Department of Microbiology

Proposed Syllabus
for
M. Sc. Microbiology
(Academic session 2016-2017)

Central University of Rajasthan
NH-8, Bandarsindri,
Kishangarh-305817
Dist. Ajmer

M.Sc. Microbiology (Revised Course Structure implemented from academic session 2016- 17)

Semester I

Code	Title of the course	Type of Course	Credits
MSMB 101	Prokaryotic and Eukaryotic Microbiology	Core	3
MSMB 102	Microbial Biochemistry	Core	3
MSMB 103	Physics, Chemistry and Statistics for Biologist	Core	3
MSMB 104	Techniques and Instrumentation in Microbiology	Core	3
MSMB 105	Molecular Genetics	Core	3
MSMB 106	Elective I A. Petroleum Microbiology B. System Microbiology C. Among the electives offered by Biotechnology and Biochemistry	Elective	3
MSMB 107	Laboratory I	Core	3
MSMB 108	Laboratory II	Core	3

Total credits: 24

Semester – II

Code	Title of the course	Type of Course	Credits
MSMB 201	Microbial Physiology	Core	3
MSMB 202	Virology	Core	3
MSMB 203	Immunology	Core	3
MSMB 204	Microbial Enzymology	Core	3
MSMB 205	Bioinformatics and Intellectual Property Rights	Core	3
MSMB 206	Elective II A. Bioengineering B. Fungal Biotechnology and Bioprospecting C. Among the electives offered by Biotechnology and Biochemistry	Elective	3
MSMB 207	Laboratory III	Core	3
MSMB 208	Laboratory IV	Core	3

Total credits: 24

Semester – III

Code	Title of the course	Type of Course	Credits
MSMB 301	Microbial Pathogenicity	Core	3
MSMB 302	Recombinant DNA Technology	Core	3
MSMB 303	Environmental and Agricultural Microbiology	Core	3
MSMB 304	Food and Diary Microbiology	Core	3
MSMB 305	Industrial Microbiology	Core	3
MSMB 306	Elective III A. Extreme Microbiology B. Biomass and Energy systems C. Among the electives offered by Biotechnology and Biochemistry	Elective	3
MSMB 307	Laboratory V	Core	3
MSMB 308	Laboratory VI	Core	3

Total credits: 24

Semester – IV

Code	Title of the course	Type of Course	Credits
MSMB 401	Journal Club Presentation	Tutorial/Presentation	3
MSMB 402	Review of Literature for Major project	Tutorial	3
MSMB 403	Major Project (Research Dissertation)	Tutorial/Laboratory	15
MSMB 404	Research Dissertation Presentation	Tutorial/Presentation	3

Total credits: 24

MSMB-101 Prokaryotic and Eukaryotic Microbiology Credit 3

Unit I

Origin and evolution of microbial world; Pathway of discovery in Microbiology; Haeckel's three kingdom concept, Whittaker's five kingdom concept, three domain concept of Carl Woese. General characteristics of various groups of prokaryotes: bacteria including, Rickettsiae, Chlamydiae, Spirochaetes and Actinomycetes, Cyanobacteria and Mycoplasmas.

Eubacteria: cell structure, nutrition, isolation and cultivation. Diversity, nutrition, ecology, significance of Gram-positive (Firmicutes, Actinobacteria) and Gram-negative [Proteobacteria (cyanobacteria, Rhizobia, methanotrophs, myxobacteria, magnetotactic bacteria), *Deinococcus-Thermus*, Spirochaetes, Bacteroidetes].

Unit II

Classification of bacteria and Archaea according to the Bergey's Manual of Systematic Bacteriology. Tools for Systematics: Numerical taxonomy, Phylogenetic analysis, Polyphasic approach; Modern methods of studying microbial diversity; Microbial culture collections.

Phyla of Archaea, Significance of Archaea, Evolutionary developments of Archaea, Cell structure Archaea, Metabolism and energetics of Archaea (*Thermoplasma*, *Sulfolobus*, *Pyrococcus)*.

Phycology: Algal and Cyanobacterial diversity and distribution; Characteristics: cell structure, pigmentation, thallus organization, nutrition, reproduction, alternation of generations; Identification; Culturing, Classification; Phylogeny; Economic importance and applications; Phycovirus, Symbiotic associations of algae with fungi;.

Unit III

Mycology: Fungal diversity and distribution; Cell structures, growth and development, nutrition, reproduction, life cycle; Classification of fungi, Major taxonomic groups of fungi; Identification; Cultivation; Phylogeny;

Yeasts: General characteristic, structure, classification, life cycles (important forms), sexual and asexual reproduction of Yeasts;

Protozoa: Classification, Morphology, reproduction, modes of nutrition, modes of transmission, locomotory organelles, Life cycle, Cultivation of Protozoa. Structure and significance: *Leishmania, Trichomonas, Entamoeba, Plasmodium*

Recommended Books:

1. Madigan MT, Martinko JM, Dunlap PV, Clark DP (2012). Brock Biology of Microorganisms, Prentice Hall, USA.
2. Lansing M Prescott, Donald A Klein, John P Harley, Microbiology, Mc Graw Hill.
3. Michael J Pelczar, Microbiology, Tata McGraw, India.
4. Kathleen Park Talaro, Foundations in Microbiology, McGraw Hill.
5. Christiaan Hoek, David Mann, H. M. Jahns (1995). Algae: An Introduction to Phycology. Cambridge University Press
6. Constantine J. Alexopoulos, Charles W. Mims, Meredith M. Blackwell (1996). Introductory Mycology. John Wiley & Sons.
7. John Webster and Roland Weber (2007). Cambridge University Press, USA.
8. William Purvis (2000). Lichens. Smithsonian's Natural World Series.
9. D.R. Khanna (2004). Biology of Protozoa. Discovery Publishing House.
10. Mark F. Wiser. (2010). Protozoa and Human Disease. Garland Science

MSMB-102 Microbial Biochemistry Credit 3

Unit I

Carbohydrate:Monosaccharide, Disaccharide and Polysaccharide - occurrence, structure, isolation, properties and functions of homoglycans - starch, glycogen, cellulose, dextrin, inulin, chitins, xylans, arabinans, galactans. Occurrence, structure, properties, and functions of heteroglycans Glycoprotein and their biological applications. Lipid: Lipids - classification - saturated and unsaturated fatty acids, phospholipids -classification, structure and functions of lipids. Types and functions of microbial lipoproteins. Amphipathic lipids - membranes, micelles, emulsions and liposomes.

Unit II

Proteins: Classification of proteins on the basis of solubility and shape, structure, and biological functions. Primary structure - determination of amino acid sequence of proteins. The peptide bond: Ramachandran plot. Secondary structure - weak interactions involved - alpha helix and beta sheet and beta turns structure. Super secondary structures - helix-loop-helix. Tertiary structure - alpha and beta domains, quaternary structure. Vitamins and Porphyrins: Vitamins - water soluble - thiamine, riboflavin, niacin. Porphyrins the porphyrin ring system, chlorophyll and cytochrome.

Unit III

Cellular Permeability and Transport process, Bioenergetics of metabolism: oxidation–reduction reactions, coupled reactions and group transfer; enthalpy and free energy of reaction and ATP. Lipid and Nitrogen Metabolism: Oxidation of fatty acid (α, ù, Û), Assimilation of nitrates, ammonia assimilation.

Recommended Books:

1. Nelson D L, Cox M. M. Lehninger s Principle of Biochemistry. 4th ed. Freeman, 2004.
2. Lansing M. Prescott. Microbiology. 5th ed. The McGraw−Hill Companies, β00β.
3. Berg, J. M., Tymoczko, J. L., Stryer, L. Biochemistry. 6th Ed. Freeman, 2006.
4. White David. Physiology and Biochemistry of Prokaryotes. 2nd ed. Oxford University Press, New York, 2000
5. G.N. Cohen (2011), Microbial Biochemistry, Second Edition, Springer Publishers
6. D. Voet, J.G.Voet, C.W. Pratt , Fundamentals of Biochemistry, 3rd Edition by. 2004, John Wiley and Sons, New York.
7. G. Zubay, Biochemistry, , 4th Edition, 1998. Brow Dubuque, Lowa,
8. L. Stryer, Biochemistry, , 5ht, Edition.2002. W.H. Freeman and Co.
9. R.K. Murray, D.K Grammer, P.A. Mayes, V.W. Rodwell, Harper's Biochemistry, 25th Edition. 2000. Appleton and Lange.

MSMB-103 Physics, Chemistry and Statistics for Biologist Credit 3

Unit I

Physics for biologist: Rest and motion Kinematics, Newton's Laws of Motion, Friction, Circular Motion, Work and Energy, Fluid Mechanics, wave motion, Sound Waves, Optics, Kinetic Theory of Gases, Calorimetry, electric current, Electromagnetism. Heat and laws of Thermodynamics: First law of thermodynamics, Enthalpy, Second law of thermodynamics, Entropy, Gibbs free energy, Free energy and equilibrium,.

Unit II

Chemistry for biologist: Atomic structure, Periodic table, Quantum mechanics, Chemical bonding, s,p and d block elements, chemical equilibria, ionic equilibria, chemical kinetics, electrochemistry, Mole concept, Solution Chemistry, Redox chemistry; Organic Chemistry fundamentals, physical chemistry fundamentals. Thermodynamics and macromolecular structure -Basic principle, Molecular mechanics, Molecular potentials, Bonding and non-bonding potentials.

Unit III

Statistics for biologist: Introduction to Biostatistics, Frequency distribution, Variable and attribute, Line diagram, Bar diagram, Pie chart, Histogram, Mean, Median and Mode, Variance, Standard deviation, Standard error of mean, Null hypothesis, Level of significance and Probability, Student‘s t-test, Fisher's t- test, Chi-square test, Regression analysis, Analysis of Variance (ANOVA).

Recommended Books:

1. Physics by Marcelo Alonso and Edward J. Finn, Pearson
2. Concepts of physics part 1 by HC Verma, Bharti bhawan publications
3. Concepts of Physics Part 2 by HC Verma, Bharti Bhawan publications
4. Textbook of First Year Physics by C L Arora, S. Chand publishers
5. Textbook of Second Year Physics by P S Hemne & C L Arora, S. Chand publishers
6. Textbook of Third Year Physics by Dr. R S Hemne & C. L. Arora, S. Chand publishers
7. A Textbook of Chemistry by Dr. R.L. Madan, S. Chand publishers
8. Essential of Physical Chemistry, B S Bahl , G D Tuli & Arun Bahl, S.Chand Publishers
9. A Text book of Biostatistics, by A.K.Sharma, Discovery publishing house
10. Introduction to Biostatistics, By Dr. Pranab Kumar Banerjee, S. Chand Publishers

MSMB-104 Techniques and Instrumentation in Microbiology Credit

3 Unit I

Microscopy: Light Microscopy: simple and compound Microscopy, Phase Contrast, Dark field, Confocal, Atomic force and Fluorescent Microscopy; Electron Microscopy: SEM, TEM, AFM Sample preparation for microscopy; Electrophoretic techniques: Principle of Electrophoresis, Agarose gel electrophoresis, Polyacrylamide gel electrophoresis, Counter current electrophoresis, Immuno-electrophoresis, Support media; Colony counter, Nephlometry, Isoelectric focussing, colorimetry, Turbidometry .

Unit II

Chromatographic techniques: Basics of Chromatography, Paper, Thin layer and Column chromatography; Protein purification; Liquid chromatography; Gas chromatography, Affinity Chromatography, Gel Filtration, Ion Exchange Chromatography. HPLC; Centrifugation techniques: Basic principle, RCF and Sedimentation Coefficient, Types of Centrifugation - High speed and Ultracentrifugation, Differential and Density-gradient centrifugation, Analytical centrifugation and applications, Factors affecting Sedimentation, Preparative and analytical centrifugation, Safety measures of centrifugation.

Unit III

Spectroscopy: Theory and applications, UV-Visible, Fluorescence, IR, FTIR, NMR, Mass spectroscopy, Raman and Atomic absorption spectroscopy; Fluorescence polarization; Radioactivity measurement: Radioactive decay, Liquid scintillation counter- Û ray detection and its applications; Use of stable isotopes in Biological sciences; Autoradiography and tracer technique. Principle of electrochemical techniques, Redox reaction measurement, pH meter and electrode; Thermal techniques: Introduction to thermal Analysis, TG, Differential Thermal analysis and Differential Scanning Calorimetry; X-Ray Diffraction, Micro-array

Recommended Books:

1. Biochemistry by Lubert Stryer
2. Sharma BK, Instrument method of chemical analysis
3. DA Skoog , Instrument method of analysis
4. Plummer, An introduction to practical Biochemistry
5. Chatwal and Anand, Instrumentation
6. Principles and Techniques Of Biochemistry And Molecular Biology, Keith Wilson,

7. John Walker. Cambridge University Press India Pvt. Ltd.
8. Biochemical Techniques theory and practice : White R
9. Analytical Chemistry: Christion G. D.
10. A Biologist Guide to Principle and Techniques: Willson K. and Gounding K. H.

MSMB-105 Molecular Genetics **Credit 3**

UNIT -I

Structure of DNA and RNA: Organization of the Chromosome, Structure of Chromatin - Nucleosomes, Chromatin Domains and Isochores, Structure and Functional Organization of Centromeres and Telomeres, structure of DNA, Watson-Crick model, DNA polymorphism, Chromatin structure and remodeling, Histone code and histone modifications.

DNA Replication: Prokaryotic DNA Polymerase I, II and III, Eukaryotic DNA Polymerases, Fidelity and Catalytic Efficiency of DNA Polymerases, Okazaki Fragments, Replication Origin, Primosomes, Concurrent Replication Mechanism Involving Leading and Lagging Strands of DNA; Problems associated with linear replicons. Mutations and Repair

UNIT -II

Transcription: Prokaryotic RNA polymerase and sigma factors, Prokaryotic and eukaryotic promoters, Eukaryotic RNA Polymerases, Class I, II and III gene promoters, Enhancers and control regions of genes; Mechanism of transcription - Prokaryotic and eukaryotic, Transcription of protein coding genes.

RNA Processing: Processing, Capping, Polyadenylation, Splicing. Processing of Poly A- mRNA, Group I and II Introns, Alternate Splicing, RNA editing. Non-coding RNAs.

UNIT -III

Translation: Genetic Code, Ribosome Structure, tRNAs, Aminoacyl tRNA synthetase, Initiation, Elongation, Termination; Translational Control.

Regulation of Gene Expression: Prokarytes: Operon Concept, Positive and Negative Regulation, Attenuation, Catabolite Repression, Riboswitches. Eukaryotes - Generalized and specialized transcription factors, Transcriptional Activators and regulators.

Books recommended:

1. Jocelyn E. Krebs, Elliott S. Goldstein and Stephen T. Kilpatrick, Lewins Genes X, 9th Edition, Jones and Barlett Pub., USA, 2011.
2. Watson, J. D. Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick, Molecular Biology of the Gene, Benjamin Cummings; 6th Edition, 2007.
3. Robert F. Weaver. Molecular Biology, 4th Edition, McGraw-Hill.
4. Principles of Genetics: Snustad & Simmons
5. Principles of Genetics: Robert Tamarin
6. Genetics: Analysis and Principles: Brooker
7. Genetics: Principles and Analysis: Harlt & Jones
8. Molecular Cell Biology: Lodish
9. Molecular Biology of The Cell: Bruce Alberts
10. Cell & Molecular Biology: Gerald Karp

MSMB-106 Elective I **Credit 3**

A. Petroleum Microbiology

Unit I

Microbiology of oil fields: Introduction to oil fields, formation of oil reservoirs, oil production, indigenous microbial communities in oil fields, microbiology and molecular biology of sulfate-reducing bacteria, hyperthermophilic and methanogenic archaea in oil fields, fermentative, iron-reducing and nitrate-reducing microorganisms.

Unit II

Detrimental effects of bacterial activity: Biodegradation of petroleum in subsurface geological reservoirs, reservoir souring: mechanisms and prevention, microbial control of hydrogen sulfide production in oil reservoirs, microbial corrosion in the oil industry, biofouling in the oil industry.

Unit III

Application of biotechnology in oil production: Microbially enhanced oil recovery: past, present and future, biotechnological upgrading of petroleum, diversity, function and biocatalytic applications of alkane oxygenases, the microbiology of marine oil spill bioremediation, metabolic indicators of anaerobic hydrocarbon biodegradation in petroleum-laden environments, unconventional gas and oil resources: shale gas, oil sands and coal bed methane (CBM).

Recommended Books:

1. Bernard Ollivier, Mitchel Magot (2005). Petroleum Microbiology, ASM Press.
2. Corinne Whitby, Torban Lund Skovhus (2011). Applied Microbiology and molecular biology in oil field systems, Springer.
3. Larry L. Barton, W. Allan Hamilton (2007). Sulphate-Reducing Bacteria: Environmental and Engineered Systems, Cambridge University Press.

B. System Microbiology

Unit I

Basic introduction of system microbiology; An overview of "Omics" technologies including genomics, transcriptomics (RNA-Seq), proteomics, metabolomics, metagenomics and their applications in microbiology; Basic Concepts in high throughput sequencing or Next- Generation Sequencing; Overview of main Next- Generation sequencing methods and techniques and their impacts in food-microbiology, diagnostics and public health microbiology.

Unit II

An overview of Microbial Genomics; Microbial Genome Structure and organization; Characterization of core and Accessaory Genome, Principles of microbial genomics such as sequencing, assembly, annotation of microbial genomes and its application to cultured and uncultured microbial community.

A breif introduction of major bioinformatics tools and resources used in System Microbiology/Microbial Genomics Use and application of various bioinformatics databases and tools in System Microbiology/Microbial Genomics, search and retrieval of biological information and databases sequence for System Microbiology/Microbial Genomics; Microbial genome projects, Microbiome Project.

Unit III

An introduction of functional genomics; Resources for functional genomics; Different methodologies and techiques of functional genomics such as site-directed mutagenesis, Transposon mutagenesis, DNA sequencing, DNA microarray, RNA interference, and Chromatin immune precipitation. Genome annotation, Applications of functional genomics in vaccine and drug desigining, Genome editing, tools involved in genome editing such as CRISPR/Cas9.

Recommended Books:

1. Achuthsankar S Nair (2007). Computational Biology & Bioinformatics – A gentle Overview, Communications of Computer Society of India
2. Baxevanis, A.D. and Ouellette, B.F.F.(2004). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, John Wiley & Sons
3. Intellectual Property Rights: Legal and Economic Challenges for Development: Cimoli
4. Indian Patent Laws: Kankanala KC, Narasani AK
5. P Ganguly, Intellectual Property Rights, Tata McGraw Hill, 2007

MSMB-107 Microbiology Laboratory I Credit 3
(Prokaryotic and Eukaryotic Microbiology)

1. Principles and methods of sterilization.
2. Direct microscopic observations of bacterial shape – cocci, rods, chains, fungal spores, mycelium, yeast budding.
3. Preparation of Media: Nutrient broth, Nutrient agar, plates, slants, soft agar.
4. Pure culture technique: Streak plate, spread plate and pour plate methods.
5. Motility determination
6. Enumeration of bacterial / yeast cells-viable count (Plate count) Total count (Haemocytometer count).
7. Isolation and purification of cyanobacteria, fungi and bacteria.
8. Bacterial staining and fungal staining and micrometry.

MSMB-108 Microbiology Laboratory II Credit 3
(Microbial Biochemistry and Analytical techniques)

1. Demonstration of Microscopy, centrifugation, Chromatography, NMR and XRD
2. Redox measurement and pH measurements
3. Principles of colorimetry and spectrophotometry, its calibration and estimation of O.D.
4. UV-Vis Spectrophotometry and validating the Beer-Lambert's Law.
5. Qualitative and quantitative tests for Carbohydrates- Tests for glucose/starch.
6. Qualitative and quantitative tests for amino acids/ protein..
7. Isolation & Quantification of Genomic DNA from Bacterial culture
8. Polymerase Chain reaction & Agarose Gel electrophoresis

SEMESTER II

MSMB-201 Microbial Physiology Credit 3

Unit I

Introduction to Microbial Physiology: The *E.coli* Paradigm, Metabolic genetic regulation, , Energy, oxidation-reduction vs. fermentation, Nitrogen assimilation; Microbial growth: Growth cycle, continuous culture, factors affecting growth. Carbohydrate metabolism and Energy production: Glycolytic pathways, Gluconeogenesis, TCA cycle, glyoxylate cycle, energy production, oxidative phosphorylation,

Unit II

Transfer of genetic information in prokaryotes: Plasmids, Conjugation, Transformation, Transduction, Recombination, Transposable elements, Osmotic control of gene expression, SOS response and Heat shock response, Electron transport (Respiratory pathway), regulation of nitrogen assimilation and fixation, Phosphate starvation-controlled stimulon, oxidation stress, The Lon system (Proteolytic control).

Unit III

Energetics of chemolithorophs, pH Homeostasis, specific transport systems, cellulose degradation, Metabolism of aromatic compounds, Fermentation pathways in specific group of microorganisms: Lactic acid, propionic acid, butyric acid producing fermentation; Characteristics and Metabolism of autotrophs; Biosynthesis of Fatty acids; Biosysnthesis of Phospholipids, Degradation of Lipids, Endospore formation (differentiation). Bacterial Quorum sensing

Books recommended:

1. Albert G. Moat and John W. Foster, Microbial Physisology, Wiley-Liss, A John Wiley& Sons, Inc. Publications.
2. Roberts, K., Lewis J., Alberts B., Walter P., Johnson A., and Raff. M., Molecular Biology of the Cell, 5th Edition, Garland Publishing Inc., 2008.
3. Pollard, T. D., and Earnshaw, W. C., Cell Biology, 2nd Edition, Saunders Elsevier, 2008.
4. Gerald K., Cell and Molecular Biology, Concept and Experiment, 5th Edition, Wiley, 2007.
5. Lodish, H., Berk A., Kaiser C. A., Krieger M., Scott M.P., Bretscher A., Ploegh H., and Matsudaira P., Molecular Cell Biology, 6th Edition, Freeman, W. H. and Co., 2008.
6. James Darnell, Molecular Cell Biology, 6th Edition, W. H. Freeman & Co, 2007.

MSMB-202 Virology Credit 3

Unit I

General Virology: Brief outline on the history and discovery of viruses, nomenclature and classification of virus, morphology and ultrastructure; capsids and their arrangements; types of envelopes and their composition, Enveloped and non-enveloped viruses, Structural proteins – envelope proteins, matrix proteins and lipoproteins, Viral genomic organization, structure and replication – types of nucleic acid DNA (double stranded and single-stranded), RNA (double stranded, single stranded – positive sense and negative sense), Viral replication, virus related agents (viroids, prions), Viruses of Algae , Fungi and Cyanobacteria. Antivirals agents: Interferons

Unit II

Animal/Plant/Bacteria Viruses: Plant viruses: classification and structure of common plant viruses. Pathophysiology of common viral diseases of plants (ex TMV and CMV). Transmission of plant viral disease. Control and prevention of plants viral diseases.

Animal viruses: Classification and nomenclature of animal and human viruses. Brief account of some important animal and human disease. Prevention, treatment and control of viral diseases. Viral vaccines including DNA vaccines and interferons.
Bacteriophage: Morphology, structure, genome organization and life cycle (lytic and lysogenic) of M13, Mu, and Lambda phage. Phage therapy for control of bacterial diseases.

Unit III
Cultivation and Diagnostic methods of Viruses: General methods for isolation, identification, characterization and cultivation (embryonated eggs, experimental animals, and cell cultures), Direct methods of detection – light microscopy (inclusion bodies), electron microscopy and fluorescence microscopy, serological methods - haemagglutination; complement fixation; immunofluorescence methods, ELISA and Radioimmunoassays, Western Bloting, Nucleic acid based diagnosis: Nucleic acid hybridization, polymerase chain reaction, microarray and nucleotide sequencing, Infectivity assay for animal and bacterial viruses - plaque method, LD_{50}, ID_{50}, IED_{50}

Recommended Books:

1. Fields Virology Vol 1 and 2. B.N. Fields, D.M. Knipe, P.M. Howley, R.M. Chanock, J.L. Melnick, T.P. Monath, B. Roizman, and S.E. Straus, eds.), 3rd Edition. Lippincott-Raven, Philadelphia, PA.
2. Basic Virology Edward K. Wagner, Martinez J. Hewlett, David C. Bloom, David Camerini.
3. Virology: Principles and Applications John Carter, Venetia Saunders.
4. Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses. S. J. Flint, V. R. Racaniello, L. W. Enquist, V. R. Rancaniello, A. M. Skalka.
5. Virology Methods Manual. Brian W.J. Mahy (Editor), Hillar O. Kangro (Editor). Elsevier Science & Technology Books.
6. Methods and Techniques in Virology. Pierre Payment, Trudel (Editor). Publisher: Marcel Dekker.
7. Black JG, 2002 Microbiology-Principles and Explorations. John Wiley & Sons Inc. New York.
8. Dimmock, N. J., Easton, A. J., and Leppard, K. N. 2001. Introduction to Modern Virology. 5th edn. Blackwell publishing, USA.
9. Flint, S.J., Enquist, L.W., Drug, R.M., Racaniello, V.R. and Skalka, A.M. 2000.
10. Principles of Virology- Molecular Biology, Pathogenesis and Control. ASM Press, Washington,D.C.

MSMB-203 Immunology **Credit 3**

Unit-I

Overview of Immune System: Basic concepts of the Immune System, Cells and Organs of the Immune System, Innate Immunity (Inflammation, Complement System, and Cells of the innate immune response) Adaptive Immunity (T lymphocytes, B lymphocytes, Antigen, Super antigens, Immunogens, Adjuvents structure and function of Antibodies, Other cells (NK Cells, macrophages etc.) and molecules such involved in the Immune response, antigen-antibody interactions - principles and applications.

Unit-II

Innate and Adaptive Immunity: Antigen presentation, Antigen presenting cells, Major Histocompatibility Complex, Functions and Types of MHC molecules, interferons, Cytokines, Pattern recognition receptor (ex.Toll like receptors (TLR) and NOD-like receptors (NLR), Lymphocytes Development, Activation and Differentiation, B-Cell Activation, Differentiation, and Memory Generation, T-Cell Activation, Differentiation, and Memory, Immunological memory (Passive and Active Memory)

Unit-III

Immunology in Health and Diseases: Autoimmunity, autoimmune disorders, Tolerance, and Transplantation, Allergy and Hypersensitivity Reactions, Types of Hypersensitivity reactions, Immunodeficiency Disorders, Diseases of the Immune system, vaccines and Immunization, Immunology of Infectious Diseases, Cancer and Immune System, Immunotherapy, Immunodiagnostic methodologies and techniques.

Books recommended:

1. Murphy, Kenneth M., Travers, Paul and Walport, Mark, Janeway's Immuno Biology, 7th Edition, Garland Science, Taylor & Francis Group, 2008.
2. Kindt, T. J.,Osborne, B. A. and Goldsby, R. A. Kuby Immunology, 6th Edition, W. H. Freeman, 2006.
3. Paul, W. E., Fundamental Immunology, 6th Edition, Lippincott Williams and Wilkins, 2008.
4. Abbas, A. K., Lichtman, A. H. and Pillai, S., Cellular and Molecular Immunology, 6th Edition, Saunders, 2007.
5. Roitt's, Essential Immunology. Ivan M Roitt & Peter J. Delves. 10th edition. Blackwell Publishing**.**

MSMB-204 Microbial Enzymology Credit 3

UNIT-I

Enzymes as Biocatalysts: Velocity, Order and Molecularity of a chemical reaction, Kinetic equations for zero, first, second & third order reactions, Determination of order of the reaction, Remarkable properties of Enzymes as Catalysts, Lock and Key theory, Induced-fit hypothesis, Nomenclature and classification.
Enzymes Kinetics: Kinetics of single substrate reaction, Michaelis-Menten equation, steady state kinetics, Kinetic parameters, K_m, V_{max} and K_{cat}, Determination of kinetics parameters using Lineweaver-Burk, Eadie-Hofstee plot, Hanes plot, Variations of velocity with [E], [S], pH and temperature, Bi-substrate reaction kinetics, multi-substrate reactions, Uses of kinetic studies in determining enzyme mechanism.

UNIT-II

Enzyme inhibition: Types of enzyme inhibition- reversible and irreversible, competitive inhibition, non-competitive inhibition, uncompetitive inhibition and kinetics using Lineweaver-Burk and Scatchard plots.
Enzyme mechanism: Mode of action of catalysts, different type of catalysis, Nucleophilic, Electrophilic & Acid-Base Catalysis, Proximity and orientation effects, contributions of strain, Mechanism of action of Chymotrypsin, Ribonuclease and carboxypeptidase.
Allostery: Allosteric enzymes, mechanism of allosteric interactions, subunit structures and protein assembly, symmetrical and sequential model, Hill's coefficients, Cooperativity, positive and negative Cooperativity, Allostery cooperativity in hemoglobin

UNIT-III

Enzyme regulation: Enzyme Regulation of Aspartic transcarbamoylase, Metalloenzymes-carboxypeptidase A, Role of Zinc, Feedback inhibition.
Enzyme technology: Enzyme purification and recovery, Microbial production and application of lipase, amylase and protease, Enzyme Immobilization techniques, use of immobilized enzymes in industrial processes, Enzymes in clinical diagnosis, Isozymes, Abzymes, Ribozymes, Artificial enzymes, Enzyme engineering for thermostability, directed evolution, Site directed mutagenesis.

Books recommended

1. P. F. Cook and W. W. Cleland, Enzyme Kinetics and Mechanism. 3rd Edition, Garland Science,

2007.
2. Carnish Bowden, Fundamental of Enzyme Kinetics, 3rd Edition, Portland Press, 2004.
3. Price, N. C. & L. Stevens, Fundamentals of Enzymology, 3rd Edition, Oxford University Press, 1999.

MSMB-205 Bioinformatics and Intellectual Property Rights Credit 3

Unit I

Basic introduction of Bioinformatics; An overview of major bioinformatics resources; Various databases and bioinformatics tools; Use and application of bioinformatics in research, search and retrieval of biological information and databases sequence; Sequence analysis: pairwise sequence comparison, multiple sequence alignments, structure-function relationship

Unit II

Data base concept, database management system, database browsing and data retrieval, Sequence database and genome database, data structures and databases, databases such as GenBank, EMBL, DDBJ, Swissprot, Ensemble, UCSC genome browser, PlasmoDB, Searching for sequence database using FASTA and BLAST algorithm. Phylogenetic studies, alignment of sequences, gene prediction and regulation, protein classification & structure prediction. Genome analysis methods.

Unit III

Definition of IPR, function, forms of protection, importance of IPR, Patentable subject matter, Novelty, IPR and Developing World, Intellectual Property Management. International conventions and Treaties (WIPO), Introduction of Patents and patent application process (national and International), Trade Secrets, Copy Rights, Geographical Indicators, Trade Marks, PBR in UPOV, GATT and TRIPS, Patent applications- national and international, Patent infringement, Patent Claims and Legal decision-making process.

Recommended Books:

6. Achuthsankar S Nair (2007). Computational Biology & Bioinformatics – A gentle Overview, Communications of Computer Society of India
7. Baxevanis, A.D. and Ouellette, B.F.F.(2004). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, John Wiley & Sons
8. Intellectual Property Rights: Legal and Economic Challenges for Development: Cimoli
9. Indian Patent Laws: Kankanala KC, Narasani AK
10. P Ganguly, Intellectual Property Rights, Tata McGraw Hill, 2007

MSMB-206 Elective II Credit 3

A. Bioengineering

Unit I

Introduction to Bioengineering as an Interdisciplinary between biology and engineering; Material Balances: Law of Conservation of Mass; Procedure for Material-Balance Calculations with examples of Material-Balance in batch and continuous process; Material Balances with Recycle, By-Pass and Purge Streams; Stoichiometry of Growth and Product Formation. Energy Balances: General Energy-Balance Equations; Enthalpy Change in Non-Reactive Processes; cooling in downstream processing; Heat of Reaction for Processes with Biomass Production; Energy-Balance Equation in Fermentation; Unsteady-State Material Balances and Energy balance equations; Solving Unsteady-State Mass Balances; Solving Unsteady-State Energy Balances; Fluid Flow and Mixing-Fluids in Motion; Momentum Transfer; Non-

Newtonian fluids; Viscosity measurements; Rheological Properties of Fermentation Broths; Mixing in bioreactor.

Unit II

Heat-Transfer Equipment-Bioreactor and General Equipments used in and across bioreactor, mechanism of heat transfer, heat transfer between fluids, Design Equations for Heat-Transfer Systems, Application of the Design Equations; Mass Transfer: Molecular Diffusion, Role of Diffusion in Bioprocessing, Convective mass transfer, Oxygen Transfer, dissolution and solubility in bioreactors. Unit Operations involved in Bioengineering; Homogeneous Reactions: Basic Reaction Theory, Calculation of Reaction Rates, Reaction Kinetics for Biological Systems, Growth Kinetic Constants From Batch and continuous growth, Yields in Cell growth, Cell Growth Kinetics, Kinetics of Substrate Uptake by Cell, Effect of Maintenance on Yields, Kinetics of Cell Death.

Unit III

Heterogeneous Reactions in Bioengineering, Concentration Gradients and Reaction Rates in Solid Catalysts, Internal Mass Transfer and Reaction, Effectiveness Factor, External mass transfer, Liquid-Solid Mass-Transfer Correlations, Minimizing Mass-Transfer Effects, Evaluating True Kinetic Parameters, Key concepts on Heterogeneous Reactions in Bioprocessing; Bioreactor Engineering in Perspective, Bioreactor Configurations-stirred tank, bubble column and air-lift reactor, Practical Considerations for Bioreactor Construction, Monitoring and Control of Bioreactors, Ideal bioreactor Operation, sterilization.

Recommended Books:

1. Bioprocess Engineering principles by Pauline M Doran, Elsevier Science and technology Books.
2. Bioprocess Engineering- Basic Concepts by Michael L Shuler and Fikret Kargi, Pearson Education, Inc.
3. Bioprocess Technology: Volume 1 by P T Kalaiselvan and I Arul Pandi MJP PUBLISHERS.
4. Bioprocess Engineering: Systems, Equipment and Facilities by Bjorn K. Lydersen, Nancy A. D'Elia, Kim L. Nelson, Wiley India Pvt Ltd.

B. Fungal Biotechnology and Bioprospecting

Unit I

Fungal diversity; habitat relationship; different ecological groups of fungi Ecotaxonomic approach in chemical screening; primary and secondary products of metabolism; Screening of industrially useful fungal metabolites; drugs and pharmaceuticals from fungi; classification of secondary metabolites; primary and secondary screening of antibiotic producers; auxanography; enrichment culture, techniques for strain improvement and strain development; Industrial important fungal strains

Unit II

Fungal Biotechnology: Fungal biotechnological processes, Principles of fermenter design and operation with respect to Fungal process, types of fermenters used in Fungal Biotechnology, formulation of fermentation medium, analysis of fermentation products especially for fungal biotechnology. Biotechnological applications of fungi and their derivatives, applications in medical science.

Production of antibiotics—beta lactam antibiotics-penicillins and cephalospoins, Organic acids production of citric acid, fungal enzymes and their industrial applications- alpha amylases, cellulases, xylanases, proteases, Vitamins, therauptic peptides; Production and utilization of fungal biomass

Unit III

Edible fungi; Mycoproteins. Advancement in mushroom cultivation technology; Commercial mushroom species; strain improvement and cultivation; tropical mushrooms and their cultivation; mushroom spawns; nutritional aspects of mushrooms. Fungi in food processing, Fungus for Biomass pretreatment for ethanol production.

Fungal biofertilizers and biopesticides , myconematicides Recombinant technology in fungi: composition of the different types of fungal vectors, selection markers, transformation strategies, gene replacement or inactivation, applications and future perspectives.

Suggested Readings:

1. Fungal Biology, 4th ed Blackwell. by Jim Deacon
2. Alexopoulos & Blackwell, Introductory Mycology, John Willey & Sons
3. B.C.Suman & V.P.Sharma, Mushroom Cultivation in India, Daya Publishing House
4. Carlos Alborto brusso, Mohamed Hijri, Mycorrhizal Biotechnology, Capital Publishing
5. D.P.Tripathi, Mushroom Cultivation. Oxford & IBH Publication Company Pvt.ltd
6. Poonam Singh & Ashok Pandey, Biotechnology for agro-Industrial residues utilisation. (2009) ,Springer.
7. Satyanarayana T. and Johri B.N. (2005). Microbial diversity, Current Perspectives and Potential Applications , IK international
8. Nair, L. N. (2007). Topics in Mycology and Pathology, New Central Book agency, Kolkata.
9. Oliver R. P. and Michael Schweizer (1999). Molecular Fungal Biology, CUP.
10. Berry D. R. (1988). Physiology of industrial Fungi, Blackwell Scientific Publishers.
11. Zhingiang Ann (2005). Handbook of Industrial Mycology, CRC Press.

MSMB-207 Microbiology Laboratory III Credit 3

(Microbial Enzymology and Microbial Physiology)

1. Batch fermentation for production of microbial enzymes.
2. Enzymatic Assays (eg. Amylase, protease) and Yield calculations.
3. Study of factors affecting enzyme activity-substrate concentration, temperature, pH, inhibitors.
4. Determination of kinetic parameters for enzyme activity (Km & Vmax).
5. Microbial Growth Kinetics
6. Conjugation in E.coli
7. Transformation in E. coli.
8. Characterization of transformant

MSMB-208 Microbiology Laboratory IV Credit 3

(Immunology, Bioinformatics and Virology)

1. Blood group and Rh typing
2. Immuno-electrophoresis (Rocket Immuno-electrophoresis), Ouchterlony Double Diffusion
3. Radial Immunodiffusion, Agglutination and Immunoblotting
4. Usage the National Center for Biotechnology Information (NCBI), European Molecular Biology Laboratory (EMBL) and other databases for biological information
5. BLAST (Basic Local Alignment Search Tool) analysis of DNA/protein sequence
6. Transduction by Bacteriophage & Determination of Phage Titration
7. Diagnosis of Viral agents by Radio-immunoassays/ELISA (Demonstration)
8. Identification of Viral agents by PCR (Demonstration)

SEMESTER III

MSMB-301 Microbial Pathogenicity Credit 3

Unit I

Microbial Pathogenicity: Basic concepts in microbial pathogenesis, Koch's postulates, molecular Koch's postulates, microbial entry, colonization, persistence, extracellular and intracellular pathogens, viral pathogens, prokaryotic pathogens, eukaryotic (fungi and parasite) pathogens, Infectious disease cycle, virulence mechanisms of pathogens, two-component regulatory system, antigenic variation, phage variation, microbial virulence factors and their genetic regulation, Role of Biofilm and quorum-sensing in virulence, Bacterial secretion systems, various model systems which are used to understand the pathogenic mechanisms.

Unit II

Global climate change and infectious disease: Introduction of infectious diseases, basic concepts in host factors, infectious agents, transmission factors, Ecology of Parasite or vector-borne diseases, Evolution of pathogens, virulence factors, and vectors, the ecology of emerging/remerging infectious diseases Effects of climate and environmental changes on the emergence and re-emergence of infectious diseases, Impact of environmental/climate change on the incidence, prevalence, geographical distribution, and/or severity of infectious diseases, Seasonal variation in host susceptibility of certain infectious diseases.

Unit III

Plants and Human Microbial Pathogens: Basic concept of plant disease, disease cycle & pathogenicity mechanisms and symptoms associated with microbial plant diseases, types of plant pathogens (Bacteria, Fungi and Virus). Distribution and significance of normal human microbial flora, accidental pathogens, oncogenic viruses; Study of following groups of microbial pathogens (Morphological characters, pathogenesis, diagnosis, epidemiology, prophylaxis and treatment),Bacterial- *E. coli*, *Shigella*, *Salmonella*, *Campylobacter*, *Vibrio*, *Staphylococcus*, *Streptococcus*), *Helicobacter pylori*, *Clostridium*,*Mycobacterium spp*.; Viral- HIV, Dengue virus, Hepatitis, Influenza virus; Fungal- *Candida*, *Aspergillus*,; Parasite- *Plasmodium*, *Entamoeba*

Recommended Books:

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.
7. Plant pathology by George N. Agrios: 4th ed., Academic press, New York, 1969.
8. Plant pathology by R.S. Mehrotra: Tata McGraw –Hill publishing company limited. New Delhi.
9. Bacterial plant pathology, cell and molecular aspects by David C. Sigee, Cambridge University Press, 1993.
10. Molecular plant pathology by M. Dickinson: BIOS Scientific Publishers, London, 2003.

MSMB-302 Recombinant DNA Technology Credit 3

Unit I

Techniques and enzymes in genetic recombination: Core techniques and essential enzymes used in recombination: restriction endonucleases, type I, II, III, recognition sequences, properties, nomenclature, classification of type II endonucleases, their activity. DNA ligase: Properties and specificity, S1 nuclease, BAL 31 nuclease, DNA polymerase, polynucleotide kinase, phosphatase, reverse transcriptase its activity and mode of action. Chemical synthesis of DNA. Restriction digestion, ligation and transformation. Properties of Plasmid, incompatibility, isolation and purification techniques,

Unit II

Plasmid vectors and their properties, pBR 322 – its construction and derivatives, single stranded plasmids, promoter probe vectors, runaway plasmid vectors. Bacteriophage lambda (λ) as a vector. Specialized cloning strategies: Expression vectors, promoter probe vectors, vectors for library construction, genomic DNA libraries, chromosome walking and jumping, cDNA libraries, short gun cloning, directed cloning, phage display. RDT for cloning and production of interferon and insulin. PCR methods and Applications: DNA sequencing methods, Dideoxy and Chemical method, Automated sequencing.

Unit III

Molecular mapping of genome: Genetic and physical maps, physical mapping and map –based cloning, choice of mapping population, simple sequence repeat loci, southern and fluorescence in situ hybridization for genome analysis, microcloning, molecular markers in genome analysis: RFLP, RAPD and AFLP analysis, molecular markers linked to disease resistance genes, Application of RFLP in forensic, disease prognosis.

Books recommended:

1. Principles of Gene Manipulations 1994 by Old and Primrose Blackwell Scientific Publications.
2. DNA Cloning: A Practical Approach by D.M. Glower and B.D. Hames, IRL Press, Oxford. 1995.
3. Molecular Biotechnology 2nd Edition by S.B. Primrose. Blackwell Scientific Publishers, Oxford. 1994.
4. Genetic Engineering and Introduction to Gene Analysis and Exploitation in Eukaryotes by S.M. Kingsman and A.J. Kingsman, Blackwell Scientific Publications, Oxford 1998.
5. PCR Technology - Principles and Applications for DNA Amplification by Henry A. Erlich (Ed.) Stockton Press. 1989.
6. Biotechnology: A Guide to Genetic Engineering by Peters.
7. Genetic Engineering – 2000 by Nicholl.
8. Recombinant DNA and Biotechnology: Guide for Teachers. 2nd Edition by Helen Kreuz. 2001.ASM Publications.
9. Molecular Biotechnology: Principles and Applications of Recombinant DNA. 2 nd Edition. 1998 by Bernard R. Glick and Jack J. Pastemak, ASM Publications.
10. From genes to clones by Winnaker.

MSMB-303 Environmental and Agricultural Microbiology Credit 3

Unit I

Soil Microbiology: Classification of soil - physical and chemical characteristics, soil as a habitat for micro-organisms, microflora of various soil types, rhizosphere and rhizoplane.

Nitrogen fixation: asymbiotic and symbiotic nitrogen fixation systems, root nodulation, symbiotic bacteria (process of root nodule formation), leghemoglobin, nitrification and ammonification

Microbial interactions: Symbiosis, mutualism, commensalism, amensalism, competition, antibiosis, actinorrhiza, mycorrhizal fungi and its effect on plants.
Aquatic Microbiology: Water ecosystems (fresh water, pond, lakes), marine habitats (estuaries, deep sea, hydrothermal vents), eutrophication, cyanobacterial and microlagal blooms: ecological implications and human health, toxins produced by cyanobacteria and other microalgae.; Extreme environments and extremophilic microbes: Habitats, diversity, adaptations and potential applications.

Unit II
Aero-microbiology - droplet nuclei, aerosol, assessment of air quality, brief account of air- borne microbes – bacteria, fungi, and viruses, their diseases and preventive measures, phylloplane and phyllosphere microflora, global warming and climate change.
Bio-fertilizers and Biopesticides in agriculture: Principles of crop inoculation with microbial agents, microbial inoculants and production, carriers for inoculants: types and characteristics, strain selection of bacteria, cyanobacteria and microalgae for biofertilizer production, phosphate solubilising microorganisms, AM fungi, plant growth promoting rhizobacteria, (PGPR), biocontrol agents. Bacterial and mycopesticides.

Unit III
Microbial waste recycling: organic compost, vermicomposting, Biogas production, microbial sewage treatment, waste water treatment by microbes.
Microbial leaching and oxidation of minerals (copper bioleaching, cobalt bioleaching, Uranium bioleaching, biooxidation of gold ores, Nickel leaching, acid mine drainage)
Bioremediation of Xenobiotics, petroleum, oil spill, Microbial remediation of heavy metal pollution, tolerance to heavy metal by microbes, resistance developed in microbes to heavy metals,
Microbial deterioration and degradation of plant food materials, leather, store and buildings materials, paper and other cellulosic materials, fuel and lubricants, metals, plastics, cosmetics, pharmaceutical products. Global warming and Climate Change.

Recommended Books:

1. Subba Rao NS (1995). Soil Microbiology, Oxford & IBH Publishing Co. Pvt. Ltd, 4th edition.
2. Rangaswami G, Bhagyaraj DJ (2001). Agricultural Microbiology, Prentice Hall of India, New Delhi, 2nd edition.
3. Dubey RC, Maheswari DK (1999). Textbook of Microbiology, S. Chand & Co. 4. Evans GM, Furlong JC (2011).
4. Environmental Biotechnology- Theroy and application. Wiley-Blackwell.
5. Maier RM, Pepper IL, Gerba CP (2009). Environmental microbiology, Elsevier.
6. Osborn AM, Smith CCJ (2005). Molecular microbial ecology, Taylor & Francis US.
7. Ljungdahl LG, Adams MW, Barton LL, Ferry JG, Johnson MK (2003). Biochemistry and Physiology of Anaerobic Bacteria, Springer. 8. Madigan MT, Martinko JM, Dunlap PV, Clark DP (2012).
8. Brock Biology of Microorganisms, Prentice Hall, USA.
9. Environmental Biotechnology: Principles and Applications by Bruce E Rittmann and Perry L McCarty, McGraw-Hill International editions

MSMB-304 Food and Dairy Microbiology Credit 3

Unit I
Food Microbiology: Micro-organisms and their importance in food microbiology–molds, yeast, bacteria, general features and classification, principles of food preservation, asepsis, control of microorganisms (anaerobic conditions, high temperature, low temperature, drying), factors influencing microbial growth in food–extrinsic and intrinsic factors, chemical preservation and food additives, canning process for heat treatment, Fermented foods. Application of microbial enzymes in food industry.

Unit II

Contamination and spoilage-cereals, sugar products, vegetables, fruits, meat and meat products, fish and sea food, poultry and canned food, detection of spoilage and characterization, methods of food preservation. Food poisoning and foodborne infections; Bacterial toxins and mycotoxins in food; Quality assurance: Microbiological quality standards of food. Government regulatory practices and policies. FDA, EPA, HACCP, ISI, NABL.

Unit III

Microbiology of raw and pasteurized milk, Biochemical changes in fermented milk, Study on spoilage organisms in dairy industry, probiotics. Classification of various groups of microorganisms associated with diary industry, Acid fermented milks (Yoghurt, cultured butter milk), Starter cultures for fermented dairy products (*Streptococcus thermophilus*, *Lactobacillus bulgaricus*), Cheese production: Steps involved in manufacture of cheese, preservation, classification and nutritional aspects.

Recommended Books:

1. Frazier WC, Westhoff DC (1988). Food Microbiology, Mc Graw-Hill, New York.
2. Banwart GJ (1993). Basic food microbiology, CBS Publishers & Distributors Pvt Ltd.
3. Jay JM (1996). Modern Food Microbiology, Chapman and Hall, New York.
4. Ray B (1996). Fundamentals of Food Microbiology, CRC Press, USA.
5. Dairy Microbiology by Robinson Volume I and II
6. Applied Dairy Microbiology Edited by Elmer Marth and James Steele
7. Food Microbiology 2nd Edition by Adams
8. Fundamentals of Dairy Microbiology by Prajapati
9. The technology of Food preservation. Fourth Edition Norman W. Desrosier. CBI
10. Milk and Milk products –Fourth Edition Clarence Henry Eckles, Tata McGraw Hill publishing company limited.

MSMB-305 Industrial Microbiology Credit 3

Unit I

Theory and principles of industrial fermentation, Batch, fed-batch and continuous cultures, Microbial growth and product formation kinetics, media formulation and sterilization, isolation, preservation and improvement of industrially important micro-organisms, inoculum development for industrial fermentations, fermenter design, various types of fermenters used in industrial fermentation. Surface, submerged and solid-state fermentation processes

Unit II

Alcohol production: Preparation of medium, Fermentation process and recovery; Production of Malt beverages: Production of Beer- malting process, mashing process and finishing; other malt products. Production of Wine: Microbial process, wine from grapes, Fermentation and recovery, types of wine-white and red wine. Production of distilled beverages or liquors- rum, whiskey and brandy; Microbial production of organic acids- vinegar production (substrate, Microbial processing and product recovery); Citric Acid- fermentation, recovery and uses; Lactic acid-fermentation, medium and manufacturing process, recovery and uses.

Unit III

Production of antibiotics- strain improvement for secondary metabolite production; Penicillin-Fermentation and recovery; Tetracycline and Chloramphenicol production; Streptomycin-structure, meia composition, production and recovery,

Production of Amino acids: L-Lysine production and strain improvement for lysine production; L-glutamic acid production-strain improvement for glutamic acid production and recovery process; Tryptophan production and recovery.
Production of enzymes: Pectolytic enzymes-Pectinases production, harvest, recovery and uses; Invertase and Lipase production; Cellulase production and recovery;
Production of vitamins: Vitamin B12 (Cyanocobalamine) production; Riboflavin (vitamin B2) production; Biotransformation of steroids.

Recommended Books:

1. Bioprocess Engineering principles by Pauline M Doran, Elsevier Science and technology Books.
2. Bioprocess Engineering- Basic Concepts by Michael L Shuler and Fikret Kargi, Pearson Education, Inc.
3. Bioprocess Technology: Volume 1 by P T Kalaiselvan and I Arul Pandi MJP PUBLISHERS.
4. Bioprocess Engineering: Systems, Equipment and Facilities by Bjorn K. Lydersen, Nancy A. D'Elia, Kim L. Nelson, Wiley India Pvt Ltd.
5. Stanbury PF, Hall SJ, Whitaker A (1999). Principles of Fermentation Technology, Butterworth-Heinemann, 2nd edition.
6. Creuger and Creuger (2001). Biotechnology- A textbook of Industrial Microbiology, Sinauer Associates, Inc.
7. Waites MJ (2001). Industrial Microbiology: An Introduction, Wiley.
8. Industrial Microbiology, Prescott and Dunn

MSMB-306 Elective III **Credit 3**

A. Extreme Microbiology

Unit I

Concept of extremophiles v/s conventional microbial forms & archaea, habitats in universe, econiches, communities and community associations, biofilms, microbial community analysis of extreme environments using various molecular approaches (DGGE, cloning and next generation sequencing, functional genomics and transcriptomics).

Unit II

Occurrence, Physiological features, adaptation strategies of various extremophilic microbes: a) anearobes, barophiles/ peizophiles, cryophiles & thermophiles; b) oligotrophs, osmophiles, halophiles & xerophiles; c) radiophiles, metallophiles & xenobiotic utilizers; d) alkaliphiles/ basophiles, acidophiles. Potential applications of extremophilic microbes.

Unit III

Microbes in toxic environments: acid mine drainage, waste containing cyanides, xenobiotics, pesticides, heavy metals and radio isotopic materials, extremozymes and their applications, field and case studies.

Recommended Books:

1. Brock, T. D. (1978). Thermophilic Microorganisms and Life at High Temperatures, Springer, New York.
2. Fred A Rainey and Aharon Oren (2006). Extremophiles, Academic Press.
3. Horikoshi, K. and W. D. Grant (1998). Extremophiles-Microbial Life in Extreme Environments,Wiley, New York.

4. Gerday, C. And Glansdorff, N. (2007). Physiology and biochemistry of extremophiles. Washington, DC: ASM Press.

B. Biomass and energy systems

Unit I

Fundamentals of bioenergy/biofuel; terms and concepts, origin, characteristics, advantages and disadvantages, use and cost of different types of biomass resources (renewable feedstocks): agricultural energy crops, agro-horticultural lignocellulosic residual material and other biogenous waste- production, availability and attributes for bioenergy production. General principles of the carbon cycle, greenhouse effect and global climate change. Bioeconomy and sustainable bioenergy system, Current and projected future technologies for producing biofuels such as ethanol, biodiesel from oil crops, microbial fuel cells, biohydrogen.

Unit II

Biofuel generations, Pretreatment technologies, structure and function of lignocellulosic biopolymers, various types of pretreatment technologies (Physical, mechanical, chemical, biochemical, ionic liquids etcetera) bioconversion of biomass to biofuel; concept of pseudo-lignin and inhibitors, biodiesel production; environmental impacts of biofuel production; concept of Biorefinery, value-added product generation in an integrated approach, processing of biofuel residues- case studies on combined heat and power (CHP) generation. The role of transgenic plants and algae.

Unit III

Anaerobic digestion process for biogas production, Inoculum- its stability and methane potential, Process microbiology, role of microbes, types and characterization, Effect of pH, temperature, nutrients, organic loading rate (OLR) and hydraulic retention time (HRT) on biogas production from biogenous waste, Storage and stability of digestate- health and safety issues, Up-gradation of biogas to methane.
Life cycle assessment of biofuels and biofuel technologies, India's energy demand and supply management, energy cropping, energy needs for the future: regional prospects and stresses, policy issues.

Recommended Books:

1. Mahesh & Dayal (1992). Renewable Energy Environment and Development, Konark Publishers (P) Ltd.
2. Rao S & Parulakar BB (1994). Energy Technology, Khanna Publishers, New Delhi.
3. David N-S Hon DNS & Nobuo Shiraishi N (2000). Wood and Cellulosic Chemistry, CRC Press.
4. Sorensen B (2010) Renewable Energy, Academic Press.
5. Kasthurirangan G, van Leeuwen J, Robert C (2012). Sustainable Bioenergy and Bioproducts, Springer.

MSMB-307 Microbiology Laboratory V Credit 3
(Microbial Pathogenicity, Environmental and Agricultural Microbiology)

1. Isolation and characterization of microorganisms from soil, water and air samples
2. Isolation of halophiles/acidophiles/methanogens
3. Isolation of Rhizobia from root nodule using Yeast Extract Agar Medium (YEMA)
4. Widal Test
5. Antibiotic susceptibility testing
6. Demonstration of Koch's postulates in plant pathogens
7. Measuring biofilm formation by bacteria

8. Identification of pathogenic bacteria by culture and biochemical methods

MSMB-308 Microbiology Laboratory VI Credit 3
(Food and Dairy Microbiology, Industrial Microbiology and Recombinant DNA Technology)

1. Microbiological analysis of milk, Fruits, Vegetables and Fruit Juices
2. Batch fermentation for production of microbial enzymes. Yield calculations and kinetics.
3. Solid-state fermentation for production of organic acids and study of effect of moisture content.
4. Production and estimation of citric acid (using *Aspergillus niger*) by titrimetric method
5. Biosurfactant production
6. Batch, fed batch and continuous culture growth kinetics studies
7. Ligation and cloning in a plasmid vector
8. Isolation of recombinant plasmid DNA, Confirmation of the insert.