3. Enzymes: Biochemistry, Biotechnology, Clinical Chemistry by Trevor Palmer Horwood Publishing House, Chichester, England, 2001.
4. Biochemical Calculations by Irwin Segel., John Wiley and Sons, California, USA, 2004.
5. Biocatalysis – Fundamentals and Applications by A.S. Bommarius, B.R. Riebel, Wiley-VCH, Weinheim, Germany, 2004.
6. Enzymology by P.C. Engel. – LABFAX, BIOS Scientific Publishers, Academic Press, San Diego, USA, 1996.
7. Enzyme Inhibitors by U. Brodbeck., Verlag Chemie, Weinheim, Germany, 1980.
8. Guide to Protein Purification by M. P. Deutcher., Academic Press, San Diego, USA, 1993.
9. Physical Biochemistry: Principles and Applicatons by David Sheehan., John Wiley and Sons Ltd, Chichester, England, 2009.
10. Crystallography Made Crystal Clear by Gale Rhodes., Academic Press, Burlington, USA, 2006.

MICROB 0802

ENVIRONMENTAL MICROBIOLOGY

(4 credits Theory + 2 credits Practical = 6 credits)

Section A

Brief history and development of environmental microbiology: History and development of microbial ecology highlighting significant contributions of microbiologists and emergence of environmental microbiology, and significant applications of microbes in solving environmental pollution problems

Culture-dependent and culture-independent approaches for understanding microbial diversity in the environment: Understanding microbial diversity in the environment by culture-dependent approaches and their limitations, and by culture-independent molecular approaches (DNA heterogeneity by reannealing denatured environmental DNA, ARDRA, analysis of FAME profiles, measuring metabolic capabilities

using BIOLOG microtitre plates, using DNA probes and PCR primers, G+C analysis, slot-blot hybridization of community DNA, and fluorescent *in situ* hybridization of intact cells)

Microbial diversity in normal environments: Diversity of microbes in terrestrial (agricultural and desert soils), aquatic (fresh water and marine), atmospheric (stratosphere) and animal (cattle, termites, pests such as cockroach and nematodes, and human being) and their potential applications

Microbial diversity in extreme environments: Occurrence, diversity, adaptations and potential applications of oligotrophs, thermophiles, psychrophiles, barophiles, organic solvent and radiation tolerants, metallophiles, acidophiles, alkaliphiles and halophiles

Global warming: The source and variety of gases which contribute to global warming, effects of global warming and remedial measures

Section B

Lignin degradation: Lignocellulolytic microorganisms, enzymes and their biotechnological applications in: (i) biopulping, (ii) biobleaching, (iii) textiles (iv) biofules, (v) animal feed production.

Liquid waste management: Treatment of sewage (Primary, Secondary and Tertiary treatments) and Treatment of Industrial effluents (distillery, textile, pulp and paper).

Solid waste management: Waste types & their possible usages, landfill development and composting.

Bioremediation of environmental pollutants: Petroleum hydrocarbons and pesticides.

Microbes and mineral recovery: Bioleaching of copper, gold and uranium.

STUDY MATERIALS:

1. Microbial Ecology By Atlas R.M., Bartha R., Benjamin Cummings Publishing Co, Redwood City, CA., 1993.
2. Environmental Microbiology by A.H. Varnam & M.G. Evans, Manson Publishing Ltd., 2000.

3. Manual of Environmental Microbiology by Christon J. Hurst, Ronald L. Crawford, Jay L. Garland, David A. Lipson, Aaron L. Mills, ASM Press, 2007.
4. Environmental Microbiology by W.D. Grant & P.E. Long, Kluwer Academic Publishers, 1981.
5. Environmental Microbiology by R. Mitchel (2nd edition), Wiley-Blackwell, 2009.
6. Microbiology: An environmental Perspective by P. Edmonds, Macmillan, New York, 1978.
7. Environmental Microbiology by Raina Maier, Ian Pepper, & Charles Gerba, Academic Press, 2008.
8. Environmental Microbiology: Principles And Applications by Patrick K. Jjemba, Science Publishing Inc., 2004.
9. Encyclopedia of Microbiology, Six-Volume Set, 1-6 by Moselio Schaechter, Academic press, 2009.
10. Lignocellulose Biotechnology: Future Prospects by R.C. Kuhad and A. Singh, I.K. International, 2007.
11. Applied Bioremediation and Phytoremediation by A. Singh and O.P. ward, Springer, 2004.
12. Microbial and Enzymatic Degradation of Wood and Wood components, by K-E.L. Eriksson, R.A. Blanchettee and P. Ander, Springer, 1990.
13. Advances in Applied Bioremediation by A. Singh, R.C. Kuhad and O.P. Ward, Springer, 2009.

MICROB 0803

PLANT – PATHOGEN INTERACTION

(4 credits Theory + 2 credits Practical = 6 credits)

Concepts and physiology of plant diseases: What is a disease and what causes disease, pathogenesis, pathogenesis in relation to environment, effect of microbial infections on plant physiology, photosynthesis, respiration, transpiration, translocation.

MICROB 0804

MICROBIAL PATHOGENICITY

(4 credits Theory + 2 credits Practical = 6 credits)

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

Molecular microbial pathogenicity: Molecular Koch's postulates, multiplicity of virulence features, coordinated regulation of virulence genes, two component signal transudation systems and environmental regulation of virulence determinants, antigenic variation; clonal and panmictic nature of microbial pathogens, type 1-IV secretion systems, biofilms and quorum sensing.

Emerging and re-emerging pathogens: Illustrate emerging and re-emerging pathogens using *V. cholerae* O: 139, X-MDR *M. tuberculosis, Helicobacter pylori,* Enterohaemorrhagic *E. coli* (EHEC), *Cryptosporidium parvum*, Lyme disease, SARS virus, Bird flu, prions, AIDS, Dengue Hemorrhagic Fever, and *Chlamydiae*, opportunistic fungal pathogens. Mechanisms of emergence of new pathogens: microbial change and adaptation, horizontal gene transfer (HGT), pathogenicity islands (PAI), role of integrons.

Molecular microbial epidemiology: Objectives of microbial epidemiology. Biochemical and Immunological tools - biotyping, serotyping, phage typing, FAME, Curie Point PyMS, protein profiling, multilocus enzyme electrophoresis (MLEE); Molecular typing: RFLP (ribotyping, IS based), RAPD, 16S-23S IGS, ARDRA, rep (REP, ERIC, BOX)-PCR, PFGE, AFLP, MLST, MVLST, VNTR, SNP, Microarry and whole genome sequence; GIS

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.

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

Newer vaccines: Recombinant vaccines, subunit vaccines, DNA vaccines, Vaccinia, BCG and HIV– vector based vaccines

Rapid diagnostic principles: Nucleic acid probes in diagnostic microbiology, nucleic acid amplification methods, Real-time PCR, diagnostic sequencing and mutation detection, molecular typing methods, array technology.

STUDY MATERIALS:

1. Jawetz, Melnick, & Adelberg's Medical Microbiology by Brooks GF, Butel JS, Morse SA, Melnick JL, Jawetz E, Adelberg EA . 23rd edition. Lange Publication. 2004.
2. Cellular Microbiology by Cossart P, Boquet P, Normark S, Rappuoli R eds. 2nd edition. American Society for Microbiology Press. 2005.
3. Bacterial Pathogenesis: A molecular approach by Salyers AA and Whitt DD eds. American Society for Microbiology Press, Washington, DC USA. 2002.
4. Pathogenomics: Genome analysis of pathogenic microbes by Hacker J and Dorbindt U. ed. Wiley-VCH. 2006.
5. Molecular Microbiology: Diagnostic Principles and Practice by Persing DH, Tenover FC, Versalovic J, Tang Y, Unger ER, Relman DA, White TJ eds. American Society for Microbiology Press, 2004.
6. Infectious Disease Epidemiology: Theory and Practice by Nelson KE, Williams CM, Graham NMH eds. An Aspen Publication. 2001.

MICROB 0805

Practicals

(Based on theory papers)

1. To study cultural characteristics of pathogenic bacteria on following selective/differential media:

   TCBS agar; Hektoen Enteric agar; XLD agar; Endo agar; *Salmonella-Shigella* agar; Deoxycholate citrate agar

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, San Francisco, USA, 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 (5th edition) by J.M. Berg, J.L. Tymoczko, L. Stryer, W.H. Freeman and Company, New York, USA, 2008.

6. Current Protocols in Molecular Biology Edited by: Fred M. Ausubel; Roger Brent; Robert E. Kingston; David D. Moore; John A. Smith; Kevin Struhl, John Wiley and Sons, Inc. 2007

MICROB 0902

RECOMBINANT DNA TECHNOLOGY

(4 credits Theory + 2 credits Practical = 6 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.

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.

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.

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.

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.

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).

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.

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. Yeast two hybrids, three-hybrids, split hybrids and reverse hybrids. Co-immunoprecipitations, pull-downs and Far-Westerns. GFP and FRET. Phage display.

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*.

Gene regulation: Control of gene expression. Positive gene regulation, negative gene regulation and attenuation, using the *lac*, *gal*, *trp*, *ara* and *tol* operons, with emphasis on recent advances.

STUDY MATERIALS:

1. Molecular Genetics of Bacteria by Larry Snyder and Wendy Champness, 3rd edition; ASM press; 2007.
2. Fundamental Bacterial Genetics by Nancy Trun and Janine Trempy, 1st edition; Blackwell Science Publishers; 2004.
3. Modern Microbial Genetics by U.N. Streips and R.E. Yasbin, 2nd edition; Wiley Publishers; 2002.
4. Microbial Genetics by Stanly R. Maloy, John E. Cronan, Jr. & David Freifelder, 2nd edition; Narosa Publishing House; 1987.

MICROB 0904

INDUSTRIAL AND FOOD MICROBIOLOGY

(4 credits Theory + 2 credits Practical = 6 credits)

Section A

Introduction to industrial microbiology: Sources of industrially important microbes, strain development,

types of fermentation and fermenters, process optimization, and recent developments in fermentation technology.

Downstream processing of microbial products: Filtration, centrifugation, cell disruption, liquid-liquid extraction, chromatography, membrane processes, drying (lyophilization and spray drying), and crystallization

Fermentation economics: Basic objective for successful economically viable fermentation process, cost break down for well established fermentation processes, market potential of the products, cost aspects of various stages in the processes development including effluent treatment

Production aspects: Microbial strains, substrates, strain improvement, flow diagrams, product optimization, and applications of industrial alcohol (ethanol and butanol), amino acids (lysine, phenylalanine, tryptophan), antibiotics (cephalosporins, tetracyclines, polyenes), enzymes and immobilized enzymes, SCP, microbial polyesters, biosurfactants, and recombinant products (insulin, somatostatin, thaumatin).

Section B

Microbiology of foods: Vegetables, fruits, milk, fermented and non-fermented milk products, fresh meats, poultry and non-dairy fermented foods.

Microbial spoilage of foods

Food preservation: Chemical, physical and biological methods.

Fermentation processes: Production of milk and milk products, plant based products, fish products, meat products and food beverages.

Food-borne diseases

STUDY MATERIALS:

1. Biotechnology: A Text Book of Industrial Microbiology by W. Crueger & A. Crueger, Panima Publishing Corporation, New Delhi/Bangalore, 2000.
2. Principles of Fermentation Technology by P.F. Stanbury, W. Whitaker &S.J. Hall, Aditya Books (P) Ltd., New Delhi, 1997.
3. Modern Industrial Microbiology & Biotechnology by N. Okafer, Scientific Publishers, Enfield, USA., 2007.
4. Fermentation Microbiology and Biotechnology by El Mansi & Bryce, Taylor & Francis, London, Philadelphia, 1999.
5. Fermentation Biotechnology by O.P. Ward, Open University Press, Milton Keynes, U.K., 1989

6. Industrial Microbiology: An Introduction by Waites, Morgan, Rockey & Highton, Blackwell Science, 2001.

7. Biochemical Engineering and Biotechnology by B. Atkinson & F. Mavituna , The Nature Press, 1982

8. Microbial Biotechnology: Fundamentals of Applied Microbiology by Glazer & Nikaido , W.H. Freeman and Co., New York, 1995.

9. Modern Food Microbiology, 4th edition by J.M. Jay, Springer, 2006.

10. Fundamental Food Microbiology, 3rd edition by B. Ray., CRC press, 2006.

11. Food Microbiology: Fundamentals and Frontiers, 2nd edition by Michael P. Doyle, Larry R. Beuchat, Thomas J. Montville, ASM press, 2001.

12. Food Microbiology by M.R. Adams & M.O. Moss., Royal Society of Chemistry, 2000.

13. Food Microbiology by M.R. Adams, Royal Society of Chemistry, 2008.

MICROB 0905

PRACTICALS

(Based on theory papers)

1. To determine the specific growth rate and generation time of a bacterium during submerged fermentations.
2. To compare glucoamy;ase production by parent and mutant of thermphilic fungus *Thermomucor indicae* under submerged and SSF conditions.
3. To grow yeast (*S. cerevisiae*) and fungus (*Rhizopus* sp.) in artificial medium and to calculate the yield and productivity of the biomass produced.
4. To make wine from different juices by fermentation.
5. To compare glucoamylase production of free and immobilized sporangiospores of *Thermomucor indicae*.