culture; Production of citric acid using sucrose by fungi using static, submerged and solid state conditions; Production of extracellular enzymes.

Molecular biology: Isolation of genomic DNA and RNA from bacteria; Isolation of plasmid DNA from bacterial culture; Study restriction profile of isolated DNA and plasmid samples; Transformation of *E.coli* using isolated plasmid DNA by chemical method and electroporation, determine their transformation efficiency; *Agrobacterium*-mediated gene transformation; Amplify gene of interest by Polymerase Chain Reaction, its cloning and expression; DNA isolation from soil sample and study microbial diversity using 16s rDNA universal primers

M.Sc. (Microbiology)
(SEMESTER-III)
SIAL MB 01 03 04 GEC Soil Microbiology

Unit I

Development of Soil Microbiology; Distribution of microorganisms in soil; Role of microorganisms in soil fertility; Types of microbes in different soils; Influence of soil and environmental factors on soil microbiota; Unculturable soil microbiota.

Unit II

Plant-microbe interactions; Microbiology of rhizoplane, rhizosphere and phyllosphere; Biogeochemical cycles, Nitrogen fixation - symbiotic, non-symbiotic, associative symbiotic nitrogen fixation by bacteria; Microbial transformation of phosphorus, iron, sulphur and micronutrients in soil and their importance.

Unit III

Chemical composition of different soil types and their affect on soil health and plant growth; Biodegradation of plant residues by soil microbes; Soil organic matter and soil enzymes; PGPR (plant growth promoting rhizobacteria); Siderophores and antimicrobial compounds.

Unit IV

Microbial Inoculants – Biofertilizer - Mass cultivation of microbial biomass; Nitrogen fixing bacteria and cyanobacteria; Green manuring; Microbial Pesticides and other biocontrol agents- Production and their significance - *Bacillus thuringiensis*, Bt based commercial products, *Trichoderma* based antifungal agents.

Suggested readings:

1. Alexander M (1985). Introduction to Soil Microbiology, 3rd Edition, Wiley Eastern Ltd, New Delhi.
2. Rangaswami G (1979). Recent advances in Biological Nitrogen Fixation, Oxford and IBH, New Delhi.
3. Subba Rao NS (1995). Soil Microorganisms and Plant Growth, Oxford and IBH Publishing Co. Pvt Ltd, New Delhi.

M.Sc. (Microbiology)
(SEMESTER-IV)
SIAL BT 01 01 02 GE Biostatistics and Bioinformatics

Unit I

Principles and practice of statistical methods in biological research; Samples and populations; Probability distributions - addition and multiplication theorems; Baye's theorem; Binomial, Poisson, and Normal distribution; Data presentation - Types of data, methods of data representation.

Unit II

Measures of central tendency - Mean, Median, Mode; Measures of dispersion - Range, Mean deviation and Coefficient of variation, Standard deviation, Standard error; Correlation and regression; Statistical inference - Hypothesis testing, Significance level, Test of significance for large and small samples; Parametric tests; Non parametric tests; Experimental design; Use of common biostatistics softwares.

Unit-III

Bioinformatics basics; Application in research; Present global bioinformatics scenario; Databases - characteristic of bioinformatics databases, navigating databases, information retrieval system and database collaboration; Sequence databases - nucleotide sequence databases, protein sequence database, information retrieval system e.g. Entrez and SRS; Structure databases - Structure file format, Protein structure database PDB, MMDB, FSSP, SCOP, BRENDA, AMENDA and FRENDA; Pathway databases e.g. CAZy.

Unit-IV

Tools - Need for tools, data mining tools, data submission tools e.g. nucleotide submission tools and protein sequence submission tools; Data analysis tools - nucleotide sequence analysis and protein sequence analysis tools e.g. BLAST & FASTA; Prediction tools - multiple nucleotide alignment, phylogenetic tree, gene prediction, protein structure and function prediction; Modeling tools - 2D and 3D protein modeling.

Suggested Readings:

1. Baxevanis AD, Ouellett BFF (2005). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, 3rd Edition, John Wiley and Son Inc., New York, USA.
2. Casella G, Berger RL (2001). Statistical Inference (The Wadsworth and Brooks/Cole Statistics/ Probability Series), Brooks/Cole Pub Company, Belmont, CA.
3. Grant GR, Ewens WJ (2001). Statistical Methods in Bioinformatics: An Introduction. Springer Verlag, New York.
4. Gupta SC, Kapoor VK (2014). Fundamentals of Mathematical Statistics, S Chand and sons, India.
5. Gupta SP (2009). Statistical Methods, 28th edition, S Chand and Sons, India.
6. Jagota A. (2000). Data Analysis and Classification for Bioinformatics, Bioinformatics by the Bay Press.

7. Lesk MA (2008). Introduction to Bioinformatics, 3rd edition, Oxford Publication, UK.
8. Mount DW (2004). Bioinformatics Sequence and Genome Analysis, 2nd edition, CSHL Press, New York.
9. Spiegel MR, Schiller JJ, Srinivasan RA (2000). Schaum's Outline of Probability and Statistics, McGraw-Hill Trade, New York, USA.
10. Srinivas VR (2005). Bioinformatics A modern Approach, PHI publisher, India.
11. Tramontano A (2006). Introduction to Bioinformatics, 1st edition, Chapman and Hall/CRC, London, UK.