SYLLABUS

TWO YEAR FULL TIME PROGRAMME

(Choice-based credit system)

Note: Syllabus applicable for students seeking admission in the M.Sc. Microbiology Course from the academic year 2018-2019

DEPARTMENT OF MICROBIOLOGY

FACULTY OF INTERDISCIPLINARY AND APPLIED SCIENCES
UNIVERSITY OF DELHI SOUTH CAMPUS
NEW DELHI – 110021

MASTER OF SCIENCE IN MICROBIOLOGY

TWO YEAR FULL TIME PROGRAMME

The **Choice-Based Credit System** provides a framework within which there is flexibility in the design of courses and their content, simultaneously also providing the student a choice of the courses he/she wants to study based on his/her interest and learning abilities. The Courses are assigned credits on the basis of the teaching hours, which in turn is linked to the course structure and content. Evaluation follows a grading system rather than the conventional marking system, and this supports the movement of students across different educational institutions within the country.

The **M.Sc. Microbiology Programme** offered by Delhi University is of two years' duration and is divided into four semesters. The various courses of the programme are designed to include lectures, laboratory work, project work, viva, seminars, assignments and field trips. At the end of the programme the student will be well-versed in basic microbiology as well as be familiar with the most recent advances in microbiology, and will have gained hands-on experience in microbiology, including fermentation technology and molecular biology techniques.

Three categories of courses will be offered:

Core Courses (fourteen mandatory courses offered by the Department),

Electives (discipline-specific. Student must opt for two out of four courses offered by the Department)

Open Elective (student may opt for any one open elective offered by other departments of the FIAS).

The **Core Courses** are of four credits/ six credits/ eight credits and include laboratory courses as well as classroom courses. A separate research-based course that leads to a dissertation and is worth twenty-four credits is also one of the Core Courses.

The **Electives** (discipline-specific) are four credit classroom courses.

The **Open Elective** is a two credit classroom course.

A student is required to accumulate twenty-four credits each semester, a total of ninety-six credits, to fulfil the requirements for a Master of Science degree in Microbiology.

Semester one will have a total of **five** Core Courses: four theory-based courses of four credits each (100 marks each) and one laboratory course of eight credits (200 marks).

Semester two will have a total of **six** courses: three theory-based Core Courses of four credits each (100 marks each), one laboratory-based Core Course of six credits (150 marks), one Elective (discipline-specific) of four credits (100 marks) and one Open Elective of two credits (50 marks).

Semester three will have a total of **five** courses: three theory-based Core Courses of four credits each (100 marks each), one laboratory-based Core Course of eight credits (200 marks), and one Elective (discipline-specific) of four credits (100 marks)

Semester four will have **one** Core Course of twenty-four credits (600 marks). This will be a research-based dissertation which will be evaluated on the basis of .laboratory work, thesis submitted, research presentation and viva-voce.

Thirty percent of the total marks for each paper will be reserved for Internal Assessment (IA). Examinations for four credit courses will be of three hours duration and of two credit courses will be of two hours duration. Examinations for laboratory-based courses will be held over two days of eight hours each.

The detailed syllabus for each paper is appended, along with a list of suggested reading which would be further supplemented with other books/papers. The course contents would be modified to include the most recent advances each semester. While older editions of books are recommended for some topics, the books generally prescribed would consist of the latest editions.

MASTER OF SCIENCE IN MICROBIOLOGY
TWO YEAR FULL TIME PROGRAMME

AFFILIATION

The proposed Programme shall be governed by the Department of Microbiology, Faculty of Interdisciplinary and Applied Sciences, University of Delhi South Campus, New Delhi

PROGRAMME STRUCTURE

Semester-I		**Total (Theory/IA)**
MICROB 0701	Bacteriology	100 (70/30)
MICROB 0702	Microbial Physiology and Metabolism	100 (70/30)
MICROB 0703	Molecular Virology	100 (70/30)
MICROB 0704	Immunology	100 (70/30)
MICROB 0705	Practical I	200(140/60)
		Total marks :600
Semester-II		
MICROB 0801	Environmental Microbiology	100 (70/30)
MICROB 0802	Industrial Microbiology	100 (70/30)
MICROB 0803	Microbial Pathogenicity	100 (70/30)
MICROB 0804 E1*	Biophysical and Biochemical Methods	100 (70/30)
MICROB 0804 E2*	Plant-Pathogen interactions	100 (70/30)
MICROB 0805	Practical II	150
MICROB 0806 OE**	Open Elective : Microbial Biotechnology	50
* Any one of the two ** For students of other departments		Total marks: 600
Semester-III		
MICROB 0901	Molecular Biology	100 (70/30)
MICROB 0902	Recombinant DNA Technology	100 (70/30)
MICROB 0903	Microbial Genetics	100 (70/30)
MICROB 0904 E1*	Computational Biology	100(70/30)
MICROB 0904 E2*	Food Microbiology	100 (70/30)
MICROB 0905	Practical III	200
*Any one		Total marks: 600
Semester-IV		
MICROB 1001	Dissertation (laboratory work, thesis submission, research presentation, viva-voce)	Total marks: 600 (420/180)

Grand total of marks after Semesters 1, II, III and IV = 600+600+600+600 = 2400

Syllabus and Scheme of Examination for M.Sc. Microbiology

TWO YEAR FULL TIME PROGRAMME
(Choice-Based Credit System)

Note: Syllabus applicable for students seeking admission in the M.Sc. Microbiology Course from the academic year 2018-2019

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NEW DELHI – 110021

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1. The student understands and is able to explain different branches of Microbiology such as Bacteriology, Virology, and Eukaryotic Microbiology

PSO2. The student understands and is able to explain about various applications of Microbiology such as Environmental Microbiology, Industrial Microbiology and Food Microbiology

PSO3. The student is able to design and execute experiments related to Basic Microbiology, Molecular Biology, Recombinant DNA Technology, and Microbial Genetics

PSO4. The student is able to execute a short research project incorporating techniques of Basic and Advanced Microbiology under supervision.

MICROB 0701

BACTERIOLOGY
(4 **credits**)

Bacterial cell structure and appendages: Morphological features and arrangement of bacterial cells**;** overview of eubacterial cell structure: Gram-positive and Gram-negative bacteria; Extracellular appendages: flagella- arrangement, basic structure and locomotive function; pili- different types, their distribution among bacteria & related functions; fimbriae- occurrence, function and features distinguishing pili and fimbriae; glycocalyx- composition and role in bacteria; and capsule**-** microcapsule and slime. **12**

Bacterial cell wall & cell membrane: Detailed structure of gram negative and gram positive bacterial cell wall, outer membrane lipopolysaccharide (LPS), protoplasts, sphaeroplasts, L-forms, cell wall synthesis and its inhibitors including different antibiotics; periplasm; molecular and chemical structure of cell membrane; cytoskeleton including tubulin and actin structural filaments and their role in bacteria. **10**

Bacterial cell division and reproduction: Binary fission and other forms of reproduction in bacteria; assembly, maintenance and disassembly of Z ring; endospore structure and stages involved in endospore development in *Bacillus subtilis* and *Metabacterium polyspora* **10**

Overview of archaeal cell and model organisms: General characteristics of archaea; how archea are different from eubacteria; key features of model archaeal organisms:*Halobacterium; Pyrococcus; Sulfolobus;* and *Methanococcus.* **8**

Bacterial genome: Genome organization of *E.coli* and salient features of genomes of *Deinococcus radiodurans, Azotobacter vinelandii, Buchnera sp.,Agrobacterium tumefaciens* and *Epulopiscium sp.* **6**

Bacterial secretion system: Introduction; Sec secretion pathway; SecB secretion pathway; SRP pathway; Tat pathway; Type I, Type II, Type III (T3SS; injectisome, injectosome), Type IV, Type V, Type VI; Sec A2, Sortases and Type VII secretion systems. **10**

Quorum sensing: Discovery; Role in as illustrated by bioluminescence (*Vibrio fischeri, Vibrio harveyi*); virulence (*Pseudomonas aeruginosa, Staphylococcus*); competence and sporulation (*Bacillus subtilis*) and antibiotic resistance in bacteria. Quorum quenching: impact and mechanism. **8**

Course Outcomes:

The student:

CO1. Gets acquainted with the general morphology of bacteria and is conversant with the arrangement of bacterial cells.

CO2. Is familiar with the basic differences in Gram-positive and Gram-negative cell structure and knows the detailed structure of Gram-negative and Gram-positive cell walls.

CO3. Is aware of the arrangement, basic structure and locomotive function of flagella.

CO4. Is able to distinguish between pili and fimbriae based on their structure, function and occurrence in bacteria and is aware of the composition and role of extracellular capsule and glycocalyx of bacteria.

CO5. Is conversant with cell wall synthesis and its inhibitors that can be useful in anti-bacterial therapy and also has knowledge about the structure and function of outer membrane LPS of gram-negative bacteria.

CO6. Knows about the significance and generation of protoplasts, spheroplasts and L-forms.

CO7. Knows the types and function of cytoskeletal elements of bacteria.

CO8. Is conversant with the types of cell division in bacteria and is aware of the series of events that occur during binary fission including maintenance and disassembly of Z ring.

CO9. Has knowledge about structure and development of endospores.

CO10. Is familiar with general characteristics of archaea and specific key features of model archaeal organisms.

CO11. Is able to enlist the basic differences in adaptations of *Halobacterium, Pyrococcus, Sulfolobus and Methanococcus.*

CO12. Is acquainted with genome organization of *E. coli* and the salient features of the genome organization in *Deinococcus radiodurans* that allow it to survive in harsh environments.

CO13. Is aware of mechanisms of secretion that exist in bacteria and can differentiate between the Sec, SRP and Tat secretion pathway.

CO14. Is familiar with the Type I secretion system and its role in bacterial secretion.

CO15. Is conversant with the assembly and functioning of Type II secretion system.

CO16. Is conversant with the T3SS, injectisome and injectosome.

CO17. Is aware of Type IV, Type V, Type VI and Type VII secretion systems.

CO18. Is acquainted with bacterial sortases.

CO19. Has in-depth knowledge about quorum sensing in bacteria.

CO20. Is aware of historical developments that lead to the present day understanding of quorum sensing.

CO21. Knows how quorum sensing is responsible for bioluminescence in *Vibrio* sp.

CO22. Has knowledge about the role and mechanism of quorum sensing in virulence of *Pseudomonas* and *Staphylococcus.*

CO23. Is acquainted with involvement of quorum-mediated crosstalk in competence, sporulation and antibiotic resistance in bacteria.

CO24. Knows about quorum quenching, its impact and mechanism.

CO25. Is able to employ principles of quorum quenching as useful antimicrobial tools.

Suggested reading:

1. Prescott's Microbiology by J. Willey, L. Sherwood and C. J. Woolverton. 10th edition. McGraw Hill Education. 2017.

2. Brock Biology of Microorganisms by M. Madigan, K. Bender, D. Buckley, W. Sattley, D. Stahl. 15th Edition. Pearson Education. 2018.

3. Alcamo's Fundamentals of Microbiology by J. C. Pommerville. 10th Edition. Jones and Bartlett Learning. 2013.

4. General Microbiology by R. Stanier, J. Ingraham, M. Wheelis, R.Painter. 5th edition. Macmillan, Hampshire & London Publishers. 1992.

5. Microbiology by M. Pelczar, E. Chan & R. Reid. 4th Edition. McGraw Hill Education. 1998

MICROB 0702

MICROBIAL PHYSIOLOGY AND METABOLISM
(4 credits)

Growth and cell division: Measurement of growth, growth physiology, cell division, growth yields, growth kinetics, steady state growth and continuous growth. **8**

Solute Transport: Introduction; Primary and Secondary transport; Kinetics; Membrane transport protein- Porins and aquaporins, mechanosensitive channels; ABC transporter; Group translocation PEP-PTS system; catabolite repression; inducer exclusion and inducer expulsion. **8**

Central Metabolic Pathways and Regulation: Glycolysis and its regulation; Gluconeogenesis; Pentose-Phosphate Pathway; Entner-Doudoroff Pathway; Citric Acid Cycle; alternate TCA; Glyoxylate Pathway and its regulation. Examples of pathway engineering of carbon metabolic pathways to develop industrial useful strains: Co-metabolism of pentoses and hexoses; Succinic and citric acid production. **10**

Nitrogen metabolism: Inorganic Nitrogen assimilation- nitrate and ammonia assimilation; Regulation of glutamate synthetase; General reaction of amino acid and Stickland reaction; Glutathione – Distribution in Bacteria; Biosynthesis and role in redox regulation; Outline of amino acid biosynthesis; protein utilization; detail account on biochemistry of glutamate producing strains. **8**

Enzymes: Introduction, activation energy, enzyme kinetics, significance of K_m, catalytic efficiency, turnover number. Methods of plotting enzyme kinetics data: Lineweaver – Burk plot, saturation kinetics. Enzyme inhibition, models and type of inhibition. **8**

Metabolism of lipids: Biosynthesis and degradation of lipids and its regulation in *E. coli*; Lipid accumulation in yeast. **6**

Metabolism of nucleotides: Purine and pyrimidine biosynthesis; deoxyribonucleotide synthesis; regulation of purine and pyrimidine biosynthesis; inhibitors of nucleotide biosynthesis. **8**

Physiological Adaptation and Intracellular signalling: Introduction to two component system; response to physiological stress: aerobic-anaerobic shifts- Arc and Fnr system; osmotic homeostasis; response to nutritional stress: phosphate supply- Pho regulon; and stringent response. **8**

Course Outcomes:

The student:

CO1. Is acquainted with the various ways to measure microbial growth.
CO2. Is conversant with microbial growth physiology and cell division.
CO3. Is familiar with calculations of growth yields and kinetic parameters of growth and

is acquainted with steady state and continuous growth.

CO4. Is aware of solute transport in bacteria, primary and secondary transport of solutes across bacterial cell membranes.

CO5. Can calculate kinetics of solute transport.

CO6. Is conversant with membrane transport proteins- porins, aquaporins, mechanosensitive channels and ABC transporters.

CO7. Has knowledge about group translocation via the PEP-PTS system.

CO8. Knows about catabolite repression, inducer exclusion and inducer expulsion.

CO9. Is acquainted with the central metabolic pathways for carbon metabolism including glycolysis, pentose-phosphate pathway and Entner-Doudoroff pathway and is familiar with the regulation of the various metabolic pathways.

CO10. Is conversant with the citric acid cycle and aware of the alternate TCA and Glyoxylate pathway.

CO11. Is acquainted with gluconeogenesis and its regulation in bacteria.

CO12. Is able to predict the ways and outcomes of pathway engineering of carbon metabolic pathways to develop industrially useful strains.

CO13. Is acquainted with inorganic nitrogen assimilation and regulation of glutamate synthetase.

CO14. Knows about the central reaction of amino acids and Stickland reaction.

CO15. Is aware of central distribution of glutathione in bacteria and is familiar with the biosynthesis and role of glutathione in regulation of cellular redox.

CO16. Is conversant with the outline of amino acid biosynthesis and conversant with protein utilization by bacteria.

CO17. Knows the biochemistry of glutamate overproducing strains.

CO18. Is acquainted with biosynthesis and degradation of lipids in *E. coli* and has in-depth knowledge about regulation of lipid catabolism and anabolism in *E. coli.*

CO19. Knows the basis of lipid accumulation in yeasts.

CO20. Is acquainted with purine and pyrimidine biosynthesis along with biosynthesis of deoxyribonucleotides, knows about the regulation of purine and pyrimidine biosynthesis, inhibitors of nucleotide biosynthesis and their applications.

CO21. Is conversant with intracellular signaling in bacteria and is aware of the two-component system.

CO22. Knows how bacteria respond to physiological stress including aerobic- anaerobic shifts by Arc and Fnr systems.

CO23. Is aware of osmotic homeostasis and is acquainted with bacterial response to nutritional stress including details about the Pho regulon and stringent response.

CO24. Is able to derive and calculate various enzyme kinetic constants.

CO25. Is able to predict mechanisms of enzyme inhibition by various inhibitors.

Suggested reading:

1. Biochemistry by Geoffrey L. Zubay. 4th Edition. Brown Co, USA. 1999.

2. Microbial Physiology by A.G. Moat, J. W. Foster and M. P. Spector. 3rd Edition. John Wiley & Sons. 2002

3. Lehninger Principles of Biochemistry by D. L. Nelson and M. M. Cox. 6th Edition. W. H. Freeman. 2012

4. The Physiology and Biochemistry of Prokaryotes by D. White, J. Drummond, C. Fuqua. 4th Edition. Oxford University Press. 2011.

5. Microbial Biochemistry by G. N. Cohen. 2nd Edition. Springer. 2014.

6. Lippincott's Illustrated Reviews: Biochemistry edited by D. R. Ferrier. 6th Edition. Lippincott Williams & Wilkins. 2013

7. Biochemical Calculations: by Irwin H. Segel. 2nd Edition. Wiley. 2004.

8. Understanding Enzymes by T. Palmer, E.Horwood. 3rd Edition. Wiley. 1991.

MICROB 0703

MOLECULAR VIROLOGY
(4 credits)

Introduction to Virology: The Big Picture of all viruses using a common strategy. Virus classification. The infectious cycle, Studying Virus infection. Koch's Postulates for viruses. **2**

Virus Genome and Genetics: Virus genome types. Double stranded DNA (dsDNA). Gapped DNA genomes. Single-stranded (ssDNA) genomes. Double stranded RNA (dsRNA). Single stranded RNA (ssRNA): (+) strand RNA. Single stranded (+) sense RNA with DNA intermediate. Single stranded RNA (-) sense. Ambisense RNA genomes. **4**

Virus Structure: Metastability, The tools for viral structural biology. Helical Symmetry. Icosahedal symmetry. Triangulation number. Quasi-equivalence. Attachment and Entry. Initiation of infection. Affinity. Avidity. Cellular receptor for viruses. Getting into the Nucleus. Disassembly. **4**

RNA directed RNA synthesis, Reverse Transcription & Integration, Translation: Identification of RNA polymerase. How RNA synthesis occurs in viruses? Reverse transcriptase. Retrovirus genome organization. Steps of DNA synthesis in Retroviruses. Regulation of translation in virus infected cells. **6**

Genomic replication of DNA viruses: Basic rules of genome replication in DNA viruses. Viral origins of DNA replication. Generic steps in Transcription. Host Polymerases. Initiation. Splicing. Alternate splicing. Promoter Structure. Steps in Regulation of transcription. Enhancers. Virus coded transcriptional regulators. Transcriptional cascade. Export. **6**

Virus Assembly: Metastable structures. Concentrating components for assembly. Getting things to the right place. How do Virus make Sub-assemblies. Sequential and Concerted assembly. Packaging signals. Packaging of segmented genome. Acquisition of an envelope. Budding strategies. **2**

Virus Infections basics: Fundamental questions of viral pathogenesis. Virion defenses to hostile environment. Viral spread. Viremia. Determinants of tissue tropism. Virus shedding. Transmission of infection.Host defense.Innate immune response. **6**

Virus Host Interactions: Virus Virulence. Identifying virulence genes. Toxic viral proteins. Cellular virulence genes. Immunopathology. Systemic Inflammatory Response Syndrome. Immune complexes. Virus induced auto-immunity. **2**

Acute & Persistent Infections: General pattern of infection. Inapparent acute infections. Defense against the acute infection. Influenza. Polio. Measles. Rotavirus. Persistent Infections. Chronic vs. Latent Infection. **6**

Vaccines & Anti-Viral drugs: Herd Immunity. Requirement of an effective vaccine. Different ways of making vaccine. Inactivated vaccine. Subunit vaccines. Subunit vaccines. Live attenuated vaccines. Polio eradication. Anti-Viral drugs. Search for anti-viral drugs. The path for drug discovery. Mechanism based screens. Cell based screen. Antiviral screening. Resistance to antiviral drugs. **6**

Virus Evolution&Emerging Viruses: Main drivers of virus evolution. The qusispecies concept. Error threshold. Genetic bottlenecks. Muller ratchet. Genetic shift and drift. Theories on origin of Virus. Evolution of new viruses. Emerging Viruses. Factors that drive viral emergence. Evolving host-virus relationship. **6**

Unusual Infectious Agent: Viroids. Origin of viroids. Satellites. Prions. Transmissible spongiform encephalopathy (TSE) caused by prions. Prion hypothesis. Prion species barrier. **2**

Viral Cancer, Transformation and Oncogenesis: Virus induced cancer. Avian leucosis retroviruses. Proviral DNA sequences. Proto-oncogenes. DNA tumor Viruses. The link between DNA virus biology and transformation. **6**

Virus Evasion strategies: Strategies for evasion, Translational regulation, Innate defence targets, Viral modulators of interferon, Autophagy, Apoptosis, Apoptotic pathway and viruses, Immune modulation, Immune modulation strategies. **4**

Investigation of a virus outbreak: Case study of health risk associated with a virus epidemic. The origin of outbreak, the spread, the intervention strategies, public health response. **2**

Course Outcomes:

CO1. Student is able to describe the defining viral attributes, the general properties of viruses, and steps in virus infection cycle.
CO2. Student is able to describe the principle of virus classification, list the virus families, and describe methods of study virus infection.
CO3. Student is able to give a general overview of viral genomes and their types
CO4. Student is able to describe methods of studying virus structure, details of virus structure, and the concepts of metastability, quasi-equivalence and triangulation number.
CO5. Student is able to describe the basis of virus attachment and entry in host cells, receptors for viruses, cellular intake mechanisms, co-receptors, and virus disassembly.
CO6. Student is able to describe replication strategies used by DNA viruses; viral origins of DNA replication, problem in winding and unwinding of DNA, problems in replication
CO7. Student is able to describe steps in transcription: initiation, splicing, virus coded transcriptional regulators, transcriptional cascade in DNA viruses
CO8. Student is able to describe replication strategies used by RNA viruses; universal rules for RNA directed RNA synthesis, translation, mRNA structure and translational machinery, maximizing the coding capacity of the viral genome,

regulation of translation in virus infected cells.

CO9. Student is able to describe replication strategies used by retroviruses, retrovirus genome organization, steps of DNA synthesis in Retroviruses, overview of integration process, retro-elements.

CO10. Student is able to describe virus assembly reactions, packaging signals, and budding strategies

CO11. Student is able to describe fundamental questions of virus infection in host, determinants of tissue tropism.

CO12. Student is able to describe host defense against virus infection

CO13. Student is able to describe general characteristics of acute viral infections, pathogenesis of Influenza virus, Polio virus, Measles virus, and Rotavirus infection.

CO14. Student is able to describe general characteristics of chronic, persistent, latent infections, pathogenesis of Papillomavirus infections, EBV infection.

CO15. Student is able to describe how live viral vaccines are made, how inactivated viral vaccines are made, Polio vaccine and story of polio eradication.

CO16. Student is able to describe antiviral drug discovery process, mechanism of drug resistance.

CO17. Student is able to describe concepts in virus evolution, virus quasi-species

CO18. Student is able to describe basis of emergence of novel virus, Emerging Viruses

CO19. Student is able to describe Viroids, Satellites

CO20. Student is able to describe Prions,Transmissible spongiform encephalopathies (TSE) caused by prions

CO21. Student is able to describe transformation of infected cells by DNA viruses

CO22. Student is able to describe transformation of infected cells by RNA viruses, virus mediated tumorigenesis and oncogenesis

CO23. Student is able to describe strategies for virus evasion from host defense.

CO24. Student is able to describe viral modulators of interferon, autophagy, apoptosis

CO25. Student is able to describe health risk associated with a virus epidemic using a case study

Suggested reading:

1. Principles of Virology: Molecular Biology, Pathogenesis and Control of Animal Viruses by S.J. Flint, L.W. Enquist, V.R. Racaniello, and A.M. Skalka. 2nd edition. ASM Press. 2004.
2. Introduction to Modern Virology EPZ by N. Dimmock, A. Easton and K. Leppard. 5thedition. Blackwell Publishing. 2005.
3. Basic Virology by Edward K. Wanger, M. Hewiett, D. Bloom and D. Camerini. 3rdedition. Blackwell Publishing. 2007.
4. Principles of Molecular Virology by A.J. Cann. 3rdedition. Elsevier Academic Press. 2001.

MICROB 0704

IMMUNOLOGY
(4 credits)

Three fundamental concepts in immunology: Specificity, discrimination of self from non-self and memory. **8**

Immune cell receptors: Detailed structure and development of B cell (Ig) and T cell (TcR) receptors; Structure of CD4, CD8, MHC-I, MHC-II molecules, cellular adhesion molecules (ICAM, VCAM, selectins, integrins); Pattern Recognition Receptors (PRRs) and Toll-like receptors (TLR); Markers of suppressor / regulatory cells - $CD4^+$ $CD25^+$ $Foxp3^+$ T_{reg} , iNKT. **12**

Genetic organization: Organization of the genes for B and T cell receptors. Genetic organization of MHC-I and MHC-II complex (both HLA and H-2). Molecular mechanisms responsible for generating diversity of antibodies and T cell receptors. Peptide loading and expression of MHC-I and MHC-II molecules; Hybridoma technology and monoclonal antibodies, antibody engineering including bispecific antibodies. **12**

Immune response and signaling: Humoral and cell-mediated immune response; Innate immune response and pattern recognition; Recent advances in innate immune response especially NK-DC interactions; Important cytokines and their role in immune mechanisms: TNF, IFN-γ, IL-1, IL-2, IL-4, 1L-6, 1L-12, IL-17, TGFβ; Cell signaling through MAP kinases and NF-κB. **8**

Tolerance and autoimmunity: Central and peripheral tolerance, and their mechanism; Mechanisms of autoimmunity; Immune checkpoints, Autoimmune components of diabetes mellitus (DM), multiple sclerosis (MS), pernicious anemia; Infections leading to autoimmune diseases. **8**

Immunological disorders and hypersensitivity: Deficiencies / defects of T cells, B cells, and phagocytic cells; Comparative study of Type I-V hypersensitivities with examples. **8**

Transplantation and tumor immunology: Alloreactive response; Graft rejection and GVHD; HLA-matching; Use of CRISPR-Cas for generating transgenic animals for xenotransplantation; Tumor antigens, immune response to tumors and immunotherapy of tumors. **8**

Course Outcomes:

CO1. Student is able to describe the fundamental concept in immunology namely specificity, discrimination of self from non-self and immunological memory

CO2. Student is able to describe detailed structure of important cells of the immune system namely B cells receptors, T cell receptors,CD4 and CD8 molecules,MHC-I and MHC-II molecules

CO3.Student is able to describe detailed structure of pattern recognition receptors,toll like receptors, suppressor and regulatory cells andCD4+, CD25+, Foxp3+, Treg, iNKT cells.

CO4. Student is able to describe genetic organization of genes for B cell receptors

CO5. Student is able to describe genetic organization of genes for T cell receptors

CO6. Student is able to describe genetic organization of genes for MHC-I and MHC-II Complex

CO7. Student is able to describe molecular mechanisms responsible for generating diversity of antibodies and T cell receptors

CO8. Student is able to describe peptide loading and expression of MHC-I and MHC-II molecules

CO9. Student is able to describe hybridoma technology and production of monoclonal antibodies

CO10. Student is able to describe antibody engineering

CO11. Student is able to describe immune response and signaling

CO12. Student is able to describe humoral immune response

CO13. Student is able to describe cell mediated immune response

CO14. Student is able to describe innate immune response by pattern recognition

CO15. Student is able to describe NK-DC interactions

CO16. Student is able to describe major cytokines and their role in immune mechanisms

CO17. Student is able to describe role of TNF-IFN, IL-1, IL-2 in immune mechanisms

CO18. Student is able to describe role of IL-4, IL-6, IL-10, IL-12, IL-17 and TGFβ in immune mechanisms

CO19. Student is able to describe cell signaling through MAP kinases and NF-kB

CO20. Student is able to describe tolerance and autoimmunity, central and peripheral tolerance and their mechanisms

CO21. Student is able to describe autoimmune components of diabetes mellitus, multiple sclerosis, experimental autoimmune encephalitis and infections leading to autoimmune disease.

CO22. Student is able to describe immunological disorders and hypersensitivity, deficiencies and defects of T cells and B cells, deficiencies and defects of complement and phagocytic cells

CO23. Student is able to describe comparative study of Type IV hypersensitivities with examples

CO24. Student is able to describe transplantation immunology, alloreactive response, graft rejection and GVHD, HLA matching and transgenic animals for xenotransplantation

CO25. Student is able to describe tumor antigens, immune response to tumors and

immunotherapy of tumors

Suggested reading:

1. Kuby Immunology by J.A. Owen, J. Punt , S.A. Stranford. 7th edition. WH Freeman. 2013.

2. Cellular and Molecular Immunology by A.K. Abbas, A.H. Lichtman, S. Pillai. 9th edition. Saunders Elsevier. 2018.

3. Janeway's Immunobiology by K. Murphy and W. Casey. 9th edition. Garland Science Publishing. 2017.

4. Review of Medical Microbiology and Immunology by W.Levinson. 15thedition.Lange Publication. 2018.

5. Fundamental Immunology by W.E. Paul. 7th edition. Lippincott Williams and Wilkins. 2013.

6. Roitt's Essential Immunology by P.J. Delves, S.J. Martin, D.R. Burton, I.M. Roitt. 13th edition. Blackwell Publishing. 2017.

MICROB 0705

PRACTICAL I

(8 credits)

1. Handling and upkeep of micropipette for measuring small volumes
2. Principles of sterilization techniques and their application in microbiology lab
3. Working with a biosafety cabinet in a BSL2.5 lab
4. Culturing of eukaryotic cells of epithelial and lymphoid origins
5. Counting and passaging of eukaryotic cells of epithelial and lymphoid origins
6. Principles and techniques of freezing and thawing of eukaryotic cells for long term storage
7. Fluorescent microscopy for live/ fixed cell imaging
8. To purify and identify the given bacterial sample by determining their:- Colony morphology, staining characteristics and biochemical characteristics
9. To perform DNA extraction of the given bacterial culture and to carry out PCR amplification of the isolated DNA using universal 16S rRNA gene primers.
10. To analyze the given 16srRNA sequences by using BLAST and construct a phylogenetic tree based on the comparison results.
11. To determine the G+C content by determining the melting temperature (Tm) of the DNA of given microbial culture.
12. To draw the titration curve of amino acid and determine its pI.
13. To study glucose uptake by *E.coli*.
14. To prepare standard curve of BSA and determine the concentration of unknown protein sample using Bradford method using regression equation.
15. To separate amino acids, sugars and lipids using Thin Layer Chromatography (TLC)
16. To prepare standard curve of ammonia and determine its uptake by bacterial cells with respect to time and temperature
17. To determine the specific growth rate of E.coli in different media.
18. To study the diauxie growth curve of E.coli in media containing glucose and lactose and perform β-galactosidase assay.
19. To determine activity and specific activity of the enzyme sample provided.
20. To study the pH optima, pH stability, temperature optima and temperature stability of the given enzyme sample and to calculate inactivation constant (Kd) and $t_{1/2}$ of the enzyme reaction.
21. To determine K_m, V_{max} and K_{cat} of a purified enzyme.
22. To calculate activation energy (Ea) of the given enzyme sample using Arrhenius plot.

23. To perform immunoelectrophoresis.
24. To perform radial immunodiffusion assay.
25. To perform rocket immunoelectrophoresis.
26. To stain a tissue by immunohistochemical reaction
27. To study quantitative precipitation assay
28. To perform dot-ELISA.
29. To perform latex agglutination test
30. To perform western blotting.
31. To study morphological and staining characteristics of lymphocytes, neutrophils, monocytes, eosinophils, and basophils.

Course Outcomes:

The Student:

CO1. Is able to use different sterilization procedures and learn handling of micropipette.
CO2. Is able to handle Biosafety Cabinet for culturing cells, virus infection and study of viral cytopathic effects.
CO3. Can use Fluorescence Microscopy for live cell imaging and intracellular localization of viral proteins in different sub-cellular compartments.
CO4. Is versed with identification and classification of given bacterial isolate by performing variety of cultural, biochemical and molecular tests. Is able to construct phylogenetic tree using bioinformatic techniques.
CO5. Can determine pI of amino acids by titration method
CO6. Is able to determine concentration of sugar and protein in a given sample after drawing a standard curve. Is able to study glucose uptake by *E.coli.*
CO7. Is able to perform TLC for separating a mixture of amino acids, lipids, and sugars.
CO8. Is able to study ammonium uptake by *E.coli*.
CO9. Is able to determine specific growth rate of *E.coli* in different media.
CO10. Can draw a diauxic growth curve in lactose and glucose medium and learn to perform β-galactosidase assay.
CO11. Understands the techniques of enzyme assay to determine its specific activity, pH optima, pH stability, temperature optima and temperature stability and calculate inactivation constant (Kd) and $t_{1/2}$ of the enzyme reaction based on the temperature stability curve.
CO12. Can determine K_m, V_{max} and K_{cat} of a purified enzyme and determine its activation energy by plotting Arrhenius curve.
CO13. Is able to perform immunoelectrophoresis, immunodiffusion assay.

CO14. Is able to perform rocket immunoelectrophoresis.
CO15. Is able to stain a tissue by immunohistochemical reaction
CO16. Is able to perform quantitative precipitation assay
CO17. Is able to perform dot-ELISA.
CO18. Is able to perform latex agglutination test
CO19. Is able to perform western blotting.
CO20. Can differentiate lymphocytes, neutrophils, monocytes, eosinophils, and basophils based on morphological and staining characteristics.

Suggested Reading:

1. Microbiology: A laboratory manual by JG Cappucino and C.T. Welsh. 11th edition. Pearson. 2017.

2. Biochemistry Lab Manual by D.A. Thompson. 3rd edition. CreateSpace Independent Publishing Platform. 2013.

3. Biochemical calculations: how to solve mathematical problems in general biochemistry by Irwin H. Segel, Wiley, 2nd Edition 2004.

MICROB 0801

ENVIRONMENTAL MICROBIOLOGY
(4 credits)

Development in field of environmental microbiology: Development of microbial ecologyand emergence of field of environmental microbiology,significant applications of microbes in solving environmental pollution problems **6**

Culture-dependent and culture-independent approaches for understanding microbial diversity in the environment: Understanding microbial diversity in the environment by culture-dependent and culture-independent approaches, Analysis by FAME, measuring metabolic capabilities using BIOLOG, G+C analysis, slot-blot hybridization of community DNA,and fluorescent *in situ* hybridization of intact cells, Metagenomic analysis of solid and aquatic sediments **10**

Microbial diversity in extreme environments: Occurrence, diversity, adaptations and potential applications ofoligotrophs, thermophiles, psychrophiles, organic solvent and radiation tolerants, metallophiles,acidophiles, alkaliphiles and halophiles, Biotechnological applications. **6**

Soil and water microbiology: Importance of soil microorganisms, nutrient transformation processes, plant-microbe symbiosis, microbial antagonism, biofilms and their biotechnological applications, drinking water microbiology and quality control. **8**

Biomass waste management of plant's residues: Lignocellulolytic microorganisms, enzymes and their biotechnological applications in: (i) biopulping, (ii) biobleaching, (iii) textiles (iv) biofules, (v) animal feed production. **4**

Liquid waste management: Treatment of sewage (Primary, Secondary and Tertiary treatments), Treatment of Industrial effluents (distillery, textile, pulp and paper), methods to detect various pollutants (metals, sediments, toxin and organic matters) **8**

Solid waste management: Solid waste types, composting, landfill development, incineration methods, composting and sustainable agriculture,plastic degrading microorganisms as a tool for bioremediation, challenges in waste management **6**

Bioremediation of environmental pollutants: Petroleum hydrocarbons and pesticides, use of biosensors for their detection. **8**

Microbes in oil and mineral recovery: Microbial enhanced oil recovery, Bioleaching of copper, gold and uranium, electronic waste management. **8**

Course Outcomes:

The student:

CO1. Is aware of developments in the field of environmental microbiology and microbial ecology.
CO2. Gains knowledge about significant applications of microbes in solving environmental pollution problems.
CO3. Understands microbial diversity in the environment by culture-dependent and culture-independent approaches.
CO4. Learn various techniques for analysis of microbial diversity in environment such as FAME, BIOLOG, G+C content,slot-blot and fluorescent in situ hybridization
CO5. Learns about metagenomic analysis of solid and aquatic sediments.
CO6. Gets thorough with the occurrence, diversity and adaptations of oligotrophs, thermophiles and psychrophiles.
CO7.Gains knowledge about organic solvent and radiation tolerants, metallophiles,acidophiles, alkaliphiles and halophiles.
CO8. Studies various potential applications of extremophilic organisms.
CO9. Gets acquainted with importance of microorganisms of soil, their involvement in various nutrient transformation processes and their biotechnological applications.
CO10. Learns plant-microbe symbiosis, microbial antagonism and biofilm formation by microbes.
CO11.Knows about potability of water and its quality control.
CO12.Understands biomass waste management of plant's residues involving lignocellulolytic microorganisms.
CO13. Learns biotechnological applications of lignin and cellulose degrading microbes and their enzymes in biopulping, biobleaching, textiles, biofuels and animal feed production.
CO14.Gains knowledge about liquid waste management of sewage including primary, secondary and tertiary treatments methods.
CO15.Learns about treatment of Industrial effluents of generated from various industries such as distillery, textile, pulp and paper.
CO16. Becomes well versed with methods to detect various pollutants in environment such as metals, sediments, toxins and organic matter.
CO17. Is able to know different types of solid wastes.
CO18. Gets knowledge of methods of solid waste management such as composting, landfills and incineration methods and challenges in waste management.
CO19. Knows how to use compost for sustainable agriculture.
CO20.Understands Bioremediation of environmental pollutants like petroleum hydrocarbons and pesticides.
CO21. Becomes acquainted with the use of biosensors as detection tools of pollutants.
CO22. Learns about plastic degrading microorganism as a tool for bioremediation.
CO23. Gets familiar with microbes in enhanced oil recovery and mineral recovery.
CO24. Gains knowledge of the use of microbes in bioleaching of copper, gold and uranium.
CO25. Knows about electronic waste management.

Suggested reading:

1. Microbial Ecology by R.M. Atlas and R. Bartha. 3rd edition. Benjamin Cummings Publishing Co, USA. 1993.

2. Environmental Microbiology by A.H. Varnam and M.G. Evans. Manson Publishing Ltd. 2000.

3. Manual of Environmental Microbiology edited by C.J. Hurst, R.L. Crawford, J.L. Garland, D.A. Lipson, A. L. Mills and L.D. Stetzenbach. 3rd edition. Blackwell Publishing. 2007.

4. Environmental Microbiology by W.D. Grant and P.E. Long. Kluwer Academic Publishers. 1981.

5. Environmental Microbiology edited by R. Mitchel and J-D Gu. 2nd edition. Wiley-Blackwell. 2009.

6. Microbiology: An environmental Perspective by P. Edmonds. Macmillan, New York. 1978.

7. Environmental Microbiology by R. Maier, I. Pepper and C. Gerba. 2nd edition. Academic Press. 2009.

8. Environmental Microbiology: Principles And Applications by P.K. Jjemba, Science Publishing Inc. 2004.

9. Lignocellulose Biotechnology: Future Prospects by R.C. Kuhad and A. Singh. I.K. International. 2007.

10. Applied Bioremediation and Phytoremediation by A. Singh and O.P.Ward. Springer. 2004.

11. Microbial and Enzymatic Degradation of Wood and Wood components by K-E.L. Eriksson, R.A. Blanchettee and P. Ander. Springer. 1990.

12. Advances in Applied Bioremediation by A. Singh, R.C. Kuhad and O.P. Ward. Springer. 2009.

13. Environmental Microbiology of Aquatic & Waste systems by N. Okafor. 1st edition,.Springer, New York. 2011.

14. Microbial Ecology by L.L. Barton and D.E. Northup. 1st edition. Wiley Blackwell. 2011

MICROB 0802

INDUSTRIAL MICROBIOLOGY
(4 credits)

Introduction to industrial microbiology: Introduction to microbial products and fermentation processes, sources of industrially important microorganisms, stoichiometric analysis of biochemical reactions, carbon and nitrogen balance, oxidation-reduction principle in fermentation, recent developments in fermentation technology. **4**

Microbial growth kinetics: Batch cultivation, continuous cultivation, multistage chemostat, feedback systems, types of fed-batch cultures, open and closed systems, Monod kinetics of microbial growth, growth and non-growth associated product formation, product formation kinetics and mathematical modeling, bioprocess optimization strategies (exponential fed-batch, DOstat, pHstat) **10**

Sterilization methods and principles: Media sterilization, mathematical modeling of sterilization processes, Arrhenius equation, Del factor, effect of sterilization on media quality and yield coefficients, batch and continuous sterilization, *filter and steam sterilization at industrial scale* **6**

Designing of industrial Strains and media optimization: Industrially important microorganisms, preservation techniques for microbial cultures, inoculum development, microbial strain improvement, high throughput screening methods, recombinant DNA technology in strain improvement, metabolic engineering and flux analysis, media optimization strategies likePlackett–Burman Design, Box-Wilson central composite design,response surface methodology **6**

Design and types of fermenters: Basiccomponents of a fermenter, fermenter construction materials, designing of laboratory and industrial scale fermenters, types of impellers, mechanical seal, types of baffle and spargers, sampler design, foam controller, types of fermenter like stirred tank, bubble column*,Airlift, hollow fibers chambers, p*acked beds, fluidized beds, perfusion cultures, photo-bioreactorsand animal cell culture bioreactor. **8**

Bioprocess instrumentation and control parameters: Measurement of various control parameter in bioreactor like pH, dissolved oxygen, temperature, antifoam, principles of feed-back control, PID control,*respiratory quotient,*effect of dissolved Oxygen on microbial production processes, effect of foam and anti-foam on oxygen transfer,oxygen mass transfer coefficient, measurement of KLa values using sulfite oxidation techniques, gassing-out techniques, fluid rheology, newtonian and non-newtonian fluids,bingham plastic, pseudo plastic, power number, Reynolds number **6**

Downstream processing of microbial products: Batch filtration,centrifugation, cell disruption, liquid-liquid extraction, solvent recovery**,**supercritical fluid extraction,various chromatography techniques in product recovery, diafiltration,ultra-filtration and reverse osmosis, drying (lyophilization and spray drying), whole broth processing and crystallization. **8**

Applications of industrial microbiology/Production aspects: Development of heterologous expression platforms like bacteria, yeast, mammalian and insect cells, process optimization of recombinant biopharmaceuticals; industrial enzymes (cellulases, laccase, amylases, biosurfactants,thaumatin, food additives etc.), therapeutic proteins (haemostasis factors, thrombolytic agents, hormones and recombinant vaccines), antibodies (chimaeric and humanized antibodies, antibody fragments), microbial transformation process,cell surface display technology, development of biosimilars, good manufacturing practices, intellectual property rights and technology transfer, different phases of clinical trials of therapeutic biomolecules**12**

Fermentation economics: Basic objective for successful economically viable fermentation process, cost breakdown for well-established fermentation processes, market potential of the products, cost aspects of various stages inthe processes development including effluent treatment **4**

Course Outcomes:

The student

CO1. Is able to understand the importance of industrially important organism and the fermentation processes involved in the production of various microbial products with focus on the current trends in fermentation technology.

CO2. Is able to differentiate between batch, fed-batch and continuous cultivation systems and their optimization strategies.

CO3. Understands the concept of growth and non-growth associated product formation and Monod kinetics of microbial growth.

CO4. Learns the importance and principles of sterilization, mathematical modelling of sterilization processes and the effect of sterilization on media quality and yield coefficients.

CO5. Is able to differentiate between batch and continuous sterilization.

CO6. Gains insight on industrially important microbes and their preservation, inoculum development and techniques involved in the development of industrially relevant strains including recombinant DNA technology.

CO7. Attains knowledge about media optimization strategies like response surface methodology, Plackett–Burman Design, Box-Wilson central composite design.

CO8. Is able to differentiate between the design of a laboratory and industrial scale fermenter as well the different types of fermenters like stirred tank, bubble column, airlift, hollow fibers chambers, packed beds, fluidized beds, perfusion cultures, photo-bioreactors and animal cell culture bioreactor.

CO9. Acquires the information on the basic components of a fermenter such as impellers, baffles, spargers, foam controllers and their design and construction.

CO10. Gets introduced to the methods of measurement of various bioreactor control

parameters like pH, dissolved oxygen, temperature, antifoam.

CO11. Is able to understand the concept of PID control and respiratory quotient.

CO12. Gathers information on the effect of dissolved oxygen on microbial production processes.

CO13. Is able to clearly understand the effect of foam and anti-foam on oxygen transfer and oxygen mass transfer coefficient (KLa) and various techniques of measuring KLa.

CO14. Attains knowledge and is able to differentiate between upstream and downstream processing of microbial products.

CO15. Understands various downstream processing techniques for filtration, cell disruption, liquid-liquid extraction, solvent recovery, supercritical fluid extraction, various chromatography techniques in product recovery, diafiltration, ultra-filtration and reverse osmosis, drying (lyophilization and spray drying), whole broth processing and crystallization.

CO16. Acquires knowledge of the different heterologous expression platforms like bacteria, yeast, mammalian and insect cells.

CO17. Understands process optimizationinvolved in the development of recombinant biopharmaceuticals, industrial enzymes, therapeutic proteins and antibodies.

CO18. Gathers information on microbial transformation processes, cell surface display technology and development of biosimilars.

CO19. Understands the importance and concept of good manufacturing practices in the development of microbial products.

CO20. Learns about the different phases of clinical trials involved in testing of therapeutic biomolecules.

CO21. Is able to understand the concept of intellectual property rights and technology transfer during product development.

CO22. Learns about the importance of fermentation economics involved in the development of an economically viable bioprocess.

CO23. Is able to analyse cost breakdown of well-established fermentation processes and cost aspects of various stages of process development.

CO24. Understand about the market potential of industrial products.

CO25. Is able to set up a batch fermentation for the production of a given recombinant protein.

Suggested reading:

1. Principles of Fermentation Technology by P. Stanbury, A. Whitaker, S. Hall. 3rd edition. Butterworth-Heinemann. 2016.

2. Bioprocess Engineering: Basic Concepts by M. L. Shuler and F. Kargi, 2nd edition. Pearson Education India. 2015.

3. Modern Industrial Microbiology & Biotechnology by N. Okafor. 1st edition. CRC Press, USA. 2007.

4. Fermentation Microbiology and Biotechnology edited by E.M.T. El-Mansi, C.F. Bryce, A.L. Demain and A.R. Allman. 3rd edition. CRC Press. 2012.

5. Microbial Biotechnology: Fundamentals of Applied Microbiology by A.N. Glazer and H. Nikaido. 2nd edition. Cambridge University Press. 2007.

6. Pharmaceutical Biotechnology: Concepts and Applications by G. Walsh. John Wiley & Sons Ltd. 2007.

7. Pharmaceutical Biotechnology: Fundamentals and Applications by J.A.D. Crommelin, R. D. Sindelar, and B. Meibohm. 4thEdition. Springer. 2013.

MICROB 0803

MICROBIAL PATHOGENICITY
(4 credits)

Classical view of microbial pathogenicity: Define pathogenicity and virulence; Quantitative measures of pathogenicity: minimal lethal dose (MLD), LD_{50}, ID_{50}, $TCID_{50}$. Virulence determinants: colonization, toxins, enzymes and invasiveness. Facultative / obligate intracellular pathogens. **10**

Molecular microbial pathogenicity: Molecular Koch's postulates, multiplicity of virulence determinants, coordinated regulation of virulence genes, and environmental regulation of virulence determinants by two component signal transudation systems, antigenic variation; clonal and panmictic nature of microbial pathogens, type three secretion system (TTSS, T3SS), Role of biofilms and quorum sensing in microbial pathogenecity. **10**

Emerging and re-emerging pathogens: Illustrate emerging and re-emerging pathogens using *V. cholerae* 0139, X-MDR *M. tuberculosis, Helicobacter pylori,* Enterohaemorrhagic *E. coli* (EHEC), *Cryptosoridiumparvum*, Bird/swine flu, AIDS and Dengue Hemorrhagic Fever, opportunistic fungal pathogens. Mechanisms of emergence of new pathogens: horizontal gene transfer (HGT) and pathogenicity islands (PAI). **10**

Molecular microbial epidemiology: Objectives of microbial epidemiology. Biochemical and Immunological tools - biotyping, serotyping, phage typing, multilocus enzyme electrophoresis (MLEE); Molecular typing: RAPD, rep (REP, ERIC, BOX)-PCR, IS based typing, PFGE, AFLP, MLST, VNTR and whole genome sequence; Use of geographical information system (GIS) for microbial epidemiology. **8**

Environmental change and infectious diseases: Global warming lead increase in vector-borne and water-borne infectious diseases; Impact of increasing urbanization, international travel and trade on infectious diseases. **4**

Antimicrobial resistance (AMR) : Recent concepts – Multidrug efflux pumps, extended spectrum β-lactamases (ESBL), X-MDR *M. tuberculosis*, Methacillin-resistant *S. aureus* (MRSA), Role of integrons. **6**

Newer vaccines: Recombinant vaccines, subunit vaccines, DNA vaccines, Vaccinia-BCG- and HIV– vector based vaccines. **6**

Rapid diagnostic principles: Nucleic acid probes in diagnostic microbiology, nucleic acid amplification methods, Real-time PCR, Lateral flow assays, diagnostic sequencing and mutation detection, automated instruments for detection / diagnosis of infectious agents (BACTAC and Vitek-2, GeneExpert). **10**

Course Outcomes:

CO1. Student is able to describe classical view of microbial pathogenicity and is able to differentiate between pathogenicity and virulence including quantitative measures of virulence viz. minimum lethal dose, LD50, ID50, and TCID50
CO2. Student is able to describe virulence determinants – colonization, toxins, enzymes and invasiveness with varied examples from different pathogens
CO3. Student is able to describe facultative or obligate intracellular and describe molecular Koch's postulates
CO4. Student is able to describe multiplicity of virulence factors and coordinated regulation ofvirulence genes
CO5. Student is able to describe two component signal transduction systems and environmental regulation of virulence determinants
CO6. Student is able to describe clonal and panmictic nature of microbial pathogens,1-IV secretion systems, importance of biofilms and quorum sensing
CO7. Student is able to describe emerging and re-emerging pathogens using examples of *V.cholerae, M.tuberculosis*, *H.pylori*, enterohaemorrhagic *E.coli*
CO8. Student is able to describe basis of microbial pathogenicity inSARS virus, Bird flu, prions, AIDS, Dengue Hemorrhagic Fever
CO9. Student is able to describe basis ofmicrobial pathogenicity in Lyme disease, *Cryptosporadium parvum, Chlamydiae* and opportunistic fungal infections.
CO10. Student is able to describe mechanism of emergence of new pathogens by microbial change and adaption, horizontal gene transfer, pathogenicity islands, and the role of integrons in these mechanisms
CO11.Student is able to describe objectives of microbial epidemiology, describe biotyping, serotyping, phage typing
CO12. Student is able to describe various tools of epidemiology viz.FAME, Curie Point, pyMS, protein profiling, multilocus enzyme electrophoresis, molecular typing, RAPD, 16S-23S IGS, ARDRA, different types of PCR, PFGE, AFLP and concepts of MVLST, VNTR, SNP microarray and whole genome sequencing
CO13. Student is able to describe role of environmental change on infectious diseases like global warming lead increase in vector borne infectious disease, role and impact of increasing urbanization and international travel and trade on infectious disease
CO14. Student is able to describe concepts of antimicrobial, multidrug efflux pumps, extended spectrum β-lactamases, X-MDR *M.tuberculosis*, methicillin-resistant *S.aureus*(MRSA)
CO15. Student is able to describe newer vaccines, recombinant vaccines, subunit vaccines, DNA vaccines, vaccinia-, BCG- and HIV- vector based vaccines
CO16. Student is able to describe principles of rapid diagnostic
CO17. Student is able to describe nucleic acid probes in diagnostic microbiology
CO18. Student is able to describe nucleic acid amplification methods diagnostics
CO19. Student is able to describe diagnostic sequencing and mutation detection
CO20. Student is able to describe molecular typing methods for pathogen detection using the array technology for detection of pathogens

Suggested reading:

1. Jawetz, Melnick, & Adelberg's Medical Microbiology by Carroll KC, Hobdon JA, Miller S, Morse SA, Mietzner TA. 27th edition. Lange Publication, 2016.

2. Beginner's guide to comparative genome analysis using next generation sequence data by Edward DJ and Holt KE, Microbial Informatics and Experimentation, 3:2, https://doi.org/10.1186/2042-5783-3-2, 2013.

3. Bacterial Pathogenesis: A molecular approach by Wilson BA, Salyers AA, Whitt DD and Winkler ME. 3rd edition. American Society for Microbiology Press, Washington, DC USA, 2011.

4. Bacterial Pathogenesis: Molecular and Cellular Mechanisms by Locht C and Simonet M, Caister Academic Press, 2012.

5. Molecular Microbiology: Diagnostic Principles and Practice by Persing DH, Tenover FC, Hayden R, Leven M, Miller MB, Nolte FS, Tang YW, Belkum AAV. 3rd edition. Washington, American Society for Microbiology Press, 2016

6. Infectious Disease Epidemiology: Theory and Practice by Nelson KE and Williams CM. 4th edition. Jones and Bartlett, 2019.

MICROB 0804 E1

BIOPHYSICAL AND BIOCHEMICAL METHODS
(4 credits)

Spectroscopy: Various theories exploring the concept of light: Corpuscular theory, Wave theory, Electromagnetic theory, Planck's concept and modern theory. Basic concepts, principles and biological applications of different types of spectroscopy: absorption spectroscopy, fluorescence spectroscopy, phosphorescence, Infrared and Raman spectroscopy, Optical Rotatory Dispersion (ORD), Circular Dichroism (CD). **14**

Microscopy: Basics of microscopy: image formation, magnification, resolution, Biological applications and instrumentation of various kinds of microscopy: Optical Microscopy, Fluorescence, Confocal and Electron Microscopy. **8**

Macromolecular structure determination: Basics of X-ray Crystallography: symmetry, space groups, unit cells, structure factors, reciprocal lattice, Fourier transform, electron density, phase problems and it's solutions, Biological applications and interpretations. Basics of Magnetic resonance spectroscopy: chemical shifts, resonance condition, relaxation studies, coupling and decoupling, biological application and interpretations of Nuclear Magnetic Resonance (NMR) & Electron Spin Resonance (ESR). **16**

Separation Techniques I (Chromatography): Basics principles and applications of various chromatography methods:Partition and Absorption chromatography, gel filtration, ion-exchange and affinity chromatography. Biological applications of HPLC and FPLC. **10**

Separation techniques II (Hydrodynamic methods): Basics of centrifugation based methods:viscosity, diffusion, sedimentation equilibrium, dialysis, solvent fractionation, centrifugation, Biological applications and interpretations of Density Gradient methods, Ultracentrifugation methods.Basics of electrophoresis: electrophoretic mobility and affecting factors, Biological applications and interpretation of different types of electrophoresis: PAGE, gradient gel, Agarose Gel Electrophoresis, 2D Electrophoresis, Dialectrophoresis, iso-electric focussing. **12**

Radioactive methods: Basics of Radioactive isotopes and radioactive decay, sample preparation, counting, Safety precautions during handling, biological applications. **4**

Course Outcomes:

The student:

CO1. Understands the various theories used to explain interaction of light with a given substance .
CO2. Understands the differences between different types of spectroscopic methods.
CO3. Learns about methods to determine concentrations of biological macromolecules

through use of UV absorption spectroscopy.

CO4. Learns to determine the secondary and tertiary structure changes in a given protein though use of CD-spectroscopy.

CO5. Is acquainted with use of fluorescence spectroscopy to monitor the stability of a given protein under different environmental conditions.

CO6. Learns about relationship between wavelength, magnification and resolution in microscopy.

CO7. Gets acquainted with various types of dyes used for fluorescence microscopy.

CO8. Learns the application of electron microscopy to structural biology.

CO9. Understands and correctly interprets the data in research papers discussing a macromolecular crystal structure.

CO10. Learns to appreciate the differences between X-ray diffraction and NMR based methods for macromolecular structure determination.

CO11. Develops an understanding for the common pitfalls in the two macromolecular structure determining techniques.

CO12. Understands the principle and application of chromatography in general.

CO13. Learns the difference between various types of current chromatography methods available.

CO14. Becomes well versed with choosing the most appropriate type of ion-exchange chromatographic method applicable to a given system.

CO15. Has good knowledge of the various types of affinity tags available for purification of proteins produced through heterologous overexpression.

CO16. Should be able to design a multi-step purification protocol for a target protein of interest.

CO17.Gets familiar with different types of hydrodynamics based separation methods.

CO18. Learns about the specific applications of different types of hydrodynamic methods

CO19. Understands the factors affecting the electrophoretic mobility of macromolecules.

CO20. Understands and correctly interprets the protein molecule migration on PAGE under native and SDS conditions.

CO21. Knows about the utility of 2-dimensional electrophoresis in analyzing mixture of proteins.

CO22. Understands the basics of radioactive decay.

CO23. Is well versed with the safety precautions to be used during the use of radioactive substances.

CO24. Has an understanding of the biological applications where radioactive methods necessarily offer an advantage over other techniques.

CO25. Is able to selectively combine various methods learnt to analyze the structure and function of biological macromolecules especially proteins.

Suggested Reading:

1. Fundamentals of Molecular Spectroscopy by Colin Banwell. 4th edition. McGraw Hill.1994.

2. Principles of Fluorescence Spectroscopy by J. Lakowicz and R. Joseph. 2nd edition. Springer.1999.

3. Molecular Fluorescence: principles and Applications by B. Valeur. 2nd edition. Wiley. 2013.

4. NMR – Conformation of Biological Molecules by G. Govil and R.V. Hosur. 1st edition. Springer- Verlag, 2011.

5. Biomolecular crystallography: Principles, practice and application to structural biology by B. Rupp. 1st edition. Garland Science. 2009.

6. Optical methods in Biology by E.M. Slayter. 1st edition. John Wiley. 1970.

7. NMR of proteins and nucleic Acids by K. Wuthrich. 1st edition. Wiley Interscience Publications. 1988.

8. Biophysical chemistry, Part 2: Techniques by C. R. Cantor, P. R. Schimmel. 1st edition. W.H Freeman and Co. 2008.

MICROB 0804 E2

PLANT – PATHOGEN INTERACTION
(4 credits)

Concepts and physiology of plant diseases: Causes of disease, pathogenesis, pathogenesisin relation to environment, effect of microbial infections on plant physiology, photosynthesis, respiration,transpiration, translocation. **10**

Biochemical basis of plant diseases: Enzymes and toxins in plant diseases, phytoalexins. **8**

Some important plant diseases and their etiological studies: Crown gall, symptoms of viral diseases and theircontrol, diseases of some important cereals, vegetables and crops. **10**

Genetical basis of plant diseases: Genetics of host-pathogen interactions, resistance genes, resistance mechanismin plants. **6**

Disease control: Principles of plant disease control, physical and chemical methods of disease control, biocontrol,biocontrol agents - concepts and practices, fungal agents, *Trichoderma* as biocontrol agent, biocontrol agents – uses and practical constraints. **12**

Molecular approach: Molecular diagnosis, transgenic approach for plant protection, futuristic vision of molecular diagnosis, applications and constraints. **10**

Disease forecasting: History and important milestones in disease control, disease forecasting and its relevance in Indian farming. **8**

Course Outcomes:

The student:

CO1. Is able to understand the concept of plant diseases and plant pathogens
CO2. Is able to differentiate between the terms pathogen and pathogenesis with respect to plant diseases
CO3. Is able to understand the role of the environment in pathogenesis
CO4. Is able to explain terms like disease triangle and disease tetrahedron
CO5. Is able to understand and describe the effect of microbial infections on plant physiology
CO6.Is able to understand and describe the effect of microbial infections on photosynthesis carried out by plants
CO7. Is able to understand and describe the effect of microbial infections on plant respiration
CO8. Is able to understand and describe the effect of microbial infections on transpiration
CO9. Is able to understand and describe the effect of microbial infections on

translocation

CO10. 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.Is able to establish and describe the role of microbial toxins in pathogenesis

CO12.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. Is able to analyze the relevance of phytoalexins in disease management

CO14. Is able to critically explain the etiological studies and symptoms of crown gall and its causative agent *Agrobacterium tumefaciens*

CO15. Is able to understand the symptoms of viral diseases and able to describe the etiology of the viral causative agents

CO16.Is able to describe the genetics of host-pathogen interactions during disease establishment

CO17.Is able to analyze the role of resistance genes and resistance mechanisms as part of plant defense mechanisms

CO18.Is able to describe different physical, chemical and biological methods of plant disease control

CO19.Is able to describethe use of fungi as biocontrol agents (mycoparasitism) with focus on *Trichoderma* and describe various commercial preparation of biocontrol agents

CO20.Is able to differentiate between direct, indirect and mixed-path antagonism

CO21.Is able to understand the different molecular diagnostic techniques for identification of plant pathogens e.g. LAMP PCR

CO22. Can analyze the use of transgenic approaches for plant disease management and control

CO23. Is able to assess the relationship between disease control and disease forecasting and can enlist various computer based forecasting programmes

CO24. Is able to critically analyze the relevance of disease forecasting especially in the Indian scenario

CO25.Can identify the structural and microscopic features of different pathogenic fungi like *Candida, Aspergillus* and *Microsporum*sp.

Suggested reading:

1. Plant Pathology by G. N. Agrios. 5th edition. Academic Press. 2005

2. Plant Pathology by R.S. Mehrotra, and A. Aggarwal, 3rd edition. Tata McGraw Hill. 2017

3. Bacterial plant pathology: cell and molecular aspects by D. C. Sigee. Cambridge University Press.1993.

4. Molecular plant pathology by M. Dickinson. BIOS Scientific Publishers, London. 2003.

5. The essentials of Viruses, Vectors and Plant diseases by A.N. Basu& B.K. Giri. Wiley Eastern Limited.1993.

6. Biocontrol of Plant Diseases (Vol. I) by K.G. Mukerji and K.L.Garg. CRC Press Inc.,USA.1988.

7. Molecular Biology of Filamentous Fungi by U. Stahl and P. Tudzyski. VCH VerlagsgesellschaftmbH. 1992.

MICROB 0805

PRACTICAL II

(6 credits)

1. To determine the microbial activity in the soil by measuring the CO2 evolution and study the effect of moisture and organic matter on microbial activity.
2. To determine the dehydrogenase activity in soil by microorganisms.
3. To determine the nitrate reduction in soil by microorganisms.
4. To isolate metagenome from the given soil samples and to study its diversity using Denaturing gradient gel electrophoresis (DGGE).
5. To study the basic properties (pH, water holding capacity, moisture content and organic matter content) of the given soil sample.
6. To determine the microbial activity of soil by estimating the hydrolysis of FDA.
7. To perform total plate count with soil samples and calculate the ratio of proteolytic and amylolytic bacteria.
8. To study the microbiological quality of water samples from different sources.
9. To study the decolorization of distillery or textile industrial waste.
10. To isolate the plasmid pGAPZA (containing GFP gene) from DH5ά E. coli cells.
11. To perform restriction digestion with Avr 2 of the plasmid, pGAPZA (with GFP).
12. To carry out transformation in *Pichia pastoris* competent cells using electroporation technique.
13. To perform overexpression studies of green fluorescent protein (GFP) in *Pichia pastoris* host system.
14. Purification of GFP protein from *P. pastoris* lysis by nickel- NTA affinity chromatography.
15. To set up fermentation process (batch fermentation) for the production of Protein X.
16. To concentrate and purify the given protein sample using column chromatography and analyze by SDS-PAGE
17. To set up SSF and SMF for the enzymes cellulase and xylanase using the fungal isolates and estimate the enzyme activities.
18. To study the production of lignocellulolytic enzymes (cellulases, hemicellulases and lignin degrading enzymes such as Lip, Mnp and Laccase.
19. To study the use of cellulases in saccharification of cellulosic material
20. To grow yeast (*S. cerevisiae*) and fungus (*Rhizopus* sp.) in artificial medium and to calculate the yield andproductivity of the biomass produced.
21. To study cultural characteristics of pathogenic bacteria on following selective/differential media:

22. TCBS agar; Hektoen Enteric agar; XLD agar; Endo agar; Salmonella-Shigella agar; Deoxycholate citrate agar
23. To study pathogenicity of *Staphylococcus aureus* by coagulase test
24. To perform the rapid (P/A format) coliform test.
25. To study antimicrobial susceptibility testing using an octadisc.
26. To determine minimal inhibitory concentration (MIC) of an antibiotic using an E-test.
27. To perform sterility testing of a sample.
28. To study resident microflora of skin.
29. To study resident microflora of oral cavity.

Course Outcomes:

The student:

CO1. Is able to determine the basic properties (pH, water holding capacity, moisture content and organic matter content) of the given soil sample
CO2. Is able to measure the microbial activity in the soil by measuring the CO2 evolution, dehydrogenase activity, hydrolysis of FDAand nitrate reduction.
CO3. Can isolate metagenomic DNA from soil and perform denaturing gradient gel electrophoresis (DGGE).
CO4. Can perform total plate count with soil samples, calculate the ratio of proteolytic and amylolytic bacteria, isolate fungi present in soil samples and calculate their relative abundance and frequency of occurrence.
CO5. Can test the microbiological quality of water samples from different sources.
CO6. Knows how to enzymatically decolorize distillery or textile industrial waste.
CO7. Can perform plasmid isolation from *E. coli* cells and can perform restriction digestion and transformation of the plasmid
CO8. Is able to transform *Pichia pastoris* competent cells using electroporation technique.
CO9. Is able to overexpress green fluorescent protein (GFP) in *Pichia pastoris* host system and carry out purification of GFP protein from *P. pastoris* lysis by nickel-NTA affinity chromatography.
CO10. Is able to set up fermentation process (batch fermentation) for the production of Protein X and is able to concentrate and purify the given protein sample using column chromatography and analyse it by SDS PAGE.
CO11. Can set up SSF and SMF for the enzymes cellulase and xylanase using the fungal isolates and estimate the enzyme activities.
CO12. Knows how to produce lignocellulolytic enzymes (cellulases, hemi-cellulases and lignin degrading enzymes such as Lip, Mnp and Laccase.
CO13. Is aware of the usage of cellulases in saacharification of cellulosic material
CO14. Can grow yeast (*S. cerevisiae*) and fungus (*Rhizopus* sp.) in artificial medium and calculate the yield andproductivity of the biomass produced.

CO15. Can identify pathogenic bacteria on selective/differential media:
CO16. Can carry out the coagulase test for pathogenicity of *Staphylococcus aureus*
CO17. Is able to perform the rapid (P/A format) coliform test.
CO18. Can determine the antimicrobial susceptibility testing using an octadisc and minimal inhibitory concentration (MIC) of an antibiotic using an E-test.
CO19. Is able to perform sterility testing of a sample and is acquainted with the resident microflora of skin and oral cavity.
CO20. Is able to identify selected pathogenic fungi viz. *Microsporum* sp.,*Candida albicans*, and *Aspergillus* sp. Based on their cultural and microscopic characteristics.

Suggested Reading

1. Microbiology: A laboratory manual by JG Cappucino and N Sherman. 10th edition. Pearson. 2014.

2. Environmental Microbiology: A lab manual by I. Pepper, C. Gerba and J. Brendecke. 46th edition. Academic Press. 2011.

MICROB 0806 OE

MICROBIAL BIOTECHNOLOGY

(2 Credits)

Introduction to microbial biotechnology: Biotechnology and its applications in microbial processes. Strains development, selection of hyper producers, microbial products, Metabolic engineering in development of industrial products and environment management **8**

Recombinant gene expression platforms: Development of recombinant heterologous expression systems e.g. *E. coli*, yeast, mammalian and insect cells. Plant cells as bio-factories. Control parameters in stability of these expression platforms at industrial scale. **4**

Designing large scale industrial processes: Application of bioprocess engineering in microbial product development, Batch fermentation, Fed-batch fermentation, type of bioreactors, designs and control parameters in a fermenter, High cell density cultivation strategies, continuous cultivation processes. Sterilization of large scale bioreactors, measurement of growth and product formation kinetics, Limiting parameters in large scale process development, Oxygen mass transfer coefficient. **10**

Development of microbial products: Fermented milk products, probiotics, Malt beverages, wines, distilled liquors,*Good laboratory practice* (*GLP*),Current Good Manufacturing Practice (CGMP), Recombinant biomolecules and therapeutic proteins, Vaccines production**,** DNA based vaccines, Antibody production, Therapeutic enzymes, Industrial enzymes and green fuel production, Development of bio-pesticides and bio-fertilizers, Development of biosimilars, Analysis of process economics **10**

Course Outcomes:

The student:

CO1. Is introduced to the concept of microbial biotechnology and its application in microbial processes.
CO2. Understand about strain development and selection of hyper producing industrial –ly relevant strains for production of microbial products.
CO3. Learns about the technique of metabolic engineering for development of industrial products.
CO4.Is able to differentiate between various recombinant gene expression platforms like bacterial, yeast, mammalian and insect cells and plant cells.
CO5. Is able to understand the control parameters involved in the stability of expression

platforms at industrial scale.
CO6. Is introduced to the concept of bioprocess engineering in microbial product development.
CO7. Is able to differentiate between batch, fed-batch and continuous cultivation strategies.
CO8. Learns about the design and control parameters in bioreactor.
CO9. Attains knowledge about sterilization of media and large scale bioreactors.
CO10. Understands about microbial growth measurement and product formation kinetics.
CO11. Acquires knowledge of the limiting parameters in large scale process development including oxygen mass transfer coefficient.
CO12. Gains insight into good laboratory practises and current good manufacturing practices (CGMP).
CO13. Learns about the bioprocess development of recombinant therapeutic proteins, vaccines, antibodies, therapeutic and industrial enzymes.
CO14. Understands about production of fermented milk products and beverages, wines and distilled liquors.
CO15. Is introduced to the concept of biosimilars.

Suggested reading:

1. Principles of Fermentation Technology by P. Stanbury, A. Whitaker, S. Hall. 3rd edition. Butterworth-Heinemann. 2016.

2. Modern Industrial Microbiology & Biotechnology by N. Okafor. 1st edition. CRC Press, USA. 2007.

3. Microbial Biotechnology: Fundamentals of Applied Microbiology by A.N. Glazer and H. Nikaido. 2nd edition. Cambridge University Press. 2007.

4. Pharmaceutical Biotechnology: Concepts and Applications by G. Walsh. John Wiley & Sons Ltd. 2007.

5. Pharmaceutical Biotechnology: Fundamentals and Applications by J.A.D. Crommelin, R. D. Sindelar, and B. Meibohm. 4thEdition. Springer. 2013.

MICROB 0901

MOLECULAR BIOLOGY
(4 credits)

The nature of Genetic material: The structure of DNA and RNA; melting of DNA, superhelicity, Organization of microbial genomes, Organization of eukaryotic genomes, chromatin arrangement, nucleosome formation. **8**

DNA replication: Arrangement of replicons in a genome, various modes of replication, continuous, discontinuous synthesis, various replication enzymes, replication fork and priming, leading and lagging strand, elongation,termination, specific features of replication in prokaryotes and eukaryotes, action of topoisomerases, telomere maintenance and chromatin assembly, single stranded DNA replication, relationship between DNA replication and cell cycle, DNA copy number maintenance. **10**

Recombination and Repair of DNA: DNA repair and recombination, DNA mismatch repair, Double Strand Break repair, recombination as a molecular biology tool, CRISPR-Cas systems for editing, regulating and targeting genomes. **8**

Transcription: Transcription machinery of prokaryotes, various transcription enzymes and cofactors, initiation, elongation and termination, sigma factors, transcription machinery of eukaryotes, various forms of RNA polymerase and cofactors, initiation, elongation and termination, promoters, enhancers, silencers, activators, effect of chromatin structure, regulation of transcription. **10**

Post-transcriptional processes: RNA processing, splicing, capping and polyadenylation, rRNA and tRNA processing, RNA Editing; RNAi and miRNAs, Antisense RNA, Post-transcriptional gene regulation. **10**

Translation: The genetic code and protein structure, Mechanisms of translation in prokaryotes, Mechanisms oftranslation in eukaryotes, initiation complex, ribosomes and tRNA, factors, elongation and termination, in vitrotranslation systems, polycistronic/ monocistronic synthesis, Regulation of translation, RNA instability, inhibitors oftranslation, stringent response in bacteria. **12**

Post-translational processes: Protein modification, folding, chaperones, transportation; The Signal Hypothesis,protein degradation. **6**

Course Outcomes:

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

CO6. Student is able to describe various replication enzymes
CO7. Student is able to describe replication fork and priming
CO8. Student is able to describe initiation of DNA replication, elongation and termination
CO9. Student is able to describe basis of DNA copy number maintenance
CO10. Student is able to describe DNA mismatch repair, double stranded break repair in DNA
CO11. Student is able to describe transcription machinery of prokaryotes, various transcription enzymes and cofactors in prokaryotes
CO12. Student is able to describe initiation reaction of transcription in prokaryotes, elongation in transcription and termination reaction in transcription in prokaryotes
CO13. Student is able to describe transcription machinery in eukaryotes, various forms of RNA polymerase and cofactors in eukaryotes
CO14. Student is able to describe initiation reaction and elongation of transcription in eukaryotes
CO15. Student is able to describe termination reaction in transcription in eukaryotes
CO16. Student is able to describe promoters, enhancers and silencers in eukaryotes transcription
CO17. Student is able to describe effect of chromatin structure in eukaryotic transcription
CO18. Student is able to describe regulation of eukaryotic transcription, regulation of prokaryotic transcription
CO19. Student is able to describe regulation of lac operon, trp operon
CO20. Student is able to describePost-transcriptional processes, RNAi and miRNAs, Antisense RNA, Post-transcriptional gene regulation
CO21. Student is able to describe the genetic code and protein structure, mechanism of translation in prokaryotes, mechanism of translation in eukaryotes
CO22. Student is able to describe formation of initiation complex in translation, ribosome assembly in translation
CO23. Student is able to describe elongation process in translation, termination of translation
CO24. Student is able to describe in vitro translation systems, describe poly-cistronic and mono-cistronic synthesis, regulation of translation, basis of RNA stability, inhibitors of translation
CO25. Student is able to describe post-translational processes, protein modifications, protein folding and chaperons, signal hypothesis

Suggested reading:

1. Gene IX by Benjamin Lewin. Jones and Bartlett Publishers. 2007.
2. Molecular Biology by R.F. Weaver , 4th edition. McGraw Hill, USA. 2007.
3. Molecular Biology of the Gene by J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levin, R. Losick. 6th edition. Benjamin Cummings. 2007.
4. Molecular Biology of the Cell by B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, P. Walter. 5th edition. Garland Science, New York and London. 2007.

5. Biochemistry by J.M. Berg, J.L. Tymoczko, L. Stryer. 5th edition. W.H. Freeman and Company, USA. 2008.
6. Current Protocols in Molecular Biology edited by: F. M. Ausubel, R. Brent, R.E. Kingston, D. D. Moore, J. A. Smith, K. Struhl. John Wiley and Sons, Inc. 2007.

MICROB 0902

RECOMBINANT DNA TECHNOLOGY
(4 credits)

Basics of DNA cloning: Simple cloning and cloning using linkers and adaptors. Cloning into various kinds of vectors – plasmids, phages lambda and M13, phagemids, cosmids, P1 phage, PACs, BACs and YACs. Selection and screening of clones. **4**

Methods of DNA and protein analysis: Agarose, polyacrylamide and pulsed field gel electrophoresis of DNA. Southern and Northern Blotting. Radiolabelling probes. Isolation and purification of DNA. RFLP analysis. DNA fingerprinting and its application in forensics, in disease diagnosis and in identification of strains. Native PAGE, SDS-PAGE and two-dimensional PAGE analysis of proteins. Western Blotting analysis. **6**

Polymerase Chain Reaction: Concept of PCR and various thermophilic enzymes used in PCR. Gradient PCR versus Touchdown PCR. Designing primers. Cloning PCR products. Long PCR, Inverse PRC, Vectorette PCR, RT-PCR, 5' and 3' RACE, qPCR, Real Time PCR using SYBR Green, Scorpion primers and TaqMan probes, MOPAC, Multiplex PCR, Differential Display PCR, RAPD fingerprinting of micro-organisms, Ligation Chain Reaction, Overlap PCR, Rolling Circle Amplification Technology. **10**

Construction of cDNA and genomic DNA libraries: Vectors used in the construction of cDNA versus genomic DNA libraries. Steps and enzymes involved in the construction of cDNA versus genomic DNA libraries. Screening libraries by colony hybridization and colony PCR. Screening expression libraries. Enriching for clones in cDNA libraries by positive selection and subtractive hybridization. Identifying genes in complex genomes by direct selection of cDNA and exon trapping. **4**

Genome sequencing: DNA sequencing by Sanger's method – traditional and cycle sequencing. Physical mapping by restriction fragment fingerprinting of BAC clones and STS mapping. E-PCR. Whole genome shotgun sequencing. Clone-by-clone shotgun sequencing of genome – preparation of BAC/YAC library, map construction, clone selection, subclone library construction, random shotgun phase, finishing phase and sequence authentication. Genome annotation at the nucleotide level, protein level and process level. Comparative genome sequencing of micro-organisms to identify and categorize SNPs. Array CGH. Next Generation sequencing methods. **6**

Transcriptional analysis of gene expression and transcriptomics: Gene expression analysis by Northern Blotting, RT-PCR, EST analysis and the use of reporter genes. Enzymatic and bioluminescent reporters. Reporters used in protein localization and trafficking studies. Promoter analysis – deletion analysis and linker scanning analysis coupled to reporter assays, mapping transcriptional start sites by S1 nuclease mapping, primer extension studies or 5' RACE. Transcriptome analysis by DD-PCR and EST analysis, DNA microarrays (cDNA arrays and oligo arrays), Serial Analysis of Gene Expresion (SAGE), RNA-seq. **8**

Overexpression of recombinant proteins: Overexpression and tagging of recombinant proteins in *E.coli,* driven by lac, T7 and Tet-regulatable promoters, Expression in *B. subtilis*. Overexpression systems in *S.cerevisiae*, *P.pastoris, S.pombe* and *K.lactis*. Baculovirus overexpression system. Mammalian cell overexpression system. **4**

Analysis of protein-DNA and protein-protein interactions: Gel retardation assay, DNA footprinting by DNase I and chemical methods, yeast one-hybrid assay, ChIP-chips, ChIP-seq. Yeast two hybrids, three-hybrids, split hybrids and reverse hybrids. Co-immunoprecipitations, pull-downs, Far-Westerns. GFP and FRET. Phage display. **8**

Protein engineering and proteome analysis: Insertional and deletion mutagenesis. Site directed mutagenesis by conventional and PCR-based methods. Proteome analysis by 2D gel electrophoresis coupled to mass spectrometric analysis. Protein arrays and their applications. **6**

Pharmaceutical products of DNA technology: Human protein replacements – insulin, hGH and Factor VIII. Human therapies – TPA, interferon, antisense molecules. Vaccines – Hepatitis B, AIDS, and DNA vaccines. **4**

Transgenics and animal cloning: Creating transgenic animals and plants**.** Animal cloning. **4**

Course Outcomes:

CO1. Student is able to describe and explain the use of various cloning vectors and is able to design a cloning experiment.
CO2. Student learns how to analyze restriction fragment length polymorphism patterns by agarose gel electrophoresis.
CO3. Student can explain the applications of restriction fragment length polymorphism patterns, such as disease diagnosis, and DNA fingerprinting in forensics.
CO4. Student can differentiate between Southern, Northern and Western blotting techniques and their applications.
CO5. Student can design primers for PCR, and design and execute experiments to amplify genes and to create mutations by overlap PCR
CO6. Student learns how to fingerprint micro-organisms using RAPD and can describe the identification of SNPs by ligation chain reaction
CO7. Student can plan the construction and screening of genomic and cDNA libraries
CO8. Student learns to analyze gene expression using real time PCR
CO9. Student is able to describe in detail how genomes are sequenced
CO10. Student is able to compare and critique the different next generation sequencing methods
CO11. Student learns about analysis of global gene expression using DNA microarray Technology and about the genome-wide identification of DNA binding sites of proteins using ChIP-on-chip
CO12. Student is able to explain experiments to study protein-DNA interactions by EMSA and footprinting
CO13. Student is able to discuss experiments to analyze protein-protein interactions and

is able to compare and critique the different methods to analyze protein-protein interactions

CO14. Student is able to summarize the use and applications of various reporter genes

CO15. Student learns about the uses of GFP and its derivatives

CO16. Student is able to analyze proteins by SDS-PAGE electrophoresis

CO17. Student is able to understand how to analyze proteome differences using two-dimensional gel electrophoresis.

CO18. Student learns the basic principles of mass spectrometry

CO19. Student learns about the use of protein arrays.

CO20. Student is able to describe the use of bacteria and yeasts for overexpression of recombinant proteins in different hosts

CO21. Student can describe the use of baculovirus system for expression of recombinant proteins

CO22. Student can describe how gene knockouts are made and can write about the importance of transgenic plants

CO23. Student is able to explain how animals are cloned and is able to critique the pros and cons of animal cloning

CO24. Student is able to discuss the latest technology in therapeutic cloning and is able to critique the pros and cons of therapeutic cloning

CO25. Student is able to judge the importance of recombinant DNA technology in creating pharmaceutical products, write about pharmaceutical products of DNA technology such as insulin, hGH, and about DNA vaccines and their importance

Suggested reading:

1. Molecular Biology by D.P. Clarke & N. Pazdernik.. 2nd edition. Academic Press. 2012.

2. Molecular Cloning: A laboratory manual by J. Sambrook and D. Russell. 4th edition. Cold Spring Harbor laboratory Press. 2012.

3. DNA Technology: The Awesome Skill by I. Edward Alcamo. Harcourt Academic Press. 2001.

4. Molecular Biology of the Gene by J. Watson, T. Baker, S. Bell, A. Gann, M. Levine and R. Losick. 7th edition. Pearson. 2014.

5. Gene Cloning and DNA Analysis: An Introduction by T.A. Brown. 7th edition.Wiley-Blackwell Publishers. 2016.

MICROB 0903

MICROBIAL GENETICS
(4 credits)

Genetic analysis of bacteria: Importance and uses of mutation analysis. Inheritance in bacteria, types of mutations, spontaneous and induced mutagenesis, isolating mutants, selecting mutants, mutant enrichment. Reversions versus suppression. Complementation tests, recombination tests and gene replacements. Cloning genes by complementation. Cloning genes by marker rescue. **6**

Gene transfer and mapping by conjugation: Basis of fertility in bacteria. Self-transmissable and mobilizable plasmids. Molecular mechanism of gene transfer by conjugation – genes and proteins involved. Regulation of gene transfer by conjugation. Hfr strains. Mapping bacterial genomes using Hfr strains. Chromosomal DNA transfer by plasmids – by integrated plasmids, by chromosome mobilization and by creation of prime factors. Transfer systems in gram positive bacteria. Ti plasmid transfer system and its application in creating transgenics. **8**

Lytic bacteriophages: Lytic development cycle using phages T4 and T7 as models. Regulation of expression of genes in phage T4 – transcriptional activators, antitermination, a new sigma factor and replication-coupled transcription. Regulation of gene expression in phage T7 – a phage-encoded RNA polymerase. Replication of T4 versus T7 phages – recent advances. Replication and packaging of filamentous phages M13 and f1 – recent advances. Genetic analysis of phages – complementation and recombination tests with phages. Genetic experiments with the rII genes of phage T4. Deciphering the genetic code using rII mutants. Constructing phage genetic linkage maps using two-factor and three factor crosses. **8**

Gene transfer by transformation and transduction: Natural transformation and competence. Molecular basis of natural transformation – DNA uptake competence systems in gram positive and gram negative bacteria. Regulation of competence in *B.subtilis*. Importance of natural transformation. Artificially induced competence. Generalized versus specialized transduction - T4 and lambda phage. Mapping bacterial genes by transduction. **6**

Lysogenic phages: Lambda phage – gene and promoter organization. Lambda lytic cyle – regulation of gene expression – very early, early and late genes. Establishment and maintenance of lysogeny. Regulation of gene expression in lysogenic phase - role of cI, cII and cIII proteins. Lambda immunity region and immunity to superinfection. Events leading to induction – role of cI and cro repressors in regulating the events. Other lysogenic phages – P2 and P4. Lysogenic phages and bacterial pathogenesis. **6**

Transposons: Discovery of transposition. Classes of bacterial transposons. Regulation of transposition activity. Effects of transposition in bacteria. Genetic requirements for transposition. Assays to analyze transposition events – suicide vectors and mating out

assays. Molecular mechanisms of transposition – genetic evidence supporting the mechanisms.Conjugative transposons. Transposon mutagenesis. Cloning out genes by transposon mutagenesis. Mu transposon, Mu*d* transposons and gene fusions, mini-Mu elements and their use in *in vivo* cloning. Yeast Ty-1 transposon. Site-specific recombination – *loxP*-Cre system, phase variation system in *Salmonella*. **10**

Gene regulation: Control of gene expression. Positive gene regulation, negative gene regulation and attenuation, using the *lac*, *gal*, *trp*, *ara* and *tol* operons. **12**

Model organisms used in genetic studies: yeast (*Saccharomyces cerevisiae*), fruitfly (*Drosophilamelanogaster*), nematode worm (*Caenorhabditis elegans*), mouse (*Mus musculus*), Arabidopsis (*Arabidopsis thaliana*). **8**

Course Outcomes:

CO1. Student can discuss the importance of mutation analysis, predict the phenotype of the organism based on the mutations it carries, and can differentiate between reversion and suppression
CO2. Student is able to analyze mutations using complementation and recombination tests
CO3. Student is able to design a strategy to create gene replacement in bacteria
CO4. Student is able to design strategies to clone genes by complementation and by marker rescue
CO5. Student is able to describe the fertility factor in bacteria and is able to execute a conjugation experiment between two bacteria
CO6. Student is able to discuss how plasmid copy number is regulated in different types of plasmids
CO7. Students is able to differentiate between Hfr strains and strains carrying F plasmid
CO8. Student is able to construct a genetic map of bacterial genome using conjugation-based method
CO9. Student is able to compare and critique chromosomal DNA transfer by creation of prime factors and by integrated plasmids
CO10. Student is able to discuss the use of Ti plasmid in creating transgenic plants
CO11. Student is able to list the steps in phage infection and multiplication within the host bacterium
CO12. Student is able to compare and contrast the lytic development cycles of T4 and T7 phage
CO13. Student is able to construct genetic linkage maps using two-factor and three factor cross
CO14. Student is able to discuss the basis of natural competence in gram-positive and gram-negative bacteria and is able to explain the regulation of competency in sporulating bacteria
CO15.Student is able to compare and contrast generalized versus specialized transduction and learns how to make maps based on cotransduction frequencies
CO16. Student is able to list the events in the lytic and lysogenic phass of lambda phage life cycle

CO17. 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
CO18. Student is able to list the outcomes of transposition events and to differentiate between cut-and-paste versus replicative transposition
CO19. Student can design strategies to mutagenize bacteria using transposons
CO20. Student can explain the use of *loxP*-cre and FLP-*FRT* systems in constructing conditional knockouts
CO21. Student is able to differentiate between the life-styles of lambda phage and mu phage
CO22. Student is able to validate the statement that mu phage is a transposon and is able to design an experiment using mini-mu elements for creating gene fusions in reporter assays
CO23. Student is able to differentiate between positive and negative regulation of gene expression
CO24. Student is able to differentiate between inducible and repressible systems
CO25. Student is able to describe the regulation of the lac, trp, gal, ara and tol operons

Suggested reading:

1. Molecular Genetics of Bacteria by L. Snyder, J. Peters, T. Henkin and W. Champness. 4th edition. ASM Press. 2013.

2. Fundamental Bacterial Genetics by N. Trun and J. Trempy. 1st edition. Wiley-Blackwell Publishing. 2004.

3. Modern Microbial Genetics edited by U.N. Streips and R.E. Yasbin. 2nd edition. Wiley-Liss Publishers. 2002.

4. Microbial Genetics by S.R. Maloy, J.E. Cronan, Jr. and D. Freifelder. 2nd edition. Jones and Bartlett Publishers. 1994.

MICROB 0904 E1

COMPUTATIONAL BIOLOGY
(4 credits)

Section A: Sequence analysis

Biological Databases: Introduction; Types of databases in terms of biological information content; Protein and gene information resources; Different formats of molecular biology data Specialized resources for genomics, proteomics and metabolomics. **8**

Sequence Alignment: Methods and algorithms of pairwise and multiple sequence alignment;Global and local alignment; Alignment scoring matrices; Database similarity searching; Different approaches of motif detection; Concept and use of protein families; Concept of orthology, paralogy and homology in gene and protein sequences. **8**

Molecular Phylogenetics: Methods and tools for phylogenetic analysis; Creation evaluation and interpretation of evolutionary trees; Advantages and disadvantages of phenetic and cladistic approaches. **8**

Genomics and Gene Annotation: Organization and structure of prokaryotic and eukaryotic genomes; Genome annotation and databases; Automated *in-silico* methods of finding gene and relevant features; Genome Sequencing using first and seconding generation sequencing methods; Advantages of genome sequencing projects in modern biological research. **8**

Section B: Structural Bioinformatics

Protein Structure Databases: Different databases of macro-molecular biomolecules; Accessing and mining protein structure classification databases such as SCOP, CATH; Tools for viewing and interpreting macromolecular structures. **10**

Protein Structure Comparison: Various algorithms and programs for superimposition of structures; RMSD calculations, multiple structure alignment methods such as DALI and VAST. **6**

Protein Structure Prediction &Molecular Modeling: Principles of secondary and tertiary structure predictions; *Ab-initio* and homology based methods of secondary

and tertiary structure predictions; Homology modeling; Threading and *ab-initio* protein structure prediction. **8**

Inferring Function from Protein Sequence &Structure: Using evolutionary information; Gene neighborhood; Phylogenetic profiles; Gene fusion; Catalytic templates; Prediction and analysis of binding cavities for function prediction. **8**

Course Outcomes:

The student:

CO1. Understands the difference between primary and secondary databases.
CO2. Understands the different formats of sequence and data storage in various publicly available databases.
CO3. Learns about methods to create a pairwise alignment.
CO4. Learns to create and usefully interpret the results of a multiple sequence alignment.
CO5. Is able to distinguish the utility of various matches suggested in online similarity search programs on the basis of scores and e-values.
CO6. Learns about the relationship between motif and function prediction in proteins.
CO7. Gets acquainted with various online tools to predict and display the conserved motifs from multiple sequence alignments.
CO8. Understands the need to create and correctly interpret phylogenetic trees to gain insight into evolutionary path of the target molecule.
CO9. Understands the major differences in genome organization of prokaryotes vs. eukaryotes.
CO10. Learns the use of various algorithms for predicting genes in genomes.
CO11. Is well versed about the data organization and retrieval from various structural biology databases, especially PDB.
CO12. Is able to retrieve the relevant information required for understanding the macromolecular structure model form the database.
CO13. Understands the basis of protein classification in databases like CATH and SCOP.
CO14. Is familiar with various (online as well as standalone) tools available for protein structure visualization.
CO15. Should be able to manipulate the structural model of a protein to highlight areas of interest (like binding sites).
CO16. Should be familiar with strengths and shortcomings of various available algorithms for protein secondary structure prediction.
CO17.Gets familiar with different algorithms available for structure comparison in proteins.
CO18. Learns about the interpretation and utility of rmsd values in structure comparison.
CO19. Knows the various tools available for comparing multiple structures simultaneously.
CO20. Is able to differentiate between the application of various methods of protein

structure prediction.

CO21. Is able to appreciate the importance and pitfalls associated with of each step of homology modeling.

CO22. Understands where homology modeling may not succeed and propose other options that can create a substitute model.

CO23. Is able to understand the reasons behind the current limitations of ab-initio protein structure prediction.

CO24. Is familiar with the interpretation of data out from metaservers analyzing the sequence and structure of proteins.

CO25. Is able to combine various methods learnt for analyzing the structure and evolutionary relationships of proteins towards predicting the function of novel proteins.

Suggested Readings:

1. Introduction to Computational Biology: An Evolutionary Approach by Haubold & Wiele. 1st edition. Springer International. 2006.
2. Introduction to Bioinformatics by A. Lesk. 3rd edition. OUP India. 2009.
3. Statistical methods in Bioinformatics: An introduction by W. Ewens and G.R. Grant. 2nd Edition. Springer-Verlag. 2006.
4. Bioinformatics: Sequence and genome analysis by D. Mount. 2nd edition. Cold Spring Harbor Lab Press. 2004.
5. Bioinformatics: A practical guide to the analysis of genes & proteins. Edited by Baxevanis and Outlette. 2nd edition. John Wiley and Sons. 2001.
6. An Introduction to Protein Informatics by K-H Zimmermann. 1st edition, Springer International. 2007.
7. Fundamental Concepts of Bioinformatics by Krane. 1st edition. Pearson Education. 2003.
8. Discovering Genomics, Proteomics and Bioinformatics by Campbell. 2nd edition. Campbell Pearson Education. 2007.
9. Structural bioinformatics: an algorithmic approach by F. J. Burkowski. 1st edition, Chapman & Hall/CRC. 2009.
10. Structural Bioinformatics edited by J. Gu, P.E. Bourne. 2nd Edition. Wiley-Blackwell. 2009.

MICROB 0904 E2

FOOD MICROBIOLOGY
(4 credits)

Microorganisms important in food microbiology: Taxonomical classification of microbes associated with food products, their phenotypic and biochemical identification. Food associated molds, yeasts, yeast-like fungi and bacteria. General microbiome of food material **8**

Microbiology of foods: Microbial habitat of specific food materials, adaptations and changes in microbiome of vegetables, fruits, milk, fermented and non-fermented milk products, fresh meats,poultry and non-dairy fermented foods. **8**

Microbial spoilage of foods: Types and causes of spoilage of cereals and cereals products, spoilage of vegetables and fruits, spoilage of meat and meat products, spoilage of fish and other sea foods, spoilage of eggs and other poultry products, spoilage of milk and milk products. Study of microorganisms responsible for spoilage and microbial succession during spoilage. Brief insights into chemical and physical spoilage of foods. **12**

Food preservation: General principles of food preservation, various classicalphysical, chemical, and biological methods of preservation. New developments in food preservation techniques. Analysis of practical implementation of such techniques. **8**

Fermentation processes: Production of fermented milk and milk products, plant-based products, fish products, and meat products. Manufacture of starter cultures from lab to pilot scale. Batch submerged and solid-state fermentation of foods. **8**

Food beverages and enzymes: Concept of human microbiome, probiotics and prebiotics. Insight into health benefits of fermented milk products. Understanding benefits of tradition and non-traditional fermented foods. Introduction to the concept of bioactive compounds and brief study of such compounds from fermented foods including malt beverages, wines, distilled liquors and vinegar. **10**

Food-borne diseases: Food borne infections including bacterial, viral and fungal infections. Study of infections due to food borne parasites. In depth study of various types and causes of food intoxication. Summary of prevention of microbial food infections. Identification and first aid for specific types of food infections. **10**

Course Outcomes:

The student:

CO1. Knows the classification of microbes associated with food products.
CO2. Can identify food associated molds, yeasts, yeast-like fungi and bacteria by phenotypic and biochemical methods.
CO3. Is aware of microbial habitat of specific food materials.
CO4. Knows the adaptations of microbes to survive in vegetables, fruits, milk, fermented and non-fermented milk products, fresh meats,poultry and non-dairy fermented foods.
CO5. Can recognize the types and causes of spoilage of cereals and cereals products, spoilage of vegetables and fruits, spoilage of meat and meat products, spoilage of fish and other sea foods, spoilage of eggs and other poultry products, spoilage of milk and milk products.
CO6. Can enlist the microorganisms responsible for spoilage.
CO7. Is able to predict the microbial succession during spoilage.
CO8. Knows about the causes and preventive measures to avoid chemical and physical spoilage of foods.
CO9. Is acquainted with principles of food preservation, various classical physical, chemical, and biological methods of preservation.
CO10. Is aware of the new developments in food preservation techniques.
CO11. Can analyse and carry out practical implementation of food preservation techniques.
CO12. Knows how to produce fermented milk and milk products.
CO13. Knows the process of making plant-based products, fish products, and meat products.
CO14. Is acquainted with industrial manufacture of starter cultures from lab to pilot scale.
CO15. Knows the difference between batch submerged and solid-state fermentation of food.
CO16. Is aware ofhuman microbiome and its importance for human well-being.
CO17. Knows about probiotics and prebiotics.
CO18. Is acquainted with the health benefits of fermented milk products.
CO19. Has an understanding of the benefits of tradition and non-traditional fermented food.
CO20. Knows about the various bioactive compounds in fermented food material.
CO21. Knows the composition of bioactive compounds in malt beverages, wines, distilled liquors and vinegar.
CO22. Can identify food borne infections including bacterial, viral and fungal infections based on their symptoms.
CO23. Knows about the various types and causes of food intoxication.
CO24. Is aware how to prevent microbial food infections.
CO25. Can identify and provide first aid for specific types of food infections.

Suggested reading:

1. Food Microbiology by W.C. Frazier, D.C. Westoff and K.N. Vanitha. 5th edition. McGraw Hill Education. 2013.

2. Modern Food Microbiology by J.M. Jay, M.J. Loessner, D.A. Golden. 7th edition. Springer. 2006.

3. Fundamental Food Microbiology by B. Ray and A. Bhunia. 5th edition. CRC press. 2013.

4. Food Microbiology by M. R. Adams, M. O. Moss and P. McClure. 4th edition. Royal Society of Chemistry. 2015.

5. Food Microbiology: Fundamentals and Frontiers by M. P. Doyle and L. R. Beuchat. 3rd edition. ASM press. 2007.

6. Food Microbiology: An Introduction by T. Montville, K. Matthews and K.Kniel. 4th edition. ASM press. 2017.

MICROB 0905

PRACTICAL III

(8 credits)

1. Restriction digestion analysis by agarose gel electrophoresis.
2. Restriction digestion analysis by polyacrylamide gel electrophoresis.
3. Preparation of competent cells and determination of transformation efficiency
4. Alpha-complementation
5. Isolation of plasmid DNA from minicultures.
6. Isolation of plasmid from maxicultures.
7. Isolation of genomic DNA.
8. Cloning
9. Amplification of DNA by PCR
10. RAPD analysis
11. Overexpression of proteins and analysis by SDS-PAGE
12. Purification of recombinant protein
13. Western Blotting analysis
14. Phage titration
15. Bacterial transduction
16. Bacterial conjugation
17. Bacterial transposition
18. To find ORFs in given nucleotide sequence using ORF Finder.
19. To create phylogenetic tree from the given nucleotide and protein sequence.
20. To Study Protein Parameters using Protparam.
21. To study domain architecture using ExPASy PROSITE.
22. To perform protein modeling using SWISS-MODEL.
23. To create multiple sequence alignments
24. To visualize and understand structures from PDB using PyMol/DeepView.

Course Outcomes:

The student:

CO1. Is able to perform restriction digestion and carry out its analysis by agarose gel electrophoresis.
CO2. Is able to perform restriction digestion and carry out its analysis by agarose gel electrophoresis.
CO3. Learns how to prepare competent cells and determine transformation efficiency
CO4. Becomes familiar with alpha-complementation
CO5. Is able to isolation plasmid DNA from minicultures and large culture volumes.
CO6. Is able to isolate genomic DNA.
CO7. Learns how to do basic cloning
CO8. Learns how to amplify DNA by PCR
CO9. Is able to fingerprint microorganisms by RAPD analysis
CO10. Is able to overexpress recombinant proteins and analysis by SDS-PAGE

CO11. Is able to purify recombinant His-tagged protein
CO12. Is able to analyze expression by western blotting
CO13. Can carry out phage titration
CO14. Can perform bacterial transduction
CO15. Can set up bacterial conjugation
CO16. Learns how to set up bacterial transposition
CO17. Can find ORFs in given nucleotide sequence using ORF Finder.
CO18. Can create phylogenetic tree from the given nucleotide and protein sequence.
CO19. Can perform protein modeling using SWISS-MODEL.
CO20. Can create multiple sequence alignments

Suggested reading:

1. Molecular Cloning: A laboratory manual by Joseph Sambrook & David Russell, 4th edition. Cold Spring Harbor laboratory Press. 2012.

2. Sequence - Evolution - Function: Computational Approaches in Comparative Genomics by E.V. Koonin , M.Y. Galperin. Kluwer Academic, USA. 2003.

3. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins edited by A. D. Baxevanis and B.F. Francis Ouellette . 3rd edition. Wiley and Sons. 2004.

MICROB 1001

DISSERTATION

(24 credits)

Continuous evaluation (IA)	=	180 marks
Experimental work	=	120 marks
Dissertation	=	100 marks
Presentation and viva-voce	=	200 marks
Total	=	600 marks

Course Outcomes:

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 assess the microorganism's ability to produce various enzymes
CO6. Student becomes well-versed in different enzymatic assay systems
CO7. Student learns correct handling and use of instruments
CO8. Student learns correct handling of reagents and chemicals
CO9. Student learns how to execute experiemnts correctly.
CO10. Student learns the importance of including controls in all experiments
CO11. Student learns how to plot the results.
CO12. Student learns how to analyze data, using statistical tools where necessary
CO13. Student learns how to interprete the results from all possible angles.
CO14. Student learns how to present the project in the form of a slide show before and audience of 20-30 people.
CO15. Student is exposed to the science of thesis writing.