

Department of Microbiology

Program: Masters in Microbiology

Program Specific Outcome (PSO)

- PSO1. Understands and is able to explain different branches of Microbiology such as Bacteriology, Virology, and Eukaryotic microbes
- PSO2. Understands and is able to explain about various application of Microbiology such as Environmental Microbiology, Industrial Microbiology and Food Microbiology
- PSO3. Is able to design and execute experiments related to Basic Microbiology, Molecular Biology, Recombinant DNA Technology, and Microbial Genetics
- PSO4. Is able to execute a short Research project incorporating techniques of Basic and Advanced Microbiology under supervision.

Course Outcome (CO)

CO of course “DIVERSITY OF PROKARYOTIC AND EUKARYOTIC MICROBES”

- CO1. Describe the systematics and occurrence of Archaea.
- CO2. Be able to differentiate between the various groups of Archaea (Crenarchaeota, Euarachaeota, Korarchaeota, Nanoarchaeota) based on their biochemical features
- CO3. Gain an understanding of the significance of Archaea.
- CO4. Get acquainted with biochips, methane generation, ultrafiltration membranes, production of PHB and PHA, desulphurization of coal and crude oil, bioleaching of metals, enzymes, compatible solutes and other potential applications of Archaea.
- CO5. Understand conventional and molecular systematics of bacteria.
- CO6. Know the occurrence, diversity and characteristic features of true bacteria.
- CO7. Get familiar with the significance and potential applications of various groups of bacteria according to the Bergey's Manual of Systematic Bacteriology.
- CO8. Describe cultivation-independent methods for studying the composition of microbial communities and for the function and occurrence of individual groups.
- CO9. Designate genomic-based methods to study microbial diversity in nature.
- CO10. Use bioinformatic tools and databases that are used to study microbial diversity.
- CO11. Understand the implications of molecular and biochemical methods including rDNA analysis, RFLP, RAPD
- CO12. Learn other fingerprinting techniques
- CO13. Gain knowledge about fatty acid analysis, polysaccharides and lipid analysis and the role of secondary metabolites in systematics.

- CO14. Become aware of fungal endophytes of tropical plants.
- CO15. Gain knowledge about the colonization of endophytes
- CO16. Learn about adaptation techniques in endophytes.
- CO17. Get insights into the role of endophytes as latent pathogens and biocontrol agents.
- CO18. Appreciate mycorrhizal fungi
- CO19. Describe the diversity of endo- and ecto-mycorrhizal fungi.
- CO20. Learn detailed biology of arbuscular mycorrhizal fungi.
- CO21. Know the signaling, penetration and colonization of mycorrhiza inside roots and their culturing.
- CO22. Absorb the recent advances in the field of mycorrhiza.
- CO23. Recognise the agricultural importance of toxigenic fungi.
- CO24. Understand the biodiversity and characterization of toxigenic fungi.
- CO25. Be able to characterize toxic metabolites chemically and biologically.
- CO26. Gain knowledge about the role of toxigenic fungi in sustainable agriculture with special emphasis on biopesticides.
- CO27. Get acquainted with the industrial value secondary metabolites from fungi.
- CO28. Learn about the synthesis of terpenes, non-ribosomal peptides, hydrophobins, peptaibols and indole alkaloids with detailed emphasis on polyketides.
- CO29. Understand the Biodiversity of yeasts.
- CO30. Gain basic knowledge of genetics of yeasts especially gene duplication.
- CO31. Know the central metabolism and basic physiology of yeasts.
- CO32. Become aware of adaptation that eventually leads to functional evolution in yeasts.
- CO33. Have know-how about aerobiosis/anaerobiosis and changes in regulatory circuits in yeasts that are crucial during adaptation to new environments.
- CO34. Describe the antagonistic interactions in yeasts: mycocinogeny, diversity of mycogenic yeast strains and the genetic basis of mycocinogeny.
- CO35. Know the characteristics of mycocins and their mode of action.
- CO36. Be able to exploit antagonistic yeasts for agricultural purposes.
- CO37. Develop an understanding of biotechnological applications of yeasts such as production of bioactive molecules including pigments, lipids, organic acids and EPS.
- CO38. Apply yeasts as probiotics.
- CO39. Make use of yeasts in bioremediation.
- CO40. Learn the process of making various alcoholic beverages with different types of yeasts.
- CO41. Acquire knowledge about algal diversity, their morphology and molecular structure.
- CO42. Realise the market importance of algal pigments and learn algae farming for their production.
- CO43. Gain acquaintance with algal biofuels including algal oil, biodiesel and hydrogen production.
- CO44. Be educated about important bioactive molecules of algae.
- CO45. Be able to apply algae for a sustainable environment.

CO of course "MICROBIAL PHYSIOLOGY AND METABOLISM"

- CO1. Measure microbial growth by various direct and indirect methods.
- CO2. Understand growth physiology and cell division in prokaryotes.
- CO3. Calculate growth yields and growth rates.
- CO4. Gain knowledge about growth kinetics, steady state growth and continuous growth.
- CO5. Learn about methods to distinguish simple and facilitated diffusion.
- CO6. Get acquainted with primary and secondary solute transport.
- CO7. Learn about ABC transporters and their applications in drug designing etc
- CO8. Understand the phosphotransferase system for carbohydrate transport in bacteria
- CO9. Get basic knowledge of non-PTS sugars and amino acid transport.
- CO10. Develop an understanding of the central metabolic pathways
- CO11. Understand the regulation of glycolysis, PPP and gluconeogenesis
- CO12. Learn various types of ED pathways in bacteria
- CO13. Be well versed with branched TCA, reverse TCA and glyoxylate cycle.
- CO14. Metabolic engineering of carbohydrate pathway for succinic acid over production
- CO15. Develop and understanding of how strains can be engineered for co-utilisation of pentose and hexose sugars
- CO16. Have knowledge about lactose utilisation pathways
- CO17. Know how complex polysaccharides and sugars other than glucose are utilised by microbes.
- CO18. Understand amino acid metabolism and its regulation.
- CO19. Know how amino acids can be used as a source of microbial growth for better production.
- CO20. Have know-how about amino acid biosynthesis and utilisation.
- CO21. Be able to describe pathway modifications leading to lysine overproduction
- CO22. Have a historical prospective and current metabolic engineering strategies for glutamine overproduction.
- CO23. Know biosynthesis and regulation of polyamines.
- CO24. Recognise lipid composition of various microorganisms.
- CO25. Get familiar with the biosynthesis of lipids.
- CO26. Learn about degradation of lipids and energy gain by microbes.
- CO27. Gain knowledge about synthesis of glutathione and its role as cellular redox regulator.
- CO28. Understand lipid accumulation in yeasts.
- CO29. Gain knowledge about the synthesis and degradation of hydrocarbons such as PHAs and PHBs.
- CO30. Have a deep understanding of nucleotide biosynthesis and regulation of synthesis of purines and pyrimidines.
- CO31. Students will be able to recognise the inhibitors of nucleotide synthesis.
- CO32. Learn the various physiological adaptations in bacterial response to extreme conditions.

- CO33. Be acquainted with the intercellular signalling in prokaryotes.
- CO34. Be aware of the two-component system in microorganisms and learn how to utilise the signal transduction pathways for specific purposes such as inhibition of biofilm formation.
- CO35. Learn about quorum quenching and its applications.
- CO36. Gain insights into the regulatory systems during aerobic- anaerobic shifts
- CO37. Have a grasp of the Arc, Fnr, Nar and FhlA regulons.
- CO38. Understand microbial response towards alteration in phosphate supply along with functioning of the Pho regulon.
- CO39. Students will familiarize themselves with bacterial quorum sensing.
- CO40. They would have learnt the working of A and C signaling system.
- CO41. Gain insights into the signalling and physiological changes during sporulation in *Bacillus subtilis*.
- CO42. Get knowledge about the control of competence in bacteria with emphasis towards *Bacillus subtilis*.
- CO43. Understand various heat-shock responses in different bacterial species
- CO44. Get introduced to the concept of homeostasis and learn how bacteria maintain internal pH and osmotic balance.
- CO45. Get acquainted with how bacteria maintain osmotic balance in both hypo and hypertonic conditions.

CO of course "VIROLOGY"

- CO1. Student is able to describe the steps in virus infection cycle
- CO2. Student is able to describe the principle of virus classification
- CO3. Student is able to list the virus families
- CO4. Student is able to describe the general properties of viruses
- CO5. Student is able to describe methods of studying virus structure
- CO6. Student is able to describe details of virus structure and concept of triangulation number
- CO7. Student is able to describe the basis of virus attachment and entry in host cells
- CO8. Student is able to describe replication strategies used by DNA viruses
- CO9. Student is able to describe replication strategies used by RNA viruses
- CO10. Student is able to describe replication strategies used by retroviruses
- CO11. Student is able to describe RNA directed RNA synthesis in RNA viruses
- CO12. Student is able to describe translation strategies adopted by RNA viruses
- CO13. Student is able to describe transcription and RNA processing in DNA viruses
- CO14. Student is able to describe virus assembly reactions
- CO15. Student is able to describe basics of virus infection in host
- CO16. Student is able to describe host defense against virus infection
- CO17. Student is able to explain viroids and basis of their pathogenesis

- CO18. Student is able to describe prions and various transmissible encephalopathies caused by them
- CO19. Student is able to describe satellite viruses and their replication strategies
- CO20. Student is able to describe general characteristics of acute viral infections
- CO21. Student is able to describe pathogenesis of Influenza virus
- CO22. Student is able to describe pathogenesis of Polio virus
- CO23. Student is able to describe pathogenesis of Measles virus
- CO24. Student is able to describe pathogenesis of Rotavirus infection
- CO25. Student is able to describe general characteristics of chronic, persistent, latent infections
- CO26. Student is able to describe pathogenesis of Herpesviruses infection
- CO27. Student is able to describe pathogenesis of Papillomavirus infections
- CO28. Student is able to describe pathogenesis of Epstein Barr Virus infection
- CO29. Student is able to describe how live viral vaccine are made
- CO30. Student is able to describe how inactivated viral vaccine are made
- CO31. Student is able to describe how recombinant viral vaccine are made
- CO32. Student is able to describe antiviral drug discovery process
- CO33. Student is able to describe mechanism of action of antiviral drugs
- CO34. Student is able to describe concepts in virus evolution
- CO35. Student is able to describe concept of virus quasispecies
- CO36. Student is able to describe basis of emergence of novel virus
- CO37. Student is able to describe transformation of infected cells by DNA viruses
- CO38. Student is able to describe transformation of infected cells by RNA viruses
- CO39. Student is able to describe virus mediated tumorigenesis and oncogenesis
- CO40. Student is able to describe classification of plant viruses
- CO41. Student is able to describe propagation, purification, characterization and identification of plant viruses
- CO42. Student is able to describe symptoms of plant viral diseases
- CO43. Student is able to describe transmission of plant viral diseases
- CO44. Student is able to describe diversity, classification and characteristics of bacteriophages
- CO45. Student is able to explain general concept of algal, fungal and protozoan viruses

CO of course "IMMUNOLOGY"

- CO1. Student is able to describe the fundamental concept in immunology
- CO2. Student is able to describe the concept of specificity in immunology
- CO3. Student is able to describe the concept of discrimination of self from non-self in host
- CO4. Student is able to describe the concept of immunological memory
- CO5. Student is able to describe detailed structure of B cells receptors
- CO6. Student is able to describe detailed structure of T cell receptors
- CO7. Student is able to describe structure of CD4 and CD8 molecules
- CO8. Student is able to describe structure of MHC-I and MHC-II molecules
- CO9. Student is able to describe pattern recognition receptors
- CO10. Student is able to describe toll like receptors

- CO11. Student is able to describe markers of suppressor and regulatory cells
- CO12. Student is able to describe markers of CD4+, CD25+, Foxp3+, Treg, iNKT cells
- CO13. Student is able to describe genetic organization of genes for B cell receptors
- CO14. Student is able to describe genetic organization of genes for T cell receptors
- CO15. Student is able to describe genetic organization of genes for MHC-I and MHC-II complex
- CO16. Student is able to describe molecular mechanisms responsible for generating diversity of antibodies
- CO17. Student is able to describe molecular mechanisms responsible for generating diversity of T cell receptors
- CO18. Student is able to describe peptide loading and expression of MHC-I and MHC-II molecules
- CO19. Student is able to describe hybridoma technology and monoclonal antibodies
- CO20. Student is able to describe antibody engineering
- CO21. Student is able to describe immune response and signaling
- CO22. Student is able to describe humoral immune response
- CO23. Student is able to describe cell mediated immune response
- CO24. Student is able to describe innate immune response and pattern recognition
- CO25. Student is able to describe recent advances in innate immune response
- CO26. Student is able to describe NK-DC interactions
- CO27. Student is able to describe major cytokines and their role in immune mechanisms
- CO28. Student is able to describe role of TNF-IFN, IL-1, IL-2 in immune mechanisms
- CO29. Student is able to describe role of IL-4, IL-6, IL-10, IL-12, IL-17 and TGF β in immune mechanisms
- CO30. Student is able to describe cell signaling through MAP kinases and NF- κ B
- CO31. Student is able to describe tolerance and autoimmunity
- CO32. Student is able to describe central and peripheral tolerance and their mechanisms
- CO33. Student is able to describe mechanisms of autoimmunity
- CO34. Student is able to describe autoimmune components of diabetes mellitus
- CO35. Student is able to describe autoimmune component of multiple sclerosis, experimental autoimmune encephalitis
- CO36. Student is able to describe infections leading to autoimmune disease
- CO37. Student is able to describe immunological disorders and hypersensitivity
- CO38. Student is able to describe deficiencies and defects of T cells and B cells
- CO39. Student is able to describe deficiencies and defects of complement and phagocytic cells
- CO40. Student is able to describe comparative study of Type IV hypersensitivities with examples
- CO41. Student is able to describe transplantation and tumor immunology
- CO42. Student is able to describe alloreactive response
- CO43. Student is able to describe graft rejection and GVHD, HLA matching
- CO44. Student is able to describe transgenic animals for xenotransplantation
- CO45. Student is able to describe tumor antigens, immune response to tumors and immunotherapy of tumors

CO of course "ENVIRONMENTAL MICROBIOLOGY"

- CO1. Understand the chronological history and development of environmental microbiology.
- CO2. Be acquainted with significant contributions of microbiologists.
- CO3. Get insights into the emergence of environmental microbiology.
- CO4. Be able to apply culture-dependent and culture-independent approaches for understanding microbial diversity in the environment.
- CO5. Learn how molecular techniques can be used for studying microbial diversity.
- CO6. Get acquainted with methods to study DNA heterogeneity such as by reannealing denatured environmental DNA and ARDRA.
- CO7. Learn other techniques such as analysis of FAME profiles and measuring metabolic capabilities using BIOLOG microtiter plates.
- CO8. Gain knowledge about advanced techniques such as using DNA probes and PCR primers, G+C analysis, slot-blot hybridization of community DNA, and fluorescent in situ hybridization of intact cells for identification of microbial strains.
- CO9. Be aware of the microbial diversity in normal environments.
- CO10. Recognise the diversity of microbes in agricultural soils
- CO11. Learn about extremophiles that thrive in desert soils.
- CO12. Get a grasp over diversity of aquatic microbes present in fresh water and marine environments.
- CO13. Gain awareness about the microbial composition of the atmosphere (stratosphere).
- CO14. Attain knowledge about animal microbiome (cattle, termites, pests such as cockroach and nematodes) with special attention towards human microbiota.
- CO15. Learn the potential applications and implications of animal microflora.
- CO16. Acquire know-how of microbial diversity in extreme environments.
- CO17. Know about the occurrence, diversity, adaptations and potential applications of oligotrophs and barophiles.
- CO18. Get knowledge about the diversity, manifestation and applicability of thermophiles and psychrophiles.
- CO19. Get insights into occurrence and adaptations in acidophiles, alkaliphiles and halophiles.
- CO20. Gain a basic understanding of metallophiles, organic solvent and radiation tolerants.
- CO21. Understand the sources and variety of gases which contribute to global warming.
- CO22. Get introduced to the obvious as well as hidden effects of global warming and remedial measures involving microbes.
- CO23. Students will have learnt about lignin degradation by microbes.
- CO24. Attain a basic understanding of lignocellulolytic enzymes- their types and microbial sources.
- CO25. Know the enzymes and enzyme mediated processes used in bio-pulping of paper, bio-bleaching and bio-stoning of textiles at an industrial level.
- CO26. Learnt about microbial production of bio-alcohols being used as fuels
- CO27. Gain knowledge of animal feed production using microorganisms.

- CO28. Be more aware about the problem of liquid waste management in a global and Indian context.
- CO29. Understand how sewage can be treated by employing microbes at a Primary and Secondary level.
- CO30. Learn about various tertiary water treatment methods.
- CO31. Be able to distinguish between potable and non-potable water.
- CO32. Students will know how to test for coliforms, enterobacteria and pathogens in drinking water
- CO33. Be able to count total bacterial population present in drinking water sources.
- CO34. Gain in-depth knowledge about treatment of Industrial effluents from distilleries.
- CO35. Know about treatment of effluents from textile factories, pulp and paper industries.
- CO36. Get introduced to recent advances in using xenobiotic degrading microbes.
- CO37. Get aware about the problem of solid waste management in our country's context.
- CO38. Be able to differentiate waste types & their possible usages with respect to reduction and recycling of wastes.
- CO39. Get acquainted with landfill development and composting
- CO40. Learn about the succession of microbial communities during composting
- CO41. Be familiarised with bioremediation of environmental pollutants such as petroleum hydrocarbons
- CO42. Be familiar with role of microbes in pesticides remediation.
- CO43. Know the use of microbes in mineral recovery
- CO44. Acquire the basics of bioleaching of copper, gold and uranium. And how these processes are running successfully in various parts of the world.
- CO45. Learn how microbes can be applied to solve environmental pollution problems

CO of course "PLANT PATHOGEN INTERACTION"

- CO1. Student is able to understand the concept of plant diseases and plant pathogens
- CO2. Student is able to differentiate between the terms pathogen and pathogenesis with respect to plant diseases
- CO3. Student is able to understand the role of the environment in pathogenesis
- CO4. Student is able to explain terms like disease triangle and disease tetrahedron
- CO5. Student is able to understand and describe the effect of microbial infections on plant physiology
- CO6. Student is able to understand and describe the effect of microbial infections on photosynthesis carried out by plants
- CO7. Student is able to understand and describe the effect of microbial infections on plant respiration
- CO8. Student is able to understand and describe the effect of microbial infections on transpiration

- CO9. Student is able to understand and describe the effect of microbial infections on translocation
- CO10. Student is able to establish and describe the role of enzymes like cutinases, pectinases and cellulases (hydrolytic enzymes) in pathogenesis and establishment of plant diseases
- CO11. Student is able to establish and describe the role of microbial toxins in pathogenesis
- CO12. Students can differentiate between different types of microbial toxins such as non-host specific or non-host selective toxins and host specific or host-selective toxins
- CO13. Students are able to analyze the relevance of phytoalexins in disease management
- CO14. Student is able to critically explain the etiological studies and symptoms of crown gall and its causative agent *Agrobacterium tumefaciens*
- CO15. Students can write about the histopathological and cytopathological changes occurring in the plant due to disease establishment
- CO16. Students are able to understand the symptoms of viral diseases
- CO17. Students can describe the etiology of the viral causative agents
- CO18. Students can enlist various features of tobacco mosaic virus, tomato ringspot virus, tobacco leaf curl virus etc.
- CO19. Student is able to describe the genetics of host-pathogen interactions during disease establishment
- CO20. Student is able to analyze the role of resistance genes and resistance mechanisms as part of plant defense mechanisms
- CO21. Students are able to understand the principles of plant disease control
- CO22. Student is able to describe the different physical methods of plant disease control
- CO23. Student is able to describe the different chemical methods of plant disease control
- CO24. Student is able to describe the different biological methods of plant disease control
- CO25. Students are able to understand and define the concepts and practices of biocontrol agents
- CO26. Students are able to describe the use of fungi as biocontrol agents (mycoparasitism) with focus on *Trichoderma*
- CO27. Student can describe various commercial preparation of biocontrol agents
- CO28. Students are able to differentiate between direct, indirect and mixed-path antagonism
- CO29. Students can write about resident vs introduced antagonists
- CO30. Students are able to understand the different methods of applying such antagonists as part of disease management
- CO31. Students can write about the uses and practical constraints of biocontrol agents
- CO32. Students are able to understand the different molecular diagnostic techniques for identification of plant pathogens e.g. LAMP PCR
- CO33. Students can analyze the use of transgenic approaches for plant disease management and control
- CO34. Students are able to write about the applications, constraints of various molecular diagnostic techniques
- CO35. Students can understand various future prospects in molecular diagnosis of plant pathogens
- CO36. Students are able to assess the relationship between disease control and disease forecasting

- CO37. Students are able to critically analyze the relevance of disease forecasting especially in the Indian scenario
- CO38. Students can enlist various computer based forecasting programmes
- CO39. Students are able to cut cross-sections/ transverse sections of diseased portions of stem, root or leaf and stain them to observe the pathogen morphology under the microscope
- CO40. Students are able to examine the external symptoms of different plant diseases by the naked eye e.g. Wilts, soft rots, canker etc.
- CO41. Students are able to identify the morphological changes occurring due to different bacterial and viral plant pathogens
- CO42. Students can identify the structural and microscopic features of different pathogenic fungi like *Candida*, *Aspergillus* and *Microsporium* sp.
- CO43. Students are able to isolate and further identify soil borne plant pathogens by PCR based techniques for their classification
- CO44. Students can quantify the level of soil borne pathogens by MPN and dilution end point methods
- CO45. Students can carry out biochemical and physiological tests for detection of pathogens in fruits and vegetables

CO of course "MICROBIAL PATHOGENISITY"

- CO1. Student is able to describe classical view of microbial pathogenicity
- CO2. Student is able to define pathogenicity and virulence
- CO3. Student is able to describe quantitative measures of virulence
- CO4. Student is able to describe concept of minimum lethal dose, LD50, ID50, and TCID50
- CO5. Student is able to describe virulence determinants – colonization, toxins, enzymes and invasiveness
- CO6. Student is able to describe facultative or obligate intracellular pathogens
- CO7. Student is able to describe molecular Koch's postulates
- CO8. Student is able to describe multiplicity of virulence factors and coordinated regulation of virulence genes
- CO9. Student is able to describe two component signal transduction systems and environmental regulation of virulence determinants
- CO10. Student is able to describe clonal and panmictic nature of microbial pathogens,
- CO11. Student is able to describe type 1-IV secretion systems, biofilms and quorum sensing.
- CO12. Student is able to describe emerging and re-emerging pathogens
- CO13. Student is able to describe concept of emerging and re-emerging pathogens using examples of *V.Cholerae*, *M.tuberculosis*, *H.pylori*, Enterohaemorrhagic *E.coli*
- CO14. Student is able to describe basis of microbial pathogenicity in SARS virus, Bird flu, prions, AIDS, Dengue Hemorrhagic Fever
- CO15. Student is able to describe basis of microbial pathogenicity in Lyme disease, *Cryptosporidium parvum*, *Chlamydiae* and opportunistic fungal infections.
- CO16. Student is able to describe mechanism of emergence of new pathogens

- CO17. Student is able to describe microbial change and adaption
- CO18. Student is able to describe horizontal gene transfer, pathogenicity islands, and role of integrons
- CO19. Student is able to describe objectives of microbial epidemiology
- CO20. Student is able to describe biochemical and immunological tools
- CO21. Student is able to describe biotyping, serotyping, phage typing
- CO22. Student is able to describe FAME, Curie Point, pyMS, protein profiling
- CO23. Student is able to describe multilocus enzyme electrophoresis, molecular typing
- CO24. Student is able to describe RAPD, 16S-23S IGS, ARDRA
- CO25. Student is able to describe different types of PCR, PFGE, AFLP
- CO26. Student is able to describe concepts of MVLST, VNTR, SNP
- CO27. Student is able to describe microarray and whole genome sequencing tools
- CO28. Student is able to describe role of environmental change on infectious disease
- CO29. Student is able to describe global warming lead increase in vector borne infectious disease
- CO30. Student is able to describe impact of increasing urbanization and international travel and trade on infectious disease
- CO31. Student is able to describe concepts in antimicrobial resistance
- CO32. Student is able to describe multidrug efflux pumps
- CO33. Student is able to describe extended spectrum b-lactamases
- CO34. Student is able to describe X-MDR *M.tuberculosis*, Methicillin resistant *S.aureus*(MRSA)
- CO35. Student is able to describe newer vaccines
- CO36. Student is able to describe recombinant vaccines
- CO37. Student is able to describe subunit vaccines, DNA vaccines
- CO38. Student is able to describe Vaccinia, BCG and HIV- vector based vaccines
- CO39. Student is able to describe principles of rapid diagnostic
- CO40. Student is able to describe nucleic acid probes in diagnostic microbiology
- CO41. Student is able to describe nucleic acid amplification methods
- CO42. Student is able to describe real-time PCR
- CO43. Student is able to describe diagnostic sequencing and mutation detection
- CO44. Student is able to describe molecular typing methods
- CO45. Student is able to describe array technology

CO of course "MOLECULAR BIOLOGY"

- CO1. Student is able to describe the molecular structure of DNA
- CO2. Student is able to describe the molecular structure of RNA
- CO3. Student is able to describe the organization of microbial genomes
- CO4. Student is able to describe the organization of eukaryotic genomes
- CO5. Student is able to describe chromatin arrangement and nucleosome formation
- CO6. Student is able to describe arrangement of replicons in genome
- CO7. Student is able to describe various modes of DNA replication
- CO8. Student is able to describe various replication enzymes

- CO9. Student is able to describe replication fork and priming
- CO10. Student is able to describe initiation of DNA replication, elongation and termination
- CO11. Student is able to describe basis of DNA copy number maintenance
- CO12. Student is able to describe DNA mismatch repair
- CO13. Student is able to describe double stranded break repair in DNA
- CO14. Student is able to describe transcription machinery of prokaryotes
- CO15. Student is able to describe various transcription enzymes and cofactors in prokaryotes
- CO16. Student is able to describe initiation reaction of transcription in prokaryotes
- CO17. Student is able to describe elongation in transcription in prokaryotes
- CO18. Student is able to describe termination reaction in transcription in prokaryotes
- CO19. Student is able to describe transcription machinery in eukaryotes
- CO20. Student is able to describe various forms of RNA polymerase and cofactors in eukaryotes
- CO21. Student is able to describe initiation reaction of transcription in eukaryotes
- CO22. Student is able to describe elongation in transcription in eukaryotes
- CO23. Student is able to describe termination reaction in transcription in eukaryotes
- CO24. Student is able to describe promoters, enhancers and silencers in eukaryotes transcription
- CO25. Student is able to describe effect of chromatin structure in eukaryotic transcription
- CO26. Student is able to describe regulation of eukaryotic transcription
- CO27. Student is able to describe regulation of prokaryotic transcription
- CO28. Student is able to describe regulation of lac operon
- CO29. Student is able to describe regulation of trp operon
- CO30. Student is able to describe the genetic code and protein structure
- CO31. Student is able to describe mechanism of translation in prokaryotes
- CO32. Student is able to describe mechanism of translation in eukaryotes
- CO33. Student is able to describe formation of initiation complex in translation
- CO34. Student is able to describe ribosome assembly in translation
- CO35. Student is able to describe elongation process in translation
- CO36. Student is able to describe termination of translation
- CO37. Student is able to describe in vitro translation systems
- CO38. Student is able to describe polycistronic and monocistronic synthesis
- CO39. Student is able to describe regulation of translation
- CO40. Student is able to describe basis of RNA stability
- CO41. Student is able to describe inhibitors of translation
- CO42. Student is able to describe post-translational processes
- CO43. Student is able to describe protein modifications
- CO44. Student is able to describe protein folding and chaperons
- CO45. Student is able to describe signal hypothesis

CO of course "RECOMBINANT DNA TECHNOLOGY"

- CO1. Student is able to list and describe various enzymes used in cloning DNA
- CO2. Student is able to analyze the importance of cloning aids like linkers and adaptors

- CO3. Student is able to describe and explain the use of various cloning vectors
- CO4. Student is able to analyze DNA by gel electrophoresis
- CO5. Student is able to design a cloning experiment
- CO6. Student is able to execute the isolation and cloning of DNA fragments and plasmids
- CO7. Student is able to analyze restriction fragment length polymorphism patterns
- CO8. Student is able to explain the applications of restriction fragment length polymorphism patterns, such as DNA fingerprinting, disease diagnosis
- CO9. Student is able to differentiate between Southern, Northern and Western blotting techniques
- CO10. Student can compare and contrast the applications of Southern, Northern and Western blotting techniques
- CO11. Student is able to design primers for PCR
- CO12. Student is able to design and execute experiments to amplify genes
- CO13. Student can execute the mutagenesis of genes by overlap PCR
- CO14. Student is able to fingerprint micro-organisms using RAPD
- CO15. Student can describe the identification of SNPs by ligation chain reaction
- CO16. Student is able to analyze multi-gene expression by multiplex PCRs
- CO17. Student learns the use of RACE techniques
- CO18. Student can plan the construction of genomic and cDNA libraries
- CO19. Student is able to discuss screening methods for libraries
- CO20. Student is able to analyze gene expression using real time PCR
- CO21. Student is able to describe in detail how genomes are sequenced
- CO22. Student is able to compare and critique the different next generation sequencing methods
- CO23. Student is able to analyze global gene expression using DNA microarray technology
- CO24. Student can describe the utility of DNA microarrays in comparative genome sequencing
- CO25. Student is able to plan the genome-wide identification of DNA binding sites of proteins using ChIP-on-chip
- CO26. Student is able to design experiments to study protein-DNA interactions
- CO27. Student is able to design experiments to analyze protein-protein interactions
- CO28. Student is able to compare and critique the different methods to analyze protein-protein interactions
- CO29. Student is able to design and execute experiments to map transcription start sites
- CO30. Student is able to summarize the use and applications of reporter genes
- CO31. Student is able to implement the use of green fluorescent protein and its derivatives
- CO32. Student is able to analyze proteins by gel electrophoresis
- CO33. Student is able to analyze proteome differences using two-dimensional gel electrophoresis.
- CO34. Student is able to design an experiment to compare the proteomes of two organisms by mass spectrometry
- CO35. Student is able to construct a plasmid for overexpression and purification of recombinant proteins in different hosts
- CO36. Student can describe the use of baculovirus system for expression of recombinant proteins

- CO37. Student can describe how gene knockouts are constructed
- CO38. Student can write about the importance of transgenic plants
- CO39. Student is able to explain how animals are cloned.
- CO40. Student is able to critique the pros and cons of animal cloning
- CO41. Student is able to discuss the latest technology in therapeutic cloning
- CO42. Student is able to critique the pros and cons of therapeutic cloning
- CO43. Student is able to judge the importance of recombinant DNA technology in creating pharmaceutical products
- CO44. Student is able to write about pharmaceutical products of DNA technology such as insulin, hGH.
- CO45. Student is able to write about DNA vaccines and their importance

CO of course "MICROBIAL GENETICS"

- CO1. Student can discuss the importance of mutation analysis
- CO2. Student is able to predict the phenotype of the organism based on the mutations it carries
- CO3. Student is able to discuss the theories of inheritance: directed change versus random
- CO4. Student is able to differentiate between reversion and suppression
- CO5. Student is able to analyze mutations using complementation tests
- CO6. Student is able to analyze mutations using recombination tests
- CO7. Student learns to distinguish between spontaneous and induced mutagenesis
- CO8. Student is able to list the different types of mutations
- CO9. Student is able to design a strategy to create gene replacement in bacteria
- CO10. Student is able to design a strategy to clone genes by complementation
- CO11. Student is able to design a strategy to clone genes by marker rescue
- CO12. Student is able to describe the fertility factor in bacteria
- CO13. Student is able to execute a conjugation experiment between two bacteria
- CO14. Student is able to discuss how plasmid copy number is regulated in different types of plasmids
- CO15. Students is able to differentiate between Hfr strains and strains carrying F plasmid
- CO16. Student is able to construct a genetic map of bacterial genome using conjugation-based method
- CO17. Student is able to compare and critique chromosomal DNA transfer by creation of prime factors and by integrated plasmids
- CO18. Student is able to discuss the use of Ti plasmid in creating transgenic plants
- CO19. Student is able to list the steps in phage infection and multiplication within the host bacterium
- CO20. Student is able to compare and contrast the lytic development cycles of T4 and T7 phage
- CO21. Student can compare and contrast the packaging of filamentous versus icosahedral phage
- CO22. Student is able to construct genetic linkage map using two-factor cross
- CO23. Student is able to construct genetic linkage map using three factor cross

- CO24. Student is able to execute the transformation of bacteria by inducing competence artificially
- CO25. Student is able to discuss the basis of natural competence in gram-positive and gram-negative bacteria
- CO26. Student is able to explain the regulation of competency in sporulating bacteria
- CO27. Student is able to compare and contrast generalized versus specialized transduction
- CO28. Student is able to list the events in the lytic phase of lambda phage life cycle
- CO29. Student is able to list the events in the lysogenic phase of lambda phage life cycle
- CO30. Student is able to discuss at length the regulatory factors and events they control in determining whether lambda phage enters the lytic or lysogenic cycle
- CO31. Student is able to list the outcomes of transposition events
- CO32. Student is able to differentiate between cut-and-paste versus replicative transposition
- CO33. Student can design strategies to mutagenize bacteria using transposons
- CO34. Student can explain the use of *loxP*-cre and *FLP-FRT* systems in constructing conditional knockouts
- CO35. Student is able to differentiate between the life-styles of lambda phage and mu phage
- CO36. Student is able to validate the statement that mu phage is a transposon
- CO37. Student is able to design an experiment using mini-mu elements for creating gene fusions in reporter assays
- CO38. Student is able to describe the regulation of the lac operon
- CO39. Student is able to describe the regulation of the trp operon
- CO40. Student is able to describe the regulation of the gal operon
- CO41. Student is able to describe the regulation of the ara operon
- CO42. Student is able to describe the regulation of the tol operon
- CO43. Student is able to determine the phenotypes obtained in case of various mutants of these five operons
- CO44. Student is able to differentiate between positive and negative regulation of gene expression
- CO45. Student is able to differentiate between inducible and repressible systems

CO of course "INDUSTRIAL AND FOOD MICROBIOLOGY"

- CO1. Student is able to list and describe various sources for the isolation of industrially relevant microbes.
- CO2. Student is able to list various culture collection banks available.
- CO3. Student is able to define the sterilization process and various techniques used for sterilization.
- CO4. Student is able to list the methods used in strain improvement such as mutagenesis, metabolic engineering and recombinant DNA techniques.
- CO5. Student is able to define that what fermentation is.
- CO6. Student is able to define batch, fed-batch, and continuous mode of fermentation.

- CO7. Student is able to define types of bioreactor such as aerated stirred tank reactor, bubble column and bioreactors for immobilized cells.
- CO8. Student is able to define types of fermentation process i.e. solid state and submerged fermentation.
- CO9. Student is able to list the various parts of a fermenter like impeller (their different types), sparger, baffles, and designing of fermentor vessel.
- CO10. Student is able to calculate the microbial growth rate, yield coefficients, volumetric productivity and volumetric yield.
- CO11. Student is able to define oxygen mass transfer rate, Henry's law of gas transfer and oxygen mass transfer coefficient ($K_L a$).
- CO12. Student is able to demonstrate how to run a batch and fed-batch fermentation for production of various industrially relevant enzymes and biomolecules.
- CO13. Student is able to list and describe methods for downstream processing of microbial products.
- CO14. Students can define filtration, factors which influence filtration process, and what are its different types.
- CO15. Student is able to define centrifugation, Stoke's law, and different types of centrifuges
- CO16. Student can list methods of cell aggregation and flocculation.
- CO17. Student is able to define and list various physical methods of cell disruption such as sonication, solid shear, liquid shear, agitation with abrasives and freeze-thawing.
- CO18. Student is able to define and list various chemical methods of cell disruption such as use of detergents, alkali method, osmotic shock and enzymatic treatment.
- CO19. Student is able to define the chromatography and can differentiate and define various methods of chromatography used for purification.
- CO20. Student is able to purify different products based on their specific characteristics features like size, shape and charge.
- CO21. Student is able to define methods for separation like ultra-filtration and reverse osmosis.
- CO22. Student is able to list the product recovery methods like spray drying and crystallization.
- CO23. Student is able to define liquid-liquid extraction method for secondary metabolites.
- CO24. Student is able to implement the Ni-NTA chromatography, for the purification of His-tagged proteins.
- CO25. Students can calculate the fermentation economics parameters.
- CO26. Student is able to define how to make the fermentation process economically viable and reduce the recovery cost.
- CO27. Student is able to list various methods of effluent treatment.
- CO28. Student is able to design and list the methods for the industrial level production of antibiotics such as penicillin, streptomycin and cephalosporins.

- CO29. Student is able to list the methods for the industrial level production of amino acids such as glutamic acid, lysine and phenylalanine.
- CO30. Student is able to list the methods for the industrial level production of butanol and ethanol.
- CO31. Student is able to list the methods for the production of industrially relevant enzymes and bio-therapeutics products.
- CO32. Student is able to list the artificial sweeteners and their production at industrial level.
- CO33. Student is able to list the various fermented milk products.
- CO34. Student is able to list the microorganisms used as starter culture in the production of yogurt, dahi, koumiss, kefir and other milk products.
- CO35. Student is able to list different types of Cheese and how to produce them.
- CO36. Student is able to list different microorganisms involved in making different types of Cheese.
- CO37. Student is able to define what plant based fermentation products are and how to produce them. This includes sauerkraut, pickles, kimchi, olives and cucumbers.
- CO38. Student is able to list the name of microorganisms involved in the production of above mentioned plant-based fermentation products.
- CO39. Student is able to define and list the chemical, physical and biological methods of food preservation.
- CO40. Student is able to list fermentation processes involved in meat and fish production.
- CO41. Student is able to list the methods for the production of alcoholic beverages.
- CO42. Student can differentiate between lager and ale beer
- CO43. Students can differentiate the production processes of various types of wines and distilled beverages.
- CO44. Student is able to list the methods for vinegar production such as orlean process, trickling method and submerged fermentation.
- CO45. Students can enlist various food borne diseases and their causative agents.

CO of course "DISSERTATION"

- CO1. Student is able to conceive a problem based on current published research
- CO2. Student is able to carry out comprehensive survey of literature on the topic of research
- CO3. Student is able to make culture media for various microbes
- CO4. Student is able to isolate microorganism from different environmental/ food sources
- CO5. Student is able to identify the isolated microorganism using biochemical and molecular methods

- CO6. Student is able to identify and isolate important bioactive molecules from the isolated strain of microbe
- CO7. Student is able to characterize the isolated bioactive molecules using biochemical and molecular methods
- CO8. Student is able to clone genes encoding for the identified bioactive molecule from the isolated microbe
- CO9. Student is able to express recombinant bioactive molecules
- CO10. Student is able to optimize the production of the recombinant bioactive molecule]
- CO11. Student is able to use statistical tools for data analysis
- CO12. Student is able to put together a thesis including bibliography on topic of research
- CO13. Student is able to present their research findings before evaluation committee