Madras Christian College (Autonomous)

DEPARTMENT OF MICROBIOLOGY
M.Sc. APPLIED MICROBIOLOGY
COURSE CURRICULUM

From June 2018

Program Specific Outcomes

Students of M.Sc. Applied Microbiology will be able to

PSO 1: Understand the concepts of various disciplines of applied microbiology

PSO 2: Perform the role of microbiologist in quality control and quality assurance areas of food, dairy and pharmaceutical industries

PSO 3: Play a vital role in clinical diagnosis and public health sectors

PSO 4: Acquire research methodology skills and develop keen interest in research

PSO 5: Develop interest in bio-entrepreneurship

Madras Christian College

DEPARTMENT OF MICROBIOLOGY

M.Sc. APPLIED MICROBIOLOGY COURSE CURRICULUM

Semester	Core / elective subject	Sub Code	Subject	Hours per week	Credits	CA	ESE
I	Core	185MB1M01	Fundamentals of Microbiology (Theory)	8	5	50	50
	Core	185MB1M02	Fundamentals of Microbiology (Practical)	6	4	50	50
	Core	185MB1M03	Immunology and Immunotechnology (Theory)	8	5	50	50
	Core	185MB1M04	Immunology and Immunotechnology (Practical)	4	3	50	50
	Elective	185MB1E05	Microbial Physiology (Theory)	4	5	50	50
		185MB1E06	Analytical Techniques in Biology (Theory)				
			TOTAL	30	22		
II	Core	185MB2M01	Bacteriology & Parasitology (Theory)	8	6	50	50
	Core	185MB2M02	Bacteriology & Parasitology (Practical)	4	3	50	50
	Core	185MB2M03	Soil, Agricultural and Environmental Microbiology (Theory)	8	5	50	50
	Core	185MB2M04	Soil, Agricultural and Environmental Microbiology (Practical)	4	3	50	50
	Elective	185MB2E01	Research Methodology and Biostatistics (Theory)	4	5	50	50
		185MB2E02	Computer Applications and Bioinformatics (Theory)				
			Internship	-	2	-	-
			Personality Enrichment	2	4		
			TOTAL	30	28		

Semester	Core/ Elective Subject	Sub Code	Subject	Hours per week	Credits	CA	ESE
III	Core	185MB3M01	Microbial Genetics, Molecular Biology and rDNA Technology (Theory)	8	6	50	50
	Core	185MB3M02	Microbial Genetics, Molecular Biology and rDNA Technology (Practical)	4	3	50	50
	Core	185MB3M03	Food, Dairy and Pharmaceutical Microbiology (Theory)	8	5	50	50
	Core	185MB3M04	Food, Dairy and Pharmaceutical Microbiology (Practical)	4	3	50	50
	Elective	185MB3E01	Health Research and Pharmacovigilance (Theory)	4	5	50	50
		185MB3E02	Entrepreneurship in Microbiology (Theory)				
			Soft skills	2	4	50	50
			TOTAL	30	26		
IV	Core	185MB4M01	Virology and Mycology (Theory)	6	5	50	50
	Core	185MB4M02	Virology and Mycology (Practical)	4	3	50	50
	Core	185MB4E01	Microbial Technology and IPR (Theory)	5	4	50	50
	Core	185MB4E01	Microbial Technology and IPR (Practical)	4	3	50	50
	Elective	185MB4E01	Nanobiotechnology (Theory)	4	5	50	50
		185MB4E03	Microalgal Biotechnology (Theory)				
		185MB4M06	Project work	7	4	-	100
			TOTAL	30	24		
			Grand Total	120	100		

Semester I – Core Paper
Fundamentals of Microbiology

Sub Code: 185MB1M01 **Number of Hours: 8**

Course Outcomes:

Upon completion of this course, students will be able to

CO 1: Understand the concepts and fundamental principles of microbiology
CO 2: Appreciate the diversity of microorganisms
CO 3: Know the principles, working, and applications of various microscopes
CO 4: Perform identification of microbial strains
CO 5: Carry out basic microbiological analyses
CO 6: Have knowledge on containment and biosafety
CO 7: Follow safe practices in a microbiology laboratory

Unit – I:

Introduction, History and Evolution of Microbiology**;** Contributions of Van Leeuwenhock, Joseph Lister, Pasteur, Koch, Jenner, Winogradsky, Beijerinck; Impact of microbes on human welfare. Structure of Prokaryotic and Eukaryotic cell. Differences between Eubacteria, Archaebacteria and Eukaryotes.

Unit – II:

Identification, characterization and classification of microorganisms; outline of Bergey's system of classification, Hackel's three kingdom concept, Whittaker's five kingdom concept, three domain concept of Carl Woese. Major characteristics used in Taxonomy: Phenotypic characters, Biochemical tests (e.g. API, BIOLOG), numerical taxonomy, Chemotaxonomic markers, protein profiles, Nucleic acid based techniques; 16S rRNA gene sequencing.

Unit – III:

Microscopy - its principle and applications – simple, compound, Bright field, Dark field, Phase contrast, Fluroscence microscopy, transmission and scanning electron microscopy, STEM, Specimen preparation for electron microscopy. Live cell imaging, Confocal Microscopy, Two-photon microscopy, Polarized Microscopy, Atomic Force Microscopy.

Unit – IV:

Microbial cultures: Concepts of pure culture. Methods of Pure culture isolation, Enrichment culturing techniques, single cell isolation by Micromanipulator technique. Preservation and maintenance of microbial cultures. Staining techniques – Simple and differential staining, special staining – Acid fast staining, Capsule staining, Flagellar staining, Endospore staining.

Unit – V:

Microbiological media – Natural and synthetic, basal, defined complex, enrichment, selective, differential, maintenance and transport media. Control of Microorganisms: Physical

and Chemical methods, Filtration and Radiation methods. Biosafety in Microbiology – common laboratory contaminants, potentially hazardous procedures, Risk Assessment, Restricted access, Biological Safety Level (BSL).

Unit – VI:

Antimicrobial Chemotherapy, Antibiotics – Types and Modes of action, mechanisms of resistance by microorganisms – emergence of multidrug resistance and its managment. Handling and maintenance of laboratory animals – Rabbits, Guinea pigs and Mice.

Text Books:

1. Microbiology by Lansing M Prescott, Donald A Klein, John P Harley, Mc Graw Hill. 10th Edition, 2017.
2. Microbiology: An Introduction by Gerard J Tortora, Berdell R Funke, Christine L Case, Dorling Kindersley (India) Pvt Ltd., 12th Edition, 2015.
3. Microbiology: Application Based Approach by Michael J Pelczar et al., 2009
4. General Microbiology by Roger Y Stanier, John L Ingraham, Mark L Wheelis, 5th Edition, 1992.

Reference Books:

1. Principles of Microbiology by Ronald M. Atlas (1996), Amy Mc Cullen
2. Microbiology: Principles and Explorations by Jacquelyn Black, 9th Edition, 2015
3. Fundamental Principles of Bacteriology A J Salle, 2007
4. General Microbiology by Power and Daginawala, Himalaya Publishing House, Vol-I, 2012
5. General Microbiology by Power and Daginawala, Himalaya Publishing House, Vol-II, 2017
6. Foundations in Microbiology by Kathleen park Talaro, McGraw Hill. Science, 9th Edition, 2014.
7. Microbiology by Stuart Walker, W B Saunders, 2003.

Semester I – Core Practicals
Fundamentals of Microbiology

Sub Code: 185MB1M02 **Number of Hours: 6**

1. Determination of microbial diversity by Hay-infusion broth.
2. Demonstration of motility of bacteria by hanging drop experiment
3. Demonstration of motility by dark field and phase contrast microscope.
4. Staining methods- Gram staining, acid fast staining, negative staining for capsules, metachromatic granular staining, spore staining.
5. Preparation of solid, liquid and semisolid media.
6. Preparation of Enriched and Transport media.
7. Streak plate techniques, pour plate techniques, spread plate techniques, stab culture.
8. Lacto phenol cotton blue-staining of fungi.
9. Demonstration of algae by wet mount.
10. Determination of bacterial growth curve by turbidometry and cell count (viable and microscopic) methods.
11. Preparation of various biochemical media and demonstration of growth in various bacteria.
12. Micrometry

Semester I – Core Paper
Immunology and Immunotechnology

Sub Code: 185MB1M03 **Number of Hours: 8**

Course Outcome:

Upon completion of this course, students will be able to

CO 1: Understand the basic concepts of the human immune system
CO 2: Have knowledge on animal models in immunological studies
CO 3: Acquire knowledge on antigen processing, presentation and elimination
CO 4: Learn about prophylaxis using different vaccines
CO 5: Perform various immunodiagnostic techniques

Unit I

Introduction to immunity. Lymphoid reticular system: Structure and function of the cells and organs of the immune system. Gnotobiotic animals: nude mouse, knock-out mouse. Germ-free animals.

Unit II

Antigens and their properties. Immunoglobulins: Structure, types and functions. Major Histocompatibility complex [MHC]: types and properties. Antibody synthesis and diversity. Types of immunity – innate and adaptive. Phagocytosis and extracellular killing. Monoclonal antibody production.

Unit III

Complement system – classical and alternate pathways. Immunomodulators: cytokines, interleukins. Acquired immune response – Humoral and cell-mediated immune response. Immunodeficiency disorders. Hypersensitivity: Immediate and Delayed. Autoimmune disorders.

Unit IV

Immunodeficiency disorders. Hypersensitivity: Immediate and Delayed. Autoimmune disorders. Cancer immunology: tumor antigen, immune response to tumor, cancer immunotherapy. Transplantation immunology: Immunological basis of graft rejection.

Unit V

Preparation of bacterial, viral and fungal antigens. Prophylaxis: vaccines – live, killed, attenuated, Recombinant DNA vaccine, synthetic peptide vaccine and DNA vaccine. Passive immunization – antitoxins, raising of polyclonal antiserum. Immunization schedule.

Unit VI

Immunotechnology and its applications – Antigen-antibody reactions: precipitation, agglutination, complement fixation test, immunochromatography techniques, radiology in immune diagnosis. Enzyme-linked immunosorbent assay [ELISA], Western blotting, Flowcytometry and Immune electron microscopy. Recent immunological diagnostic techniques.

Text Books:

1. Kuby Immunology (2002) by R.A. Goldsby, T.J. Kindt and B.A. Osborne, W.H. Freeman and Company, New York.
2. Ivan M. Roitt and Peter J. Delves (2001) Essential Immunology, Blackwell Science Ltd. Oxford.
3. Cellular and Molecular immunology, 8th edition (2014), Abul Abbas Andrew H. Lichtman, Shiv Pillai, Elsevier.

Reference Books:

1. C.A. Janeway, P. Travers, M. Walport and M.J. Shlomchik(2001), Immunobiology: The Immune System in Health and Disease. Garland Publishing, USA.
2. Stefan E. Kaufmann, Alan Sher and Rafi Ahmed (2002) Immunology of Infectious diseases , ASM Prxess, USA
3. Peter Wood, (2001).Understanding Immunology University of Manchester, Pearson Education Lts, Essex.
4. Hand book of Human Immunology, 2nd edition, (2008), Maurice R.G. O'Gorman, Albert D. Donnenberg, C.R.C Press.
5. Manual of Clinical Laboratory and Immunology 6th Edition. 2002 by Noel R. Rose, Chief Editor: Robert G. Hamilton and Barbara Detric k (Eds.), ASM Publications.

Semester I – Core Practicals
Immunology and Immunotechnology

Sub Code: 185MB1M04 **Number of Hours: 4**

1. Preparation of bacterial antigen by homogenization.
2. Latex agglutination – RF, ASO and CRP.
3. Haemagglutination – Blood grouping and TPHA.
4. Immunodiffusion techniques – single radial, double immunodiffusion techniques.
5. Counter immunoelectrophoresis.
6. ELISA –HbsAg.
7. Preparation of lymphocytes from peripheral blood by density gradient method.
8. Peripheral blood smear and differential staining.
9. Purification of immunoglobulin by ammonium sulphate precipitation method and SDS-PAGE analysis.
10. Immunochromatography: Demonstration

Semester I – Elective Paper
Microbial Physiology

Sub Code: 185MB1E06 **Number of Hours: 4**

Course Outcomes:

Upon completion of this course, students will be able to

CO 1: Appreciate the microbial diversity based on nutritional requirements
CO 2: Learn about microbial nutrient uptake mechanisms
CO 3: Have an in-depth knowledge on microbial growth kinetics
CO 4: Understand microbial metabolic processes and their bioenergetics
CO 5: Know about concepts of bacterial photosynthesis.

Unit -I

Classification of microorganisms based on nutritional uptake. Entry of nutrients in the cell-passive diffusion, facilitated diffusion and active transport. Utilization of large molecules by extracellular enzymes.

Unit-II

Bacterial growth kinetics, measurement of generation time, synchronous growth, continuous, batch, fed batch culture.

Unit-III

Glycolysis, ED-Pathway, Gluconeogenesis, TCA Cycle, Glyoxylate cycle, HMP pathway, electron transport chain, structure and function of ATPase (bacterial), generation and maintenance of proton motive force, oxidative phosphorylation, inhibitors and un-couplers of electron transport chain and oxidative phosphorylation.

Unit-IV

Concept of anaerobic respiration, oxidized sulfur compounds, and nitrate as electron acceptor with respect to electron transport chain and energy generation, Biochemistry of methanogenesis, Biochemistry of ammonia oxidation.

Unit-V

Protein metabolism-Transamination, Decarboxylation, Deamination, Biosynthesis of purine and pyrimidine bases-salvage and de novo pathways. Fermentation-Homo/heterolactic, mixed acid and alcohol.

Unit-VI

Bacterial photosynthesis-oxygenic and anoxygenic photosynthesis-electron carriers, photosynthetic pigments, photophosphorylation in various groups of photrophic bacteria, electron donors other than water in anoxygenic photosynthetic bacteria.

Text Books:

1. Mandelstam Joel and McQuillen Kenneth (1976) Biochemistry of Bacterial Growth, Blackwell Scientific Publication London.
2. Metzler David E. (2001) Biochemistry: The chemical Reactions of Living Cells, Volume 1&2, Academic Press California.
3. Moat Albert G. and Foster John W. (1988) Microbial Physiology 2nd Ed. John Wiley and Sons New York.

Reference Books:

1. Nelson D. L. and Cox M. M. (2005) Lehninger's Principles of Biochemistry, Fourth edition, W. H. Freeman & Co. New York.
2. Voet Donald and Voet Judith G. (1995) Biochemistry, 2nd Ed.. John Wiley and sons New York.
3. White Abraham, Handler Philip, Smith Emil, Hill Rober, Lehman J. (1983) Principles of Biochemistry, Edition 6, Tata Mc-Graw Hill Companies, Inc.
4. White David (2000) Physiology and Biochemistry of Prokaryotes. 2nd Ed. Oxford University Press, New York.
5. Zubay Geoffrey (1998) Biochemistry, 4th Ed., W. C. Brown, New York.

Semester I – Elective Paper
Analytical Techniques in Biology

Sub Code: 185MB1E05 **Number of Hours: 4**

Course Outcomes:

Upon completion of this course, students will be able to

CO 1: Know about various instruments used in microbiology laboratory
CO 2: Appreciate the use of various instrumentation techniques in analytical biology.
CO 3: Have an in-depth knowledge on principles and methods of bio-analytical techniques.
CO 4: Choose the right technique for a particular analytical process.
CO 5: Understand the pilot-scale and full-scale separation techniques.

Unit I

pH metry and Buffers, Principles and applications of autoclave, hot air oven, Principles of Laminar air flow systems: Biosafety cabinets, Incubators and their types, Water bath.

Unit II

Principles, types and applications of Centrifugation (preparative and analytical) – concept of *g* and rpm, svedberg unit, Types of centrifuges.

Unit III

Colorimetry - Principle, instrumentation and applications. Spectroscopy - visible and UV spectrophotometer. Flame photometry, Mass Spectrometry, Nuclear Magnetic Resonance spectrometry. Measurement of Radioisotopes, Scintillation counter - Autoradiography. MALDI-TOFFs.

Unit IV

Chromatography Techniques: Principles, instrumentation and applications of Chromatography - Paper Chromatography, TLC/HPTLC, Ion-Exchange chromatography, Affinity Chromatography, Gel permeation, GC, LC and HPLC – Reverse-phase chromatography

Unit V

Electrophoresis – principles, factors affecting electrophoresis - Paper Electrophoresis, Gel Electrophoresis: Agarose and PAGE (SDS-PAGE and Native PAGE), 2D Gel Electrophoresis, Western Blotting. Gel Documentation. Principle, component, operation and applications of Thermocycler and FACS.

Unit VI

Principles and applications of Lyophilization, Sonication, Desiccation/Vacuum Desiccation, Microtomy/ultramicrotomy, Homogenization.

Text Books:

1. L. Veerakumari. 2015. Bioinstrumentation. MJP Publisher
2. Webster. 2007. Bioinstrumentation. John Wiley and Sons.
3. M. H. Fulekar and Bhawana Pandey. 2013. Bioinstrumentation. I K International Publishing House Pvt. Ltd
4. MJ Reilly. 2016. Bioinstrumentation. CBS Publishers

Reference Books:

1. Meena Srivastava and Rajesh Singh Yadav. 2007. Principles of Laboratory Techniques and Methods.
2. K. K. Machve. 2007. A Text Book of Bioinstrumentation. Manglam Publications.
3. Abhijit Paintal, Chinmoy Goswami and Rabindra Narain. 2011. Handbook of Bioinstrumentation. Dominant Publishers & Distributors.
4. Salmah B. Karman and S.Zaleha M. diah. 2016. Principal and Techniques of Bioinstrumentation. Intelliz Press.
5. M Prakash. 2009. Understanding Bioinstrumentation. Discovery Publishing House Pvt. Ltd.
6. Wilson K., Walker J. Principle and Techniques of Biochemistry and Molecular Biology. Cambridge University Press (2006) 6th edition.

Semester II – Core Paper
Bacteriology and Parasitology

Sub Code: 185MB2M01 **Number of Hours: 8**

Course Outcomes:

Upon completion of this course, students will be able to

CO 1: Understand about bacterial diseases, pathogenesis and treatment
CO 2: Learn about the collection, transport and processing of clinical samples
CO 3: Acquire knowledge on diagnostic procedures in bacteriology
CO 4: Gain knowledge about emerging bacterial infections
CO 5: Know about common parasitic infections
CO 6: Identify the medically-important parasites
CO 7: Have knowledge on control and prevention of parasitic diseases.

Unit-I

Classification of medically important bacteria, normal flora of human body, collection and storage of clinical specimens, transport media, microbiological examination of clinical specimens, antimicrobial susceptibility testing, methods and guide lines- CLSI, EUCAST. Antimicrobial therapy.

Unit-II

Morphology, classification, characteristics, pathogenicity, laboratory diagnosis and treatment of diseases caused by *Staphylococci, Streptococci, Pneumococci, Neisseriae, Bacillus, Corynebacteria, Mycobacteria* & *Clostridium.*

Unit-III

Morphology, classification, characteristics, pathogenicity, laboratory diagnosis and treatment of diseases caused by *Enterobacteriaceae, Pseudomonads, Vibrios, Mycoplasma, Helicobacter (Helicobacter pylori), Ricketssiae* & *Spirochaetes.* Nosocomial, and opportunistic infection - prevention and control.

Unit-IV

Introduction and classification of parasites. Laboratory techniques in Parasitology. Intestinal amoebae – *Entamoeba histolytica*, Free living amoebae – *Naegleria fowleri*, *Acanthamoebae* sp. Intestinal and genital flagellates – *Giardia lamblia, Trichmonas vaginalis*.

Unit – V

Blood and tissue flagellates – *Leishmania donovani*, *Trypanosoma cruzi* & *Trypanosoma brucei complex.* Malarial parasites, *Toxoplasma gondii*, *Cryptosporidium* sp.

Unit-VI

Infection of helminthes – Cestodes – *Taenia saginata, Taenia solium* and *Echinococcus granulosus*. Trematodes - *Fasciola hepatica, Paragonimus westermani* and *Schistosomes*. Nematodes – *Ascaris lumbricoides, Ancylostoma duodenale, Trichuris trichiura, Enterobius vermicularis* and *Wuchereria bancrofti*.

Text Books:

1. Tom Parker,M., Leslie H. Collier. (1990). Topley &Wilson's Principles of Bacteriology,Virology and Immunity (VIII Edition).
2. Greenwood, D., Slack, R.B. and Peutherer, J.F.(2002) Medical Microbiology, 16th Edn. Churchill Livingstone, London.
3. Finegold, S.M. (2000) Diagnostic Microbiology, 10th Edn. C.V. Mosby Company, St. Louis.
4. Ananthanarayanan, R. and Jayaram Panicker C.K. (2004) Text book of Microbiology. Orient Longman, Hyderabad.

Reference Books:

1. Gerhardt, P., Murray, R.G., Wood, W.A. and Kreig, N.R. (Eds) (1994) Methods for General and Molecular Bacteriology. ASM Press, Washington, DC.
2. Subhash Chandra Parija, 2004. Text book of Medical Parasitology – Protozoology and Helminthology. 2nd edition, published by All India Publishers and Distributors, Medical book publisher, New Delhi.
3. Chatterjee, 1986. Medical Parasitology. Tata McGraw Hill, New Delhi.
4. Karyakarte, R.P. and Damle, A.S., 2005. Medical Parasitolog. Revised edition. Published by Books and Allied (P) Ltd., Kolkatta.
5. Jeyaram Paniker, 2004. Text book of Medical Parasitology. 5th edition, JAYPEE brothers, Medical Publishers (P) Ltd, New Delhi.
6. Ichpujani, R.L. and Rajesh Bhatia, 2003. Medical Parasitology. 3rd edition, JAYPEE brothers, Medical publishers (P) Ltd, New Delhi.

Semester II – Core Practicals
Bacteriology and Parasitology

Sub Code: 185MB2M02 **Number of Hours: 4**

1. Staining of clinical specimens - Wet mount, Differential and Special staining methods.
2. Isolation and identification of bacterial pathogens from clinical specimens - cultivation in basal, differential, enriched, selective and special media - Biochemical identification tests.
3. Enumeration of bacteria in urine to detect significant bacteriuria.
4. Antimicrobial sensitivity testing - Kirby bauer method and Stokes method.
5. Minimum inhibitory concentration (MIC) test.
6. Minimum bactericidal concentration (MBC) test.
7. Normal saline/Lugol's iodine preparation for the examination of parasites in stool.
8. Examination of faeces by concentration methods.
9. Thin and thick blood smears examination for malarial parasite.

Semester II – Core Paper
Soil, Agricultural and Environmental Microbiology

Sub Code: 185MB2M03 **Number of Hours: 8**

Course Outcomes:

Upon completion of this course, students will be able to

CO 1: Appreciate and understand the recent findings in the area of microbial ecology
CO 2: Understand the management of crop infectious diseases in a sustainable way
CO 3: Isolate and identify the agriculturally important plant pathogens
CO 4: Learn the commercial production of biofertilizers
CO 5: Isolate, maintain and preserve the potential microbial strains from the environment
CO 6: Perform microbiological analysis of environmental samples
CO 7: Design a working model on a bioremediation system
CO 8: Understand the concepts of environment management system

Unit – I

Soil as a habitat for microorganisms - Methods of studying microbial ecology of soils - Influence of environmental factors on soil microflora - Interactions between soil microorganisms - Interaction between microbes and plants: Rhizosphere, Phyllosphere, Mycorrhiza, Actinorrhiza - Microorganisms as biofertilizers – Bacterial biofertilizers: Rhizobium, Azospirillum, Azotobacter; cyanobacterial biofertilizers - Mass production and field application of biofertilizers.

Unit –II

Biogeochemical cycling – Gaia hypothesis – Carbon reservoirs and carbon cycle - Organic matter decomposition and humus formation – Nitrogen cycling: Ammonification, nitrification and denitrification; Biological nitrogen fixation by diazotrophs; symbiotic and non-symbiotic nitrogen fixation; Biochemistry of nitrogen fixation – Phosphorous, Sulphur, Iron and Manganese cycles.

Unit –III

Epidemiology of plant diseases – Pathology, aetiology and control of economically important crop diseases caused by bacteria (bacterial blight of paddy), fungi (downy mildew of grapes, red rot of sugarcane) and viruses (Tobacco mosaic). Microorganisms as biopesticides – *Bacillus thuringiensis*; integrated pest management.

Unit –IV

Microbiology of air – Bioaerosols and Aeromicrobiological pathway – Air sampling devices and enumeration of microflora – Air-borne pathogens - Air sanitation and microbiological air standards. Microbiology of water – Water pollution and water-borne pathogens – Microbiological examination of water and indicator organisms – Sewage treatment: Primary, secondary and tertiary treatments; biological sludge treatment – Role of microorganisms in secondary treatment of industrial wastewaters.

Unit –V

Concepts of waste to wealth – Applications of biosludge - Biofuels: Bioethanol, biomethane; fertilizers/manure - Bioleaching of ores, Bioremediation and Biodegradation - Biodegradation of recalcitrant compounds: lignin, pesticides and plastics – Negative role of microorganisms in environment: biodeterioration of paper, leather and monuments; biocorrosion; biofouling and its prevention.

Unit –VI

Extremophiles and their survival strategies - Environmental prospecting of potential microbes - Molecular techniques to assess microbial community structure, function and dynamics in the environment - culturable and non-culturable bacterial analysis - Concept of metagenomics - Biological carbon sequestration - Carbon footprints, carbon credits and carbon trading – Concept of environmental economics - Environmental auditing: Environmental management system and ISO 14000.

Text Books:

1. Subba Rao N.S. (2009). Soil Microbiology (4th Edition), Oxford & IBH Publishing Co. Pvt. Ltd.
2. Robert L. Tate (2000). Soil Microbiology (2nd edition), John Wiley.
3. Rangaswami G &Mahadevan A (1998). Diseases of Crop Plants in India (4th Edition), Prentice–Hall of India Pvt. Ltd.
4. Ravichandra N.G. (2013). Fundamentals of Plant pathology. PHI Learning Pvt Ltd.
5. Sharma P.D. (2010). Microbiology and Plant pathology (2nd edition). Rastogi Publications.
6. Atlas R.N.& Bartha R. (1998). Microbial Ecology – Fundamentals and Applications (4th Edition), Benjamin Cummings.

Reference Books:

1. Pepper I.L., Gerba C.P. & Gentry T.J. (2014). Environmental Microbiology (3rd edition). Academic Press, Elsevier.
2. Bitton G. (2011). Wastewater Microbiology (4th edition). Wiley-Blackwell.
3. Bridgewater L. (2012). Standard Methods for the Examination of Water and Wastewater. American Public Health Association.
4. Woolverton C.J., Sherwood L., Willey J. (2016). Prescott's Microbiology (10th edition). McGraw-Hill Education.
5. Shrivastava A.K. (2003). Environment Auditing. A.P.H. Publishing Corporation.
6. Tinsley S., & Pillai I. (2012). Environmental Management Systems – Understanding Organizational Drivers and Barriers. Earthscan.
7. Brohe A., Eyre N. &Howarth N. (2012). Carbon Markets – An International Business Guide. Earthscan.

Semester II – Core Practicals
Soil, Agricultural and Environmental Microbiology

Sub Code: 185MB2M04 **Number of Hours: 4**

1. Enumeration of microorganisms in air by settle plate, impingement and impaction methods.
2. Enumeration of microorganisms from soil/rhizosphere soil.
3. Isolation of free-living nitrogen fixers from soil.
4. Isolation and enumeration of *Rhizobium* from root nodules of leguminous plants.
5. Isolation and enumeration of phosphate-solubilizing microorganisms from soil.
6. Construction of Winogradsky column for studying phototrophic soil bacteria.
7. Enumeration of microorganisms from phylloplane by leaf disc dilution and leaf impression methods.
8. Visual examination, observation, and identification of some common plant infections.
9. Isolation of plant pathogens: *Xanthomonas* from citrus canker leaf samples and *Erwinia* from infected carrots.
10. Isolation and identification of fungal plant pathogens.
11. Enumeration of microorganisms from water.
12. Qualitative analysis of coliforms in water by Presence-Absence test.
13. Determination of coliforms in water: MPN method and membrane filtration method.
14. Detection of faecal coliforms in water by Ejekman's test.
15. Estimation of 5-day BOD in sewage sample.
16. Determination of MLSS/sludge settlability in activated sludge sample/TSS in sewage sample.

Semester II – Elective
Research Methodology and Biostatistics

Sub Code: 185MB2E01 **Number of Hours: 4**

Course Outcomes:

Upon completion of this course, students will be able to

CO 1: Understand the needs and importance of scientific research.
CO 2: Design a research work of their interest independently.
CO 3: Acquire knowledge on different sampling techniques for research.
CO 4: Appreciate the concepts of scientific writing.
CO 5: Prepare a project proposal and write a research thesis or report.
CO 6: Apply appropriate statistical methods for the analysis of scientific research data.
CO 7: Make use of statistical software.

Unit I

Importance and need for scientific research. Research ethics. Selection of research problem. Designing of research work. Introduction to sampling methods. Different types of controls. Setting up of hypothesis.

Unit II

Scientific writing – Characteristics – Logic format for writing thesis and papers. Essential features of abstracts, introduction, review of literature, materials and methods, results and discussion. Process of peer review and scientific publication. References styles - Harvard and Vancouver systems. Chicago referencing style. Components of research proposal.

Unit III

Statistics - Definitions, functions and applications. Data - Types of data, methods of collection of primary and secondary data. Tabulation and diagrammatic presentation of data. Frequency distribution. Graphical representation – Histogram, frequency polygon, Ogive curves and Pie diagram.

Unit IV

Measures of central tendency: mean, median and mode. Measures of Variation- Range, Quartile Deviation, Mean Deviation and Standard Deviation. Correlation - Positive and negative correlation and Karl Pearson's Co-efficient of correlation. Linear and Multiple Regression equations. Estimation of an unknown variable using regression equation. Test for independence of attributes.

Unit V

Sampling techniques - Sample selection and Sample Size. Tests of significance: Small sample test (Chi-square, t-test, F-test), Large sample test (Z-test) and standard error. Analysis of variance (ANOVA) - One - way &Two- way.

Unit IV

Introduction to probability theory and its distribution (concept without problems) Binomial, Poison and Normal distribution (concept without problems). Computer applications in scientific research. Common software for documentation, presentation and analysis of data. Computer Oriented statistical techniques – Frequency table of Uni-variate, central tendency, Standard deviations,'t' test and Correlation coefficient.

Text Books:

1. Statistics for Biologists - Richard Colin Campbell, University of Cambridge, 3rd edition, 2012.
2. Statistical Methods, 8th Edition by George W. Snedecor , William G. Cochran. Campbell, R.C
3. Fundamentals of Biostatistics (2011) by Veer Bala Rastogi

Reference Books:

1. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, John W. Creswell (fifth edition).
2. Practical Statistics for experimental biologist by Wardlaw, A.C. (1985)
3. Statistics in biology, Vol. 2 by Bliss, C.I.K. Mc Graw Hill, NewYork.
4. Research Methodology for Biological Sciences, (2014) by N. Gurumani.

Semester II – Elective
Computer Applications and Bioinformatics

Sub Code: 185MB2E02 **Number of Hours: 4**

Course Outcomes:

Upon completion of this course, students will be able to

CO 1: Know about basic principles of computer science in biology
CO 2: Gain a working knowledge of Microsoft Office
CO 3: Understand fundamentals of software and programming languages
CO 4: Have knowledge on transformation of Biological Information into Computer-Based Information
CO 5: Understand about important bioinformatics databases and their applications
CO 6: Perform pair-wise and multiple sequence alignment

Unit I

Introduction to Computers. Generations of Computer development, Types of computers. Input and output devices.

Unit II

Computing Platforms – Windows, Macintosh, Unix and Linux). Web Page creation using HTML. MS Word, MS Powerpoint, MS Excel.

Unit III

Introduction to Internet, WWW, Web browsers, Network basics – LAN, WAN, WLAN. Application of Computers in Military, Education, Industry and Diagnostic Microbiology.

Unit IV

Introduction to Bioinformatics, Research area and Challenges in Bioinformatics. Programming Languages in Bioinformatics – PERL and PYTHON. Database systems - Importance of biological databases. Primary and secondary databases- sequence and structure databases. Genomic databases. Scoring matrices- PAM, BLOSUM. Heuristic database search methods- BLAST and FASTA.

Unit V

Sequence alignment: Pair wise sequence alignment- Dynamic Programming for Sequence Similarity- Smith Waterman Algorithm and Needleman Wuntch Algorithm. Pairwise alignment tools. Multiple Alignments and Phylogenetic analysis: Progressive and iterative alignment and tools based on these algorithms- Clustal Omega and MultiAlign. Introduction and basic tools for phylogenetic analysis.

Unit VI

Microarray - DNA & Protein arrays. Drug discovery - Structure based drug designing and virtual screening by automated docking, de novo sequence; Molecular docking, evaluation of docking prediction. Computer Aided Drug design.

Text Books:

1. Dave Taylor. 2nd ed, 2000. HTML 4.0. Tata McGraw –Hill Publishing Company Ltd, New Delhi
2. Paul Mcfedries. 2016. My Microsoft office 2016 Sams publishing techmedia, New Delhi.
3. Rajagopalan. 1987. Understanding Computers Tata McGraw–Hill Publishing Company Ltd, New Delhi.
4. HH Rashidi & LK Buehler (2002). Bioinformatics Basics: Applications in Biological Science and Medicine, CRC Press, London
5. David W. Mount. 2004. Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press.
6. Des Higgins & Willie Taylor (2002). Bioinformatics: Sequence, structure and databanks, Oxford University Press
7. Arthur M. Lesk, 2013. Introduction to Bioinformatics. 4th Editon. Oxford University press.

Reference Books:

1. Sharon Crawford. 1998. Windows 98 No Experience Required. BPB publications, New Delhi
2. Systems Biology: Definitions and perspectives by L.Alberghina H.V.westerhoff, Springer. 2005
3. Andreas D. Baxevanis, B. F. Francis Ouellette. 2004. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, 3rd Edition. John Wiley & Sons, Inc. Publication.
4. Westhead, Parish and Twyman. 2002 Instant notes in Bioinformatics. Taylor & Francis Publications.
5. Bibekanand Mallick. 2008. Bioinformatics: Principles And Applications. Oxford University press.
6. Özlem Taştan Bishop. 2014. Bioinformatics and Data Analysis in Microbiology. Caister Academic Press.
7. Brian D. Robertson and Brendan W. Wren. 2012. Systems Microbiology: Current Topics and Applications. Caister Academic Press.

Semester III – Core Paper
Microbial Genetics, Molecular Biology and rDNA Technology

Sub Code: 185MB3M01 **Number of Hours: 8**

Course Outcomes:

Upon completion of this course, students will be able to

CO 1: Understand genomics, gene expression and regulation.
CO 2: Appreciate the role of microorganisms in modifying genes and proteins for fundamental research.
CO 3: Develop insight into gene mapping and construction of genomic libraries.
CO 4: Learn about genetic characterization of mutants.
CO 5: Apply the principles and techniques of molecular biology in a wide arena.

Unit – I

Historical perspectives of Microbial genetics and Molecular biology- Overview of Mendelian Genetics- Nucleic acids as genetic material-structure and properties-repetitive DNA-linking number-heterochromatin & euchromatin-gene concept.

Unit – II

Organization of prokaryotic genetic material (nucleoid) and eucaryotes (chromosomes, ploidy and nucleosomes), Molecular mechanism of DNA replication in prokaryotes and eukaryotes. Gene expression-transcription-types of RNA polymerases-DNA foot printing-promoters, enhancers and silencers-post transcriptional modification, Genetic code, translation, post translational modification.

Unit – III

Gene regulation –An overview on levels of regulation-Operon concept-Positive and negative regulation in E.coli-Lac Operon and Ara operon, regulation by attenuation-Trp Operon. Eucaryotic gene regulation. Gene transfer mechanism- transformation, Conjugation and transduction. Gene mapping in E.coli & Yeast. Introduction to Phage Genetics.

Unit – IV

Mutation and Mutagenesis- Molecular mechanism of mutation – genetic analysis of mutants, DNA damage and repair-Types of damage and repair mechanisms. Carcinogenicity testing (Ames test). Genetic recombination-Molecular models of recombination & transposons-Structure of bacterial transposons and molecular mechanism of transposition.

Unit – V

Tools of recombinant DNA technology-Restriction enzymes- types and properties, DNA joining enzymes-(ligase, topoisomerse, recombinase) and oligonucleotides-linkers, adapters, homopolymer tailing. Source DNA-genomic DNA, synthetic DNA, cDNA and PCR products. Vectors –plasmid, phage, cosmid, shuttle and expression vectors. Cloning hosts-E.coli and Yeast, Cloning strategies.

Unit – VI

Construction of genomic and c-DNA libraries, screening and isolation of recombinants-reporter genes, Genomics-mapping and sequencing genomes, Comparative genomics. Proteomics -analysis of protein expression, Metabolomics-brief introduction.

Text Books:

1. Molecular Biology. 1995, by David Freifelder, Narosa Publ. House.
2. Text Book of Molecular Biology. 1994, by Sivarama Sastry et al, Macmillan India Ltd.
3. Gene Cloning and DNA Analysis – An Introduction. Fifth edition-2006 .T.A Brown. Blackwell Pub.
4. Principles of Gene Manipulation: An introduction to genetic engineering. 2001. 6th ed. Old and Primrose. Blackwell Scientific Publ.
5. David Freifelder, John Cronan and Stanly R. Maloy. 2009. Microbial Genetics. 2nd Edition. Narosa publishing house.
6. Keya Chaudhuri. 2012. Recombinant DNA Technology. The Energy and Resources Institute, TERI

Reference Books:

1. Advanced Molecular Biology: A Concise Reference. 1998, by R.M. Twyman. Viva Books Pvt. Ltd.
2. Concepts of Genetics, Seventh edition -2007, William S. Klug & Michael R. Cummings. Darling Kindergluy.
3. Molecular Genetics of Bacteria. 2nd Edition, 2003. By S. Snyder and W. Champness. ASM press.
4. Principles of Gene Manipulation and Genomics. Seventh edition -2008, S.B. Primrose and R.M. Twyman. Blackwell pub.
5. Recombiant DNA Genes and Genomes: A Short course. Third edition -2007 James D. Watson, Amy A. Caudy, Richard M. Mayes & Jan A. Witkow.
6. K. Rajagopal.2012. Recombinant DNA Technology and Genetic Engineering. Tata McGraw Hill Education Private Limited.

Semester III – Core Practicals
Microbial Genetics, Molecular Biology and rDNA Technology

Sub Code: 185MB3M02 **Number of Hours: 4**

1. Quantitative estimation of DNA and RNA-Colorimetric and UV absorption methods.
2. Isolation of plasmid DNA by alkali lysis method.
3. Isolation of chromosomal DNA from bacteria.
4. Isolation of RNA from yeast.
5. Restriction digestion of DNA.
6. Ligation of DNA.
7. Transformation in E.coli.
8. Protein separation by SDS-PAGE.
9. Restriction mapping of λ phage.
10. Demonstration of Conjugation in E.coli.

Semester III – Core Paper
Food, Dairy and Pharmaceutical Microbiology

Sub Code: 185MB3M03 **Number of Hours: 8**

Course Outcomes:

Upon completion of this course, students will be able to

CO 1: Appreciate the significance of microbiology in food, dairy and pharmaceutical industries.
CO 2: Perform the role of microbiologist in Quality Control and Quality Assurance Departments in the above industries.
CO 3: Know about the production of fermented food, dairy and pharmaceutical products.
CO 4: Exploit microorganisms for efficient production of fermented products.
CO 5: Learn about the microbial standards and limits.
CO 6: Have an idea on certification and auditing procedures.

Unit – I

Scope of food microbiology; Food as a substrate for microorganisms; Microorganisms important in food microbiology; Factors influencing microbial growth in food – extrinsic and intrinsic factors. Principles of food preservation, canning, heat treatment – Determination of TDP, TDT, D, F and Z values. Concept of predictive microbiology in foods.

Unit – II

Contamination and spoilage – source of spoilage causing microorganisms, spoilage of cereals, sugar products, vegetables, fruits, meat and meat products, fish, sea foods, poultry - Methods for microbiological examination of foods - Food-borne infections and intoxication. Detection methods for food-borne pathogens.

Unit – III

Food from microbes – Fermented foods - Production of sauerkraut, idli, tempeh, soy sauce, kombucha, natto, miso, kimchi, gundruk - GM foods - Food safety, quality control and HACCP - food control agencies, fssai and other international standards, certification systems and food auditing.

Unit – IV

Dairy microbiology: Scope and Introduction – Composition of milk, types of microorganisms in milk and sources of microbial contamination of milk - Microbiological examination of milk – Principles and methods of industrial pasteurization - Manufacture of cheese, butter, acidophilus milk, yoghurt, kefir, koumiss.

Unit – V

Ecology of microorganisms in pharmaceutical industry – Water analysis and area monitoring - Microbial contamination, spoilage and standards of various pharmaceutical products –

Sterile and non-sterile pharmaceutical products – Microbial limit test of pharmaceutical products - Sterility testing and pyrogen testing - Antibiotic bioassays: diffusion assays, transferase assays – luciferase assays - HPLC in drug analysis.

Unit – VI

Pharmaceutical products from microorganisms – Commercial production of penicillin, streptomycin, bacterial vaccines, viral vaccines - Quality control and Quality assurance in pharmaceutical industries – Good pharmaceutical manufacturing practices (GPMP/GMP) in pharmaceutical industries – Regulatory authorities and their role in drug standards, quality and safety – certification systems.

Text Books:

1. Adams M.R., Moss M.O. and McClure P. (2016). Food microbiology. 4th edition. The Royal Society of Chemistry, Cambridge, UK.
2. Frazier W.C. and Westhoff D.C. (1988). Food Microbiology. 4th edition, McGraw Hill, New York.
3. Robinson R.K. (2005). Dairy Microbiology Handbook 3rd edition. Wiley Interscience.

Reference Books:

1. Food Safety Management. (2014). Edited by Motarjami Y and Lelieveld H. Academic Press, Elsevier.
2. Denyer S.P., Hodges N., Gorman S.P. and Gilmore B. (2011). Hugo and Russell's Pharmaceutical Microbiology. 8th edition, Wiley-Blackwell.
3. Sandle T. (2016). Pharmaceutical Microbiology: Essentials for Quality Assurance and Quality Control. Woodhead Publishing, Elsevier.
4. Microbiology in Pharmaceutical manufacturing. (2008). 2nd Edition. Vol I & II edited by Richard Prince. Published by PDA.
5. Mehra P.S. (2011). A textbook of Pharmaceutical Microbiology. I.K. International Publishing House Pvt. Ltd.

Semester III – Core Practicals
Food, Dairy and Pharmaceutical Microbiology

Sub Code: 185MB3M04 **Number of Hours: 6**

1. Enumeration of bacteria in milk by standard plate count method and breed count method.
2. Dye reduction test - Methylene blue test, Resazurin test.
3. Litmus milk test.
4. Microbiological analysis of food samples: bakery products, creams and spreads, fruits, vegetables.
5. Microbiological analysis of fermented/non-fermented milk products – yoghurt, curd and ice creams.
6. Isolation of lipolytic organisms from butter.
7. Design of HACCP plan/flowchart for any one food product.
8. Microbial limit test of raw materials/excipients/packing materials used in pharmaceutical manufacturing.
9. Sterility testing of injectables, saline and ophthalmic preparations.
10. Sterility testing of surgical cotton, gauze, surgical gloves, and soluble powders.
11. Determination of microbial load in non-sterile pharmaceuticals (syrups/tablets/creams).
12. Microbiological analysis of pharmacognostic preparations.
13. Evaluation of chemical disinfection by phenol coefficient test.
14. Determination of surface microbiological quality of autoclaves/vessels/incubators by contact plate method.
15. Swab testing of irregular surfaces/operators' hands.
16. Microbiological quality of air in sterile areas/filtration chambers.

Semester III – Elective Paper
Health Research and Pharmacovigilance

Sub Code: 185MB3E01 **Number of Hours: 4**

Course Outcomes:

Upon completion of this course, students will be able to

CO 1: Understand the concepts of public health.
CO 2: Acquire knowledge about emerging and re-emerging infectious diseases.
CO 3: Learn the importance of environmental sanitation and health services.
CO 4: Identify preventive strategies for prevalent health problems.
CO 5: Become familiar with pharmacovigilance concepts and practices.
CO 6: Work in pharmacovigilance firms.
CO 7: Appreciate the importance of adverse drug reactions in clinical practices.

Unit I

Concepts of Health - Biomedical concept, Ecological concept, psychological and holistic concepts. Definitions of Health – WHO definition. The practice of Public health – Measures of public health. Impact of health care on population health – usage of health services – purpose and methods of health impact assessment.

Unit II

Evolution of human disease – emerging and re-emerging infectious diseases – factors affecting the growth and spread of infectious disease – control of infectious disease. Health effects of smoking – diet and health nutrition. Importance of environmental sanitation and personal hygiene. Impact of health care on population health – usage of health services – purpose and methods of health impact assessment.

Unit III

Introduction to Pharmacovigilance: Objectives and scope of Pharmacovigilance. Types and mechanisms of ADRs, Risk factors associated with ADRs. Drug – drug interactions, other causes of drug related problems, management of patients affected by ADRs, medication errors.

Unit IV

Using drugs effectively – choice of therapy, identification of therapeutic problems, preparation of planned therapeutic regimens, Drug use in multiple illnesses, combined therapies. Principles of using approved names vs. brand names, non-text book information sources needed for effective use of drugs.

Unit V

Safety monitoring process and Good Pharmacovigilance practices (GPP): The monitoring process, differing regulations concerning safety data collection requirements. Designing a system to collect good quality information.

Unit VI

Reporting to regulatory authorities – individual case safety reports, periodic safety update reports, answering queries from regulatory authorities, updating product labeling – emphasis on safety changes. Safety file retentions.

Text Books:

1. S. K. Gupta. 2011. Textbook of Pharmacovigilance ICRI Institute Of Clinical Research (India). Jaypee Publications.
2. Park's text book of Preventive and Social Medicine – K. Park (12th edition).
3. Health education and community pharmacy: P. C. Dandiya, Z. Y. K. Zafer, Afifa Zafer.
4. Textbook of therapeutics Drug and Disease Management: Eric T Herfindel, Dick R. Gourley, 6th ed.

Reference Books:

1. Assuring Data Quality And Validity In Clinical Trials For Regulatory Decision Making : Janet Woodcock, Frederick Ognibene, John Overbeke.2003;Welly Publication
2. Mann's Pharmacovigilance. 2014. 3rd Edition. Wiley-Blackwell Publications.
3. Barten Cohert. 2011. Cobert's Manual of Drug safety and Pharmacovigilance. 2nd Edition. Jones and Bartlett Publishers, Inc
4. Judith Green and Nicki Thorogood. 2014. Qualitative methods for Health Research. 3rd Edition. SAGE Publications, Inc.
5. Greg Guest and Emily E. Namey. 2015. Public Health Research Methods. SAGE Publications, Inc.
6. Ravi Humbarwadi. 2016. Clinical Research and Pharmacovigilance. CreateSpace Independent Publishing Platform

Semester III – Elective Paper
Entrepreneurship in Microbiology

Sub Code: 185MB3E02 **Number of Hours: 4**

Course Outcomes:

Upon completion of this course, students will be able to

CO 1: Make business decisions to emerge as a successful bioentrepreneur.
CO 2: Identify a process to develop new drugs and other microbial products.
CO 3: Explore information about funding agencies.
CO 4: Gain knowledge on Government regulations on microbial products.
CO 5: Know about importance of bioprospecting in product development.
CO 6: Have knowledge on IPR procedures.
CO 7: Do holistic business.

Unit – I

Entrepreneurship: Concept, nature, scope and importance of entrepreneurship – introduction to bioentrepreneurship, Distinction between self-employment and entrepreneurship, barriers in entrepreneurship. Government regulations for microbial products.

Unit – II

Impetus in Food and Pharmaceutical Industries: New Product Development, strategies, planning for marketing, Process designing for microbial products, Food safety Laws and Standards: Food Certification Agencies. New drug development and approval process: Strategies for new drug discovery, combinatorial approaches to new drug discovery, pre-clinical and clinical trials. Biopharmaceuticals – production site, machineries, manpower, warehouse and logistics.

Unit – III

Project Planning and Management: Laboratory Competence, Health and Safety awareness. Budget Planning – Ratio analysis, Investment Process, Break even analysis, Profitability analysis, Funding agencies in India – SIDBI, SSIDC, MSME Act Small Scale Industries, NSIC.

Unit – IV

Fermentation start-ups - A brief survey of organisms (isolation, preservation and maintenance of industrially important microorganisms), processes, products. Basic concepts of Upstream and Downstream processing in Bioprocess, Standard operating protocols, Documentation criteria for laboratory, pilot scale and large-scale set ups.

Unit – V

Role of knowledge centres in biotechnology businesses: Universities and research institutions. Hypothesis generation and testing. Technology development for microbial products, Assessment of scaling up of technology, Technology transfer: Transfer agencies

and regulations. IPR: patents, copyrights, trademarks; invention step, biopiracy and bioprospecting.

Unit – VI

Advertising and Branding: Introduction, Choice of Media, Message, Measuring effectiveness of advertising. Branding: Concepts and benefits, Packaging & Labelling. Quality Management: Quality Concepts & tools, Importance and need for Quality Systems, Quality Standards with special reference to ISO, Quality System Certification Procedures.

Text Books:

1. Entrepreneurship in Biotechnology: Managing for growth from start-up By Martin Gross Mann, 2003
2. Innovation and entrepreneurship in biotechnology: Concepts, theories & cases by D. Hyne & John Kapeleris, 2006
3. Dynamics of Entrepreneurial Development and Management by Vasant Desai, Himalaya Publishing House, 2005.

Reference Books:

1. Projects Planning Analysis, Selection, Implementation & Review by Prasannan.
2. Peter F. Stanbury, Stephen J. Hall & A. Whitaker, Principles of Fermentation Technology, Science & Technology Books, 1995.
3. B. Sivasanker – Food Processing And Preservation, Prentice-Hall Of India Pvt. Ltd. New Delhi 2002.
4. Vaclavik, Vickie, Christian, Elizabeth W - Essentials of Food Science (2008)
5. Walsh, G., Biopharmaceuticals: Biochemistry and Biotechnology, Wiley (1998).

Semester IV – Core Paper
Virology and Mycology

Sub Code: 185MB4M01 **Number of Hours: 6**

Course Outcomes:

Upon completion of this course, students will be able to

CO 1: Know about the characteristics of medically-important viruses and fungi.
CO 2: Identify viral and fungal infections by serodiagnostic techniques.
CO 3: Perform a survey of emerging and re-emerging diseases.
CO 4: Gain knowledge on construction of viral vectors.
CO 5: Appreciate the development of newer diagnostic tools.

Unit-I

Historical perspectives- Morphology of viruses-General properties of viruses-Current ICTV Classification of viruses, Cultivation of viruses-Identification of virus-infected cells, sub viral agents- viroids, virusoids, and prions. Serodiagnosis.

Unit-II

Life cycle of Bacteriophages: lytic and lysogenic cycle- One step growth curve. General life cycle of bacteriophages: Øx174, M13, Mu, T4, λ, and P1 phages. Phage typing.

Unit-III

Plant viruses: Brief life cycle of type species of plant viruses-TMV and Cauliflower mosaic viruses, management of plant viral infections. Algalviruses, Mycophages, Insect viruses-Brief lifecycle. Viruses used in genetic engineering.

Unit-IV

Laboratory diagnosis and pathogenesis of Animal viruses: DNA viruses - Adeno, Pox, Herpes and Hepadna viruses. RNA viruses- Polio, Rabies and Retroviruses. Arboviruses: Dengue & Chikungunya, Ebola, H1N1 virus. Other emerging viral diseases. Viral vaccines and drugs.

Unit-V

Morphology, Taxonomy, classification of fungi, detection & recovery of fungi from clinical specimen. Dermatophytes and agents of superficial mycoses. Trichophyton, Epidermophyton & Microsporum. Yeasts of medical importance – Candida, Cryptococcus – Mycotoxins, Antifungal agents, testing methods and quality control

Unit-VI

Dimorphic fungi causing systemic mycoses, Histoplasma cocciodes: sporothrix, Blastomyces. Opportunistic fungi: - fungi causing Eumycotin mycetoma. Newer methods in diagnostic mycology.

Text Books:

1. Morag C. and Timbury M.C. (1994). Medical Virology.IV Edition Blackwell Scientific publishers.
2. Conrat H.F., Kimball P. C. and Levy J.A. (1994). Virology 3rd edition, Prentice Hall, Englewoodcliff New Jersey.
3. Mehrotra, R.S. and K.R. Aneja: An introduction to Mycology. New Age International publishers.

Reference Books:

1. Edward K. Wagner, Martinez J. Hewlett, (2004), Basic Virology, Blackwell Publishing
2. Alexopoulos, C.J. and C.W. Mims: Introduction to Mycology. Wiley Eastern Ltd, New Delhi.
3. Fundamentals of Mycology, J.H. Burnett, Publisher: Edward.
4. The Fungi. M. Charlile and S.C. Watkinson, Publisher: Academic Press.

Semester IV – Core Practicals
Virology and Mycology

Sub Code: 185MB4M02 **Number of Hours: 4**

1. Isolation of phages from natural resources.
2. Titration of phages.
3. Egg inoculation of viruses-different routes-Allantoic, amniotic, yolk sac and CAM.
4. Preparation of chick embryo fibroblast culture.
5. Observation of viral inclusion bodies (slides).
6. Identification and Classification of common fungi.
7. Mounting and staining of VAM spores.
8. Examination of different fungi by Lactophenol cotton blue staining.
9. Examination of different fungi by KOH staining.
10. Cultivation of fungi and their identification - Mucor, Rhizopus, Aspergillus, Penicillium.
11. Microscopic observation of different asexual fungal spores.
12. Microscopic observation of fungal fruiting bodies.
13. Identification of Dermatophytes.

Semester IV – Core paper
Microbial Technology and IPR

Sub Code: 185MB4E01 **Number of Hours: 5**

Course Outcome:

Upon completion of this course, students will be able to

CO 1: Get equipped with a theoretical and practical understanding of Microbial technology
CO 2: Appreciate the use of microorganisms in the manufacture of industrial products
CO 3: Appreciate the relevance of microorganisms from an industrial perspective
CO 4: Acquire knowledge on industrial fermentation process and its optimization
CO 5: Have sound knowledge on downstream processes
CO 6: Gain an understanding of the basic concepts of Patents, Trademarks, and Copy rights
CO 7: Independently perform the role of a fermentation technologist in industries

Unit – I

Fermentation – Definition, Brief history and developments in fermentation. Primary and Secondary metabolites, Types of fermentation – Solid state, liquid state, Submerged, batch, fed-batch and continuous fermentation. Fermenters – Design, Components, Types and Sterilization. Optimization of fermentation parameters – pH, temperature, foaming, aeration and agitation.

Unit – II

Industrially important microorganisms - Isolation, preservation, screening and improvement of strains - handling - development of inoculum for various fermentation processed upstream processing - media for industrial fermentation - formulation - sterilization.

Unit – III

Downstream processes : Introduction, Recovery of particulates filtration, centrifugation, sedimentation, emerging technologies for cell recovery, product isolation, extraction, solvent extraction, aqueous two phase system, sorption, precipitation, reverse osmosis, ultra filtration.

Unit – IV

Fermentation of microbial products – Single Cell Protein (SCP). Non-distilled beverages (beer and wine) and Distilled beverages (Whisky and Brandy). Aerobic fermentation (vinegar and citric acid). Vitamins (B12, riboflavin), Hormone (IAA). Enzyme (amylase, protease), Amino acids (Lysine, tryptophan).

Unit – V

Modern trends in microbial production - Bioplastics (PHB, PHA), Biopolymers (Dextran, Alginate), Biosurfactants, Probiotics, Nutraceuticals, Mushroom cultivation. Microbial Enhanced Oil Recovery (MEOR), Bioconversion and Biotransformation of steroids.

Unit – VI

Intellectual Property Rights (IPR), Patents - The GATT & TRIPs, Concept and Need for patents, Patenting of biological materials, implication of patenting, Patent process and current issues. Trademarks, Copyrights, Trade secrets, Industrial designs. Patenting of Traditional Knowledge, Patenting of transgenic organisms, genes and DNA sequences. Patent process in India, Filing and Forms – Provisional and complete specification. World Intellectual Property Organization (WIPO), Patent Cooperation Treaty (PCT) and international patenting.

Text Books:

1. Peter F. Stanbury, Stephen J. Hall, and Allan Whitaker. 2016. Principles of Fermentation Technology. 3rd Edition. Butterworth-Heinemann publishers.
2. Ronald M. Atlas. 1999. Manual of Industrial Microbiology and Biotechnology. American Society for Microbiology; 2nd Revised edition edition
3. Gerald Reed. 1981. Prescott and Dunn's Industrial Microbiology. Chapman & Hall publishers

Reference Books:

1. Samuel C. Prescott. 2016. Industrial Microbiology. Agrobios (India) Publishers.
2. L.E. Casida. 2016. Industrial Microbiology. 2nd Edition. New Age International.
3. Waites M.J., Morgan N.L., Rockey J.S. and Higton G. (2001). Industrial Microbiology: An Introduction. 1st edition. Wiley – Blackwell.
4. Fogarty W.M. & Kelly C.T. (2012). Microbial Enzymes and Biotechnology (2nd edition). Elsevier Applied Science.
5. Goldberg E. (2012). Handbook of Downstream Processing. Blackie Academic & professional, Chapman and Hall.
6. Singh K.K. (2014). Biotechnology and Intellectual Property Rights: Legal and Social Implications. Springer.

Semester IV – Core Practicals
Microbial Technology and IPR

Sub Code: 185MB4E01 **Number of Hours: 4**

1. Preparation of wine from grape juice and estimation of alcohol.
2. Immobilization of Microbial cells by entrapment method.
3. Production of alcohol using free and immobilized yeast cells.
4. Production of citric acid using Aspergillus niger.
5. Screening of antibiotic-producing organisms from soil.
6. Screening of amylase-producing organisms from soil.
7. Screening of cellulase-producing organisms from soil.
8. Isolation of protease-producing organisms from soil.
9. Preparation of Yoghurt
10. Cultivation of Spirulina (SCP)
11. Cultivation of edible mushrooms
12. Estimation of phycobilins from cyanobacteria
13. Production of antimicrobial substances from lactobacilli and demonstration of antibacterial activity of the same
14. Visit to a nearby industry

Semester IV – Elective Paper
Nanobiotechnology

Sub Code: 185MB4E01 **Number of Hours: 4**

Course Outcomes:

Upon completion of this course, students will be able to

CO 1: Know about the classification and properties of nanomaterials.
CO 2: Learn about the methods of synthesis of nanoparticles.
CO 3: Understand advanced experimental and computational techniques for studying nanomaterials.
CO 4: Know about toxicity evaluation of nanoparticles.
CO 5: Understand the applications of nanotechnology in microbiology.
CO 6: Appreciate the application of nanoparticles in diagnosis and therapeutics.

Unit-I

Introduction to nanobiotechnology, Nanosize, Types of nanomaterials and their classifications (1D, 2D and 3D etc. Nanocrystal, Nanoparticle, Quantum dot, Quantum Wire and Quantum Well etc).

Unit-II

Synthesis of Nanomaterials- physical, chemical and Biological Methods.

Unit-III

Characterization of nanoparticles – quantification – UV - Spectrophotometer, particle size-DLS, SEM, TEM, AFM, XRD, EDAX, VSM, surface charge-zeta potential, ICP-OES.

Unit-IV

Nanomaterial based Drug delivery and therapeutics-surface modified nanoparticles, MEMS/NEMS based nanoparticles, peptide/DNA coupled nanoparticles, lipid and inorganic nanoparticles for drug delivery, Metal/metal oxide nanoparticles as antibacterial, antifungal and antiviral agents.

Unit-V

Nanomaterials in diagnosis-Imaging, nanosensors in detection of pathogens. Treatment of surface water, ground water and waste water contaminated by toxic metal ions, organic and inorganic solutes and microorganisms.

Unit-VI

Toxicity of nanoparticles and Toxicity Evaluation-Cyto-toxicity, Geno-toxicity, In vivo tests/assays.

Text Books:

1. Brydson, R. M.; Hammond, C., Generic Methodologies for Nanotechnology: Characterization. In Nanoscale Science and Technology, John Wiley & Sons, Ltd: 2005
2. Leggett, G. J.; Jones, R. A. L., Bionanotechnology. In Nanoscale Science and Technology, John Wiley & Sons, Ltd: 2005.
3. Goodsell, D. S., In Bionanotechnology, John Wiley & Sons, Inc.: 2004.
4. Pradeep,T.;Nano:The Essentials-Understanding nanoscience and nanotechnology, Tata McGraw-Hill :2007.

Reference Books:

1. Nanobiotechnology by David Goodsell. John Wiley
2. Handbook of Nanostructured biomaterials and their applications in nanobiotechnology by Nalwa HS 2005. American scientific publishers
3. Nanobiotechnology by Niemeyer CM & Mirkin CA 2005 .Wiley Interscience
4. Sharon, Madhuri and Maheshwar, 2012, Bio-Nanotechnology: concepts and
5. applications. New Delhi, Ane books Pvt Ltd.

Semester IV – Elective Paper
Microalgal Biotechnology

Sub Code: 185MB4E03 **Number of Hours: 4**

Upon completion of this course, students will be able to

CO 1: Develop a keen interest in thrust research areas of microalgal biotechnology
CO 2: Have an in-depth knowledge on microalgal cultivation systems
CO 3: Learn the business prospects of commercial microalgae production
CO 4: Understand the health and commercial benefits of microalgal single cell proteins
CO 5: Acquire knowledge on the production of various value-added products
CO 6: Appreciate the use of phycoremediation technology in waste treatment
CO 7: Know about the importance of microalgal biofuel research for a sustainable future

Unit – I

Introduction to Algae: General characteristics - Classification of algae according to Fritsch: Salient features of different groups of algae – Distribution: Freshwater, brackish water and marine algae - Identification methods – Economically important microalgae.

Unit – II

Cultivation of freshwater and marine microalgae – Growth media – Isolation and enumeration of microalgae – Laboratory cultivation and maintenance – Outdoor cultivation – Photobioreactors: construction, types and operation; raceway ponds – Heterotrophic and mixotrophic cultivation -Harvesting of microalgae biomass.

Unit – III

Microalgae in food and nutraceutical applications – Algal single cell proteins – Health benefits of Spirulina - Cultivation of Spirulina and Haematococcus – Microalgae as aquatic, poultry and cattle feed – Microalgal biofertilizers.

Unit – IV

Value-added products from microalgae – Pigments – Production of microalgal carotenoids and their uses – Phycobiliproteins: their production and commercial applications – Polyunsaturated fatty acids as active nutraceuticals – Microalgal polysaccharides and their industrial applications - Microalgal secondary metabolites and their pharmaceutical and cosmetic applications.

Unit – V

Microalgae in environmental applications – Phycoremediation – Domestic and industrial wastewater treatment: High-rate algal ponds and surface-immobilized systems – Treatment of gaseous wastes by microalgae: sequestration of carbon dioxide – Scavenging of heavy metals by microalgae – Negative effects of algae: algal blooms, algicides for algal control.

Unit – VI

Microalgae as feedstock for production of biofuels – Carbon-neutral fuels - Lipid-rich algal strains: *Botryococcus braunii* – Drop-in fuels from algae: hydrocarbons and biodiesel - bioethanol, biomethane, biohydrogen and syngas from microalgae biomass – Biocrude synthesis from microalgae – Integrated biorefinery concept – Life cycle analysis of algae biofuels.

Text Books:

1. Fritsch F.E. (1959). The structure and reproduction of the algae. University Press.
2. Sharma O.P. (2011). Algae Tata McGraw-Hill Education.
3. Becker E.W. (1994). Microalgae: Biotechnology and Microbiology. Cambridge University Press.
4. Venkataraman L.V., Becker E.W. (1985). Biotechnology and Utilization of Algae: The Indian Experience. DST and CFTRI, India.

Reference Books:

1. Andersen R.A. (2005). Algal culturing techniques. Academic Press, Elsevier.
2. Fox R.D. (1996). Spirulina: Production and Potential. Edisud.
3. Bux F. (2013). Biotechnological Applications of Microalgae: Biodiesel and Value-added Products. CRC Press.
4. Singh B., Bauddh K., Bux, F. (2015). Algae and Environmental Sustainability. Springer.
5. Das D. (2015). An algal biorefinery: An integrated approach. Springer.