

15 Microbiology

TRIMESTER WISE DISTRIBUTION OF COURSES

I TRIMESTER

		L	P
MB 501	MICROBIOLOGY-I	4	1
MB 502	SOIL MICROBIOLOGY-I	3	2
MB 503	MORPHOLOGY AND ECOLOGY OF PHOTOSYNTHETIC MICRO-ORGANISMS	3	1
MB 504	TECHNIQUES IN MICROBIOLOGY	1	2
MB 608	IMMUNOLOGY-IMMUNODIAGNOSTICS IN AGRICULTURE	3	1
MB 691	SEMINAR	1	0

II TRIMESTER

MB 505/ ES 505	MICROBIAL ECOLOGY	3	1
MB 507	FOOD MICROBIOLOGY	3	2
MB 512/ AC512/ PL. PATH 521/ ENT 512/ NEMA 513	NANOTECHNOLOGY IN CROP PROTECTION	2	1
MB 601	PHYSIOLOGY OF ALGAE	3	1
MB 603	BACTERIAL PHYSIOLOGY-I	3	1
MB 607	MICROBIAL GENETICS	3	1
MB 609	RECENT ADVANCES IN MICROBIAL BIO-TECHNOLOGY	3	1
MB 691	SEMINAR	1	0

III TRIMESTER

MB 506	MICROBIOLOGY OF MILK AND WATER	2	1
MB 508	SOIL MICROBIOLOGY II	3	1
MB 602	INDUSTRIAL MICROBIOLOGY	4	1

MB 604	BACTERIAL PHYSIOLOGY- II	2	1
MB 605	ALGAE IN AGRICULTURE AND INDUSTRY	3	0
MB 606	APPLICATIONS OF MICROORGANISMS IN AGRICULTURE	1	2
MB 691	SEMINAR	1	0

Core Courses

M.Sc.: MB 501, MB 504, MB 606, BIO 501

Ph.D.: MB 503, MB 602, MB 607

MICROBIOLOGY

Major Fields : Environmental and Evolutionary Microbiology

Plant Microbe Interactions

Industrial Microbiology

Minor Field : Ph.D. student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.

M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

MB 501 MICROBIOLOGY-I

(4L+1P) I

Objective

To teach the basic concepts in development of microbiology science, diversity in structure and functions of microbial cells, classification of archaea, prokaryotes and eukaryotes and economic importance of microorganisms

Theory

UNIT I

Development and scope of microbiological science, Microbial world, History of microbiology and types of micro-organisms, Prokaryotic and eukaryotic cell, Classification and major characteristics of different microbial groups.

UNIT II

Bacterial growth and reproduction, Bacterial communication, Environmental and nutritional requirements for microbial growth, Pure cultures, Control of microorganisms: Principles, methods including radiation, Chemicals, Antibiotics etc.

UNIT III

Morphological characteristics, Internal structures and their functions in bacteria, archaea, algae, cyanophages, viroids, prions, fungi, actinomycetes, mycoplasma, rickettsias, chlamydia, viruses, bacteriophages.

UNIT IV

Economic importance of microbes, Role of microorganisms in environment, soils, mining, food, industry and pharmaceuticals, Recent development on microbial communities and role in nutrient cycling.

Practicals

Methods of isolation, purification and maintenance of microorganisms, Aseptic techniques: Sterilization and autoclaving, Selective and enrichment culturing, Use of antibiotics and chemicals, Morpho- physiological and biochemical characterization of bacteria, Isolation of selected groups of microorganisms such as nitrogen fixers and phosphate solubilizers.

Suggested Readings

- Atlas, R.M. 1984. Microbiology : Fundamentals and Applications, Collier Macmillan, London.
- Brock, T.D. 1961. Milestones in Microbiology, Infinity books.
- Brock, T.D. 2008. Biology of Microorganisms, (Ed.) Madigan MT, Martinko J M, Dunlap PV, Clark D P, 12th ed. Pearson, New Jersey.
- Davis, B.D., Dulbecco, R. and Eisen, H.N. 1990. Microbiology, 4th ed. Lippincott JB, Philadelphia.
- Jeffrey, Pommerville C. 2011. Alcamo's Fundamentals of Microbiology, Ninth Edition, Jones and Bartlett Publishers, International Student Edition, Boston, p 805.
- Meynell, G.C. and Meynell, E. 1996. Theory and Practice. In : Experimental Bacteriology, 2nd ed., Cambridge University Press, London.
- Moselio, Schaechter and Joshua, Lederberg 2004. The Desk Encyclopedia of Microbiology, Elsevier Academic Press, London, p 1149.
- Pelczar, M.J. Jr , Chan, E.C.S. and Krieg, N.R. 1997. Microbiology, Concepts and Application, 5th ed. Tata McGraw Hill New York.
- Stanier, R.Y., Adelberg, E.D. and Ingraharg, J.L. 1976. General Microbiology, 4th ed. MacMillan, New Jersey, U.S.A.
- Tauro, P., Kapoor, K.K. and Yadav, K.S. 1996. Introduction to Microbiology, Wiley Eastern.

MB 502 SOIL MICROBIOLOGY-I

(3L+2P) I

Objective

To teach the basic concepts related to soil environment (microbial cycling of elements, diversity in microbial functions, microbial interactions, plant growth promoting microorganisms: conventional and molecular methods of microbial identification and enumeration-role of microorganisms in productive systems and ecological health)

Theory

UNIT I

Soil microorganisms: Major groups, their diversity, abundance, characteristics .

UNIT II

Direct and indirect methods of studying soil microorganisms and their activities: Dilution plate count method, Burried slide technique, G+C estimate, MPN method, Staining procedures and identification aided by microscopy, Molecular methods of microbial diversity analysis : RISA, TGGE, DGGE, T-RFLP, BIOLOG, FAME analysis.

UNIT III

Carbon cycle, Decomposition of organic matter, Dynamics of micro-organisms during formation of soil organic matter, Humus and fulvic acid, Quantity and distribution of organic matter in soil.

UNIT IV

Biodegradation of starch, Cellulose, Hemicellulose, Pectin and lignin in soil , Nitrogen cycle: Ammonification, Nitrification, Denitrification, Non-symbiotic and symbiotic nitrogen fixation through bacteria and nitrogen assimilation, Soil health, Major microbial indicators and their significance.

Practicals

Quantification of total bacterial, fungal and actinomycetes counts from soils by pour & spread plate method under contrasting agronomic use, Assessment of soil microbial activity by soil respiration, dehydrogenase and FDA- hydrolysis analysis, Evaluation of cellulase activity of soil microflora in soils with and without amendment with crop residues, Evaluation of the amylolytic activity of soil microflora and its comparison with known (standard) microorganisms, Study of the decomposition rate of different agricultural residues in soil by carbon dioxide evolution method, Fractionation of soil organic matter content (Humus), Estimation of ammonia oxidizing bacteria and nitrite oxidizing bacteria from a soil sample using most probable number (MPN) technique, Isolation of free living nitrogen fixing bacteria from a soil sample.

Suggested Readings

Alexander, M. 1977. Soil Microbiology, John Wiley.

Paul, E.A. 2007. Soil Microbiology, Ecology and Biochemistry, Academic Press.

Subba Rao, N.S. 1986. Soil Microorganisms and Plant Growth, Oxford and IBH Publishing Co.

Sylvia, D.M., Fuhrmann, T.A., Hartel, P.G. and Zuberer, D.A. 2005. Principles and Applications in Soil Microbiology (2nd Edition).

Van, Elsas, Trevers, J.T. and Wellington, E.M.H. 1997. Modern Soil Microbiology, Marcel Dekker, CRC Press.

MB 503 MORPHOLOGY AND ECOLOGY OF PHOTOSYNTHETIC MICROORGANISMS

(3L+1P) I

Objective

To familiarize the students regarding the significance of photosynthetic bacteria, including cyanobacteria, their morphological features and ecology, concepts of photosynthesis-bacterial and algal photosynthesis, extremophiles and their tolerance mechanisms

Theory

UNIT I

Classification and taxonomy of photosynthetic organisms: Microalgae (cyanobacteria, green algae) and bacteria, Major characteristics of different groups, Photosynthetic eubacteria: Introduction, Characteristics of important genera of photosynthetic eubacteria.

UNIT II

Range of thallus organization and reproduction in microalgae with emphasis on blue-green algae (cyanobacteria) and green algae, Cyanobacteria / Cyanophyceae: Taxonomic approaches and evolutionary trends, Detailed account of different sub-groups.

UNIT III

Microalgal habitats: Physical and chemical characteristics, Ecology of aquatic (fresh and marine) photosynthetic microorganisms, Ecology of photosynthetic terrestrial microorganisms, Soil and rice fields, Cyanobacteria in geothermal habitats, Oil pollution and cyanobacteria, Phylogenetic approaches to study cyanobacterial distribution.

UNIT IV

Limnology, Eutrophication, Energy flow and nutrient cycling, Succession in water bodies, Lime stones, Extremophiles, Halotolerance, Osmotolerance in microalgae and photosynthetic bacteria, UV tolerance and adaptation in microalgae and photosynthetic bacteria.

Practicals

Collection of soil and water samples from IARI fields/stagnant cess pools and extreme environments and enrichment set up for isolation of cyanobacteria/photosynthetic bacteria, Winogradsky column set up for isolation of cyanobacteria/photosynthetic bacteria, Isolation, purification, identification and axenisation of isolates from the enrichment cultures, Microscopic and ecological observations on isolates from extreme environments and analyses of their adaptive mechanisms, Study of ecological habitats of algae, Preservation techniques for algae, Microscopic observations of non-heterocystous cyanobacteria and heterocystous cyanobacteria, Measurement of algal productivity from different ecological habitats, Studies on microalgae/cyanobacteria from polluted habitats, Field trip for collection of samples.

Suggested Readings

- Barsanti, L. and Gualtieri, P. 2006. *Algae: Anatomy, Biochemistry and Biotechnology*, Taylor and Francis, CRC Press.
- Boone, D.R. and Castenholz, R.W. 2001. *Bergey's Manual of Systematic Bacteriology*, Vol.I (2nd Edn.)
- Desikachary, T.V. 1959. *Cyanophyta*, ICAR Publication.
- Fritsch, F.E. 1979. *Morphology and Reproduction of Algae*, Vol.1 and II.
- Graham, L.E. and Wilcox, M. 2000. *Algae*, Prentice Hall, NJ.
- Herrero, A. and Flores, E. 2008. *The Cyanobacteria: Molecular Biology, Genomics and Evolution*, Calster Academic Press.
- Kumar, H.D. 1999, 2005. *Introductory Phycology*, Affiliated East -West Press, New Delhi.
- Packer, L. and Glazer, A.N. 1988. *Methods in Enzymology*, Vol. 167, Cyanophyta, Academic Press, London.
- Round, F.E. 1984. *Ecology of Algae*, Cambridge University Press.
- Shubert, L.E. (ed) 1984. *Algae as Ecological Indicators*, Academic Press, London
- Smith, G.M. 1951. *Manual of Phycology, An Introduction to the Algae and their Biology*, Chromica Botanica Company, USA
- Stanier, R.Y. and Cohen-Bazire, G. 1977. Phototrophic Prokaryotes: The Cyanobacteria, In: *Annual Reviews of Microbiology*, 31: 225-274.
- Venkataraman, G.S., Goyal, S.K., Kaushik, B.D. and Roychoudhury, P. 1974. *Algae : Form and Function*, Today and Tomorrow Publishers, New Delhi.
- Whitton, B.A. and Potts, M. 2000. *The Ecology of Cyanobacteria- Their Diversity in Time and Space*, Kluwer Academic Publishers, Dordrecht, The Netherlands.

Objective

To familiarize the students with basic safety rules in the microbiological laboratory and to introduce the concepts involved in different methods and techniques applied in microbiological sciences

Theory

UNIT I

An introduction to laboratory instruments, Safety rules in laboratory, Handling of different glassware, Handling of autoclave, Hot air oven, BOD incubator, Laminar flow, Colony counter, pH meter, Biological filters, Spectrophotometer, Microscopy: Light, Compound, Darkfield, Phase Contrast, Fluorescent, EM, TEM, SEM.

UNIT II

Culture: Types of culture and culture media, Inoculation techniques, Isolation of pure culture, Proof of purity of cultures, Maintenance and preservation of pure cultures, Culture collection: World scenario and Indian scenario, Techniques for microscopic examination of living microorganisms (Bacteria/Cyanobacteria): Wet mount, Hanging drop technique, Stains and staining techniques, Enumeration of bacteria, Cyanobacteria by plate count, Turbidometric method and MPN method.

UNIT III

Identification of bacteria using biochemical tests, Introduction and importance of Bergey's Manual, Bioassay techniques, Antibiotic sensitivity of bacteria.

UNIT IV

Molecular- biology techniques, Isolation of Genomic DNA and PCR amplification in bacteria and cyanobacteria, RAPD and RFLP, Isolation of plasmids, Protein profiling by SDS-PAGE, Transposon and chemical mutagenesis, Biochemical characterization in cyanobacteria.

Practicals

Introduction to safety measures in laboratory and maintenance of aseptic conditions, Microscopy and instrumentation, Media preparation and sterilization, Isolation and purification techniques, Enumeration and quantification techniques, Staining of micro-organisms: Simple staining, Negative staining, Gram staining, Capsule staining, Spore staining, Motility test, Biochemical characterization of micro-organisms, Identification of unknown bacteria, Carbohydrate fermentation, Triple sugar-iron agar test, IMViC test, Hydrogen sulfide test, Urease test, Litmus milk reaction, Nitrate reduction test, Catalase and Oxidase test, Isolation and purification of cyanobacteria, Identification of cyanobacteria, RAPD analysis in cyanobacteria, Enumeration techniques in cyanobacteria, Estimation of pigments and nitrogen fixation, Antibiotic resistance, Isolation of Genomic DNA and PCR amplification, Restriction digestion of DNA, RFLP analysis, Isolation of plasmids, Protein profiling, Transposon and chemical mutagenesis, Bioinformatic tools.

Suggested Readings

Hildebrandt, A.C. and Warren, Joel 2010. Microbiological Methods and Techniques, A text book for students, teachers and researchers, S R Scientific Publications, 31A/119, Maujpur, New Delhi-110053.

Sambrook Fritsch Maniatis, Molecular Cloning : A Laboratory Manual, Vol. I, II and III.

Shukla, Livleen, Pabbi, Sunil and Dhar, Wattal Dolly 2009. A Practical Manual on “Microbiology- Tools and Techniques – a Practical approach”, Division of Microbiology, IARI, New Delhi.

Cappucino, J. and Shuman, P. 2008. Microbiology: A Laboratory Manual. Benjamin Cummings 544p.

Plummer, D.T. 2006. Introduction to Practical Biochemistry, Tata Mc Graw Hill.

Bergey's Manual of Systematic Bacteriology: All volumes.

Gerhardt, P., Murray, R.G.F., Wood, W.A. and Krieg, N.R. 2005. Methods for General and Molecular Biology, American Society for Microbiology, Washington DC, 791p.

MB 505/ ES 505 MICROBIAL ECOLOGY

(3L+1P) II

Objective

To provide the modern concepts of microbial ecology of soil and aquatic environments, microbial interactions and biogeochemical cycling

Theory

UNIT I

Microbial community and its development, Organisms : Bacteria, Fungi, Actinomycetes, Algae, Protozoa, Viruses, Geography and micro- environment of microorganisms, Natural selection, Spatial and temporal distribution, Patterns of micro-organisms.

UNIT II

Dispersal, Colonization, Succession and the climax, Interspecific competition, Commensalism, Homeostasis, Parasitism, Predation, Proto-cooperation, Symbiosis, Ammensalism .

UNIT III

Microbiology of water bodies, Effect of micro-organisms on animals and plants, Environmental influences on microorganisms, Effect of temperature, aeration, moisture, osmotic pressure, pH, Energy cycle.

UNIT IV

Transformation of phosphorus, sulphur, iron, manganese, magnesium, copper, mercury and arsenic, Mycorrhizal links with plants and their functioning.

UNIT V

Ecology of microbial corrosion, Microbial plasticity, Relevance to microbial ecology, Modeling, Microbial contribution to climatic change, Molecular approaches for measuring the microbial diversity.

Practicals

Sampling and enumeration techniques for micro-organisms, Effect of environmental variables on nitrification, ammonification and microbial growth, Effect of temperature on bacterial interactions, Isolation of nucleic acids from environmental samples, Nitrogen transformations, Microbial corrosion and detection of microbial activities, Symbioses amongst micro-organisms, Synergism and antagonism amongst micro-organisms, Estimation of iron oxidizing and reducing bacteria from soil samples, Isolation of thermophilic, mesophilic and psychrophilic microorganisms from

soil samples, Isolation of antibiotic synthesizing microorganisms, Enumeration of sulphur oxidizing and reducing bacteria from soil, Enrichment and isolation of phosphate solubilizing microorganisms from phosphorus deficient and 'P' sufficient soils, Mineralization of phytins by bacteria and fungi, Estimation of phosphorus solubilizing activity of a bacterium and a fungus using different inert phosphorus sources.

Suggested Readings

- Maier, R.M. 2009. Environmental Microbiology, Academic Press.
- Mitchell, R. 1992. Environmental Microbiology, John Wiley and Sons.
- Paul Eldor, A. 2007. Soil Microbiology, Ecology and Biochemistry, 3rd Edition, Academic Press.
- Richard, D. Bargett, The Biology of Soil : A Community and Ecosystem Approach (Biology of Habitats).
- Richards, B.N. 1987. Microbes of Terrestrial Ecosystem, Longman.
- Subba Rao, N.S. 1986. Soil Microorganisms and Plant Growth. Oxford and IBH Publishing Co.
- Sylvia, David M., Fuhrmann, J.A., Hartel, P.T. and Zuberer, D. 2005. Principles and Applications in Soil Microbiology (2nd Edition).
- Towner, K.J. and Cockayne, A. 1993. Molecular Methods for Microbial Identification and Typing, Chapman and Hall, London, UK, pp 202.

MB 506 MICROBIOLOGY OF MILK AND WATER

(2L+1P) III

Objective

To familiarize the students with the concepts of microbial quality of milk and water, microbial risk assessment and modern concepts of waste water treatment

Theory

UNIT I

Composition of milk and factors affecting the composition, Microbiology of milk, Fermented milk products, Cheese, Pasteurisation, Spoilage of milk and its products, Microbiological methods for examination of milk and its products, Probiotics, Bacteriological standards for milk and milk products.

UNIT II

Microbiology of water, Sources and types of water, Procedures for water purification, Water pollution and its sources, Nuisance bacteria in water, Water-borne disease.

UNIT III

Sewage treatment, Biological oxygen demand, Effluent management, Sewage systems.

Practicals

Instructions on media preparation, Phosphatase test in pasteurized milk, Methylene blue reduction test in milk, Total microbial count in milk (raw, pasteurized and UHT treated milk) and water, Total microbial count in ice cream and curd, Enumeration of lactobacilli in curd and milk, Detection of *E. coli* in drinking water by β -galactosidase test, Conventional method for enumeration and detection of *E. coli* in water from different sources (rain, surface water, underground water, water from well) and from sewage, Microbiological examination of sewage effluents.

Suggested Readings

- Adams, M.R. and Moss, M.O. 1996. Food Microbiology, New Age International (P) Publishers.
- Vanderzant, C. and Splittstoesser, D.F. 1992. Compendium of Methods for Microbiological Examination of Food, Compiled by American Public Health Association Technical Committee on Microbiological Methods for Foods.
- Standard Methods for the Examination of Water and Waste Water 1989. Compiled by American Public Health Association.
- Frazier, W.C. and Westoff, D.C. 1995. Food Microbiology, Tata McGraw-Hill Publishers.
- Foster, E.M. and Nelson, F.E. 1958. Dairy Microbiology, Macmillan and Co.
- Dairy Handbook 1976. NDRI, Karnal, ICAR Publication.
- Jay, J.M. 1987. Modern Food Microbiology, 3rd ed. CBS Publishers and Distributors, Delhi 110032. p 1-642.

MB 507 FOOD MICROBIOLOGY

(3L+2P) II

Objective

To provide the basic concepts of microbial quality of food, microbial contamination and food-borne diseases

Theory

UNIT I

Food and their composition, Food as substrate for micro-organisms, Important bacteria in food microbiology, Microflora of meat, fish, eggs, fruits, vegetables, juices, flour, canned foods.

UNIT II

Food spoilages, Fermented foods (Sauerkraut, Pickle, Soy Sauce, Tempeh, Miso), Bacterial toxins in food, Food-borne diseases and intoxications, Action of microbes on different components of food, Methods of food preservation.

UNIT III

Microarray in food microbiology, Mycotoxin, Microbiological quality assurance, Specification and standards, Hazard analysis and critical control point (HACCP) concept, Methods for examination of micro-organisms in food.

Practicals

Preparation of various media, Preparation of Sauerkraut from cabbage, Determination of acidity, pH, Sensory evaluation of product, Microscopy of fermented fluid, Isolation and enumeration of lactic acid bacteria from sauerkraut, Isolation and enumeration of acid producers from pickle/ sauerkraut, Enumeration of halophiles from pickle, Enumeration of microflora (bacteria, fungi and yeast) in flour of wheat and gram, Detection of coliforms in flour and grain (Presumptive, completed and confirmed test), Enumeration of microflora of bread and pastry, Enumeration of thermophiles, psychrophiles and osmophiles in food sample, Pectinolytic bacteria in fruit sample, Enumeration of lipolytic and proteolytic bacteria in given food sample, Microbial observations of fruit surface flora and spoilage, Enumeration of microflora in juices, Detection of enterotoxigenic *Staphylococcus aureus* strains in food sample, Microbial examination of egg and canned food.

Suggested Readings

- Adams, M.R. and Moss, M.O. 1996. Food Microbiology, New Age International (P) Publishers.
- Banwart George G. 1989. Basic Food Microbiology AVI.
- Frazier, W.C. and Westoff, D.C. 1995. Food Microbiology, Tata McGraw-Hill Publishers.
- Jay, J.M. 1987. Modern Food Microbiology, 3rd Edn. CBS Publishers.
- Ray, Bibek 1996. Fundamentals of Food Microbiology, CRC Press.
- Vanderzant, C. and Splittstoesser, D.F. 1992. Compendium of Methods for Microbiological Examination of Food, Compiled by American Public Health Association Technical Committee on Microbiological Methods for Foods.

MB 508 SOIL MICROBIOLOGY-II

(3L+1P) III

Objective

To teach the basic concepts of plant-microbe interactions.

Theory

UNIT I

Plant-microbe interactions, Endophytic and pathogenic interactions, Rhizosphere, Rhizoplane, Spermosphere and phyllosphere, Root exudates, Quorum-sensing in bacteria, Flow of signals in response to carbon substrates.

UNIT II

Legume –Rhizobium symbiosis, Frankia- Actinorhizal symbioses, Classification of nodulating bacteria, Formation of nodules in leguminous plants, Types of nodules, Genetics of nodulation and nitrogen fixation, *sym* genes, *nod* genes, *nif* genes and *fix* genes, NOD factors, Hydrogenases

UNIT III

Type three secretion systems, Plant growth promoting rhizobacteria (PGPR) and their direct and indirect mechanism of action, Biocontrol agents and their action mechanism.

UNIT IV

Mycorrhizae, Types of mycorrhizae and their interactions with plants, Biochemical/ molecular aspects.

Practicals

R:S ratio in soil & endorhizosphere, Isolation of rhizobia from root nodules, Collection and TLC analysis of root exudates for amino acids, Isolation and enumeration of phyllosphere microflora, Estimation of nitrogenase activity of rhizobia, Isolation of PGPR from soil (N_2 fixers, P-solubilizers, siderophore producers, HCN producers, antibiosis), MPN estimation of rhizobia from soil, % colonization of VAM in roots, Intrinsic antibiotic resistance pattern in rhizobia, Estimation of IAA production in microbes, PCR for microbial antibiotics

Suggested Readings

- Campbell, R. 1983. Microbial Ecology, Blackwell Publishers.
- Sylvia David, M., Fuhrmann, T.A., Hartel, P.G. and Zuberer, D.A. 2005. Principles and Applications in Soil Microbiology (2nd Edition).

- Paul Eldor, A. 2007. Soil Microbiology, Ecology and Biochemistry.
- Subba Rao, N.S. 1986. Soil Microorganisms and Plant Growth, Oxford and IBH Publishing Co.
- Bargett, Richard D. 2005. Biology of Soil : A community and Ecosystem Approach.
- Towner, K.J. and Goekayane, A. 1993. Molecular Methods for Microbial Identification and Typing, Chapman and Hall, London, UK. pp. 202.
- Kosuge, T. and Nester, E. W. 1989. Plant Microbe Interactions: Molecular and Genetic Perspectives, Vol.I-IV, McGraw Hill.
- Verma, D.P.S. and Kohn, T.H. 1984. Genes involved in Microbe-Plant Interactions, Springer-Verlag.

MB 512/ AC 512 NANOTECHNOLOGY IN CROP PROTECTION

(2L+1P) II

Objective

To enable students to acquire expertise and skill to develop agrochemical formulations with nanoparticles and to acquaint them with nanotechnology

Theory

UNIT I

Introduction: History of nanotechnology – Origin, fundamental concepts, and molecular perspective, Nanomaterials: formation, stability and quality. Application of nanotechnology in agricultural chemicals, bio-pesticides, carriers, surfactants, formulation auxiliaries plant nutrients and related materials.

UNIT II

Effect of bioactive nano-materials on insect pests and beneficial insects.

UNIT III

Different types of nano-compounds and their use in the management of plant disease incited by pathogenic fungi , bacteria and viruses with special reference to copper, sulfur etc, Interaction of bioactive nano- materials on plant pathogens including fungi, bacteria, virus etc.

UNIT IV

Nematodes: Plant pathogenic and entomopathogenic nematodes, life cycle, Efficacy of nano chemicals against nematodes, Biotoxins from Xenorhabdus and Photorhabdus. Identification and quantification of biotoxins effective in nano-doses.

UNIT V

Microbes: Microbes of agricultural importance. Life cycle: genesis, growth, reproduction, identification and quantification. Nanotechnological application in microbiology.

UNIT VI

Nanomaterials: size, characterization, formation and stability. Tools for identification and quantitation: Particle size analyzers, nanosizers, scanning microscopes of different types. Development of nano-materials: Bottom-up and top-down approach: Chemical synthesis, sol-gel and emulsion polymerization techniques, wet milling, nano-milling. Stabilization of nanoparticles. Regulations and quality control.

Practicals

Identifications, and quantification of agricultural chemicals in conventional and nano formulations, Size determination, Quality of nano-formulations: Cold test, emulsion stability test, and suspensibility tests

Suggested Reading

Allhoff, Fritz, Lin, Patrick (Eds.) 2009. *Nanotechnology and Society*, ISBN: 978-1-4020- 6208-7, Springer Publications, UK.

MB 601 PHYSIOLOGY OF ALGAE

(3L+1P) II

Objective

To familiarize the students with the concepts of physiology of algae

Theory

UNIT I

Growth and synchrony, Factors regulating algal growth, Adaptive responses of cyanobacteria to abiotic stress, Circadian rhythms and their relevance in cyanobacteria, Toxin production by algae including cyanobacteria, Types/modes of their action and biosynthesis, Role of environmental/nutritional factors.

UNIT II

Respiration: Energetics, Glycolysis, Krebs cycle, Oxidative phosphorylation, Alternative pathways, Cyanobacterial respiration.

UNIT III

Photosynthesis : Light reactions, Photosystem I and II, Dark reactions, Biochemistry of carbon dioxide metabolism, Photorespiration, Chloroplast origin and evolution, Phycobilisome and phycobiliprotein structures, Carotenoids in cyanobacteria, Biosynthesis of cyanobacterial hemes, Chlorophylls and phycobilins, Chromatic adaptation.

UNIT IV

Cyanobacterial nitrogen fixation-an overview, Nitrogenase enzyme, its nature and properties, Heterocyst, its structure and function, Nitrogen fixation in non-heterocystous cyanobacteria, Assimilation of combined nitrogen, Amino acid metabolism, Environmental and nutritional factors influencing nitrogen fixation, Global regulatory mechanisms in nitrogen metabolism, Physiology of symbiotic associations of cyanobacteria, Hydrogen evolution, Microalgae as biofuel.

Practicals

Media preparation for microalgae and isolation, Biomass estimation, Pigment profile, Cellular constituents (Total soluble proteins and carbohydrates), Measurement of nitrogen fixation as acetylene reduction activity, Hydrogen production using Gas Chromatograph, Nitrate reductase and glutamine synthetase activity in cyanobacteria, Estimation of extracellular ammonia, Cell count measurement, Soil chlorophyll estimation through spectrophotometric analysis, Soil DNA extraction and analyses from inoculated soil microcosm/pot experiment, Inhibition assays for cyanobacterial toxins, Soil organic matter and nitrogen analysis

Suggested Readings

Anderson, Robert A. 2005. *Algal Culturing Technique*, Academic Press.

Bergerson, F.J. 1980. *Methods for Evaluating Biological Nitrogen Fixation*, John Wiley & Sons.

Bryant Donald, A. 1994. *The Molecular Biology of Cyanobacteria*, Kluwer Publications, Netherlands.

Carr, N.G. and Whitton, B.A. 1982. The Biology of Cyanobacteria. Blackwell Publishers.

Herrero, A. and Flores, E. 2010. The Cyanobacteria: Molecular Biology, Genomics and Evolution.

MB 602 INDUSTRIAL MICROBIOLOGY

(4L+1P) III

Objective

To familiarize the students with the developments of industrial microbiology

Theory

UNIT I

Theory and principles of industrial fermentation, Fermentor design, Different types of fermentors used in industrial fermentation, Microbial culture selection, Strain development, The formation and extraction of fermentation product, C&N sources used for industrial fermentation.

UNIT II

New approaches and advances in downstream processing, Primary and secondary metabolites, Ethanol, Second generation biofuels, Beer, Wine and Cider fermentation. Enzyme production : Rennet, Cellulase, Amylase etc., Microbial enzymes, Immobilisation of enzymes, Amino acid production : Glycine and Glutamic acid, Biomass production, Microbial insecticides.

UNIT III

Single cell protein production for use as food and feed, Organic acid, Vinegar production, Vitamin and related compounds (Carotenoid, Vitamin B₁₂, Riboflavin), Antibiotic production, Biotransformation, Bioplastics, Bioprocess cost evaluation.

Practicals

Amylase production by using *Bacillus amyloliquefaciens* and its assay, Protease production by using *Bacillus* isolate and its quantification, Wine production from grape juice and estimation of alcohol, Citric acid production from *Aspergillus* by surface culture method, Production of cellulase by SSF of rice straw through lignocellulolytic fungi: (a) Estimation of filter paper lyase activity (b) Estimation of carboxy methyl cellulase activity, Production and estimation of xylanase from rice straw through submerged fermentation, Functioning of bioreactor, Carotenoid production from yeast/cyanobacteria, Immobilization of microbial cells for enzyme production, Protease production from *Bacillus subtilis* by using soybean meal, Antibiotic production from a biocontrol agent.

Suggested Readings

Arora, D.K. 1992. Handbook of Applied Mycology – 5 Vols. (Reference Book), Marcel Dekker, New York.

Atkinson, B. and Marituna, F. 1983. Biochemical Engineering & Biotechnology Handbook, McMillian Publishers.

Casida, L.E. Jr 1989. Industrial Microbiology, Wiley Eastern Ltd., N. Delhi.

Crueger, W. and Crueger, A. 1984. Biotechnology- A Text book of Industrial Microbiology, Science Tech. Inc., Madison.

Demain, A.L. and Solomon, M.A. 1986. Manual of Industrial Microbiology, American Society of Microbiology, Washington.

- Gerald, Reed 1982. Prescott & Dunn's Industrial Microbiology, McMillan Publishers, UK.
- Glazer, A.N. and Nikaido, H.N. 1995. Microbial Biotechnology: Fundamentals of Applied Microbiology, W.H. Freeman Co., New York.
- Jones, D.G. 1983. Exploitation of Microorganisms, Chapman & Hall, Oxford.
- Miller, B.M. and Litsky, W. 1976. Industrial Microbiology, Mc Graw Hill Co., New York 451p.
- Moo-Young, Y. 1985. Comprehensive Biotechnology- 5 vols. (Reference Book), Pergamon Press, Oxford.
- Moses, V. and Cape, R.E. 1991. Biotechnology - The Science and the Business, Harwood Academic Publishers, USA.
- Peppler, H.J. and Perlman, D. 1979. Microbial Technology, Vol.1, Fermentation Technology, Vol.2, Academic Press.
- Reed, G. 1987. Prescott and Dunn's Industrial Microbiology, 2nd Edition, Academic Press.
- Rehm, H.J. and Reed, G. 1995. Biotechnology, A Comprehensive Treatise, 8 Vols. (Reference Book), Verlag Chemie, Weinheim. Also refer Second edition, 12 vols, 1995 (Rehm, H.J., Reed, G., Puhler, A., Stadler, P Eds).
- Stanbury, A.F. and Whitaker, A. 1984. Principles of Fermentation Technology – Oxford Pergamon Press, New York.

MB 603 BACTERIAL PHYSIOLOGY-I

(3L+1P) II

Objective

To teach the basic concepts of physiological processes in microorganisms-microbial growth requirement and pathways of energy generation

Theory

UNIT I

Introduction to Microbial Physiology, Microbial nutrition and Nutritional types, Metabolic diversity, Photoautotrophs, Photoheterotrophs, Chemoautotrophs, Chemoheterotrophs, Photolithoautotrophs, Chemolithoautotrophs, Photoorganoheterotrophs, Chemoorganoheterotrophs, Auxotrophs.

UNIT II

Microbial growth, Requirements for growth- Physical: Temperature, pH, Osmotic pressure, Organic growth factors, Bacterial division, Bacterial growth kinetics, Generation time, Mathematical expression of growth, Phases of growth, Balanced and unbalanced growth, Monoauxic growth and Diauxic growth, Energetics of growth, Batch culture, Synchronous growth, Continuous growth, Chemostat and Turbidostat, Growth characteristics, Measurement of microbial growth: Plate counts, Filtration, The Most Probable Number (MPN) method, Direct microscopic count, Indirect methods to check growth: Turbidity, Metabolic activity, Dry weight measurement, Growth yield and its significance.

UNIT III

Energy yielding pathways in microorganisms, Aerobic respiration: Glycolysis, Substrate level phosphorylation, Electron transport chain and oxidative phosphorylation, Alternatives to glycolysis: Hexose mono-phosphate pathway (HMP), Entner – Doudoroff Pathway (ED pathway),

Tricarboxylic acid cycle (TCA cycle) and other mechanisms, Chemiosmotic mechanism of ATP generation, Obligate anaerobes, Aerotolerant anaerobes, Integration of metabolism, Catabolism of other kind of organic substrates, Anaerobic respiration, Dissimilatory and assimilatory reductions, Types of fermentation, Fermentation balances.

UNIT IV

Microbial photosynthesis, Diversity, Chlorophylls and bacterio- chlorophylls, Accessory pigments, Light-dependent reactions and light independent reactions, Carbon dioxide assimilation in prokaryotes, Bacteriorhodopsin and Halorhodopsin and their significance, Transport of nutrients into cell.

Practicals

Designing of media to support the growth of different nutritional groups of bacteria, Demonstration of specialized media for selection and differentiation of microorganisms, Diverse growth temperature and pH requirements of microorganisms, Cultivation of anaerobic microorganisms, Atmospheric oxygen requirements of microorganisms, Determination of viable and total number of cells, Preservation techniques, Diauxic growth.

Suggested Readings

Moat, Albert G., Foster, John W. and Spector, Michael P. 1979. Microbial Physiology. John Wiley and Sons (Asia) Pvt. Ltd., (Wiley student edition).

Byung, Hong Kim and Goeffrey, Michael Gadd 2008. Bacterial Physiology and Metabolism, Cambridge University Press.

Gottschalk, G. 1979. Bacterial Metabolism, Springer Verlag.

Reddy, S. Ram and Reddy, S.M. 2005. Microbial Physiology, Scientific Publishers, P O Box 91, Jodhpur, p 332.

MB 604 BACTERIAL PHYSIOLOGY-II

(2L+1P) III

Objective

To teach the basic concepts of anabolic and catabolic reactions related to bacterial metabolism

Theory

UNIT I

Enzymes and chemical reactions, Enzyme specificity and efficiency, Naming enzymes, Classification, Enzyme components, The mechanism of enzymatic action, Factors influencing enzymatic activity: Temperature, pH, substrate concentration, Inhibitors, Feedback inhibition, Ribozymes, Coenzymes.

UNIT II

Catabolic and anabolic reactions, Collision theory, Cell wall and its biosynthesis- Types, Peptidoglycan, Gram positive cell wall, Gram negative cell wall, Archaeal cell wall, Polysaccharide biosynthesis, Lipid biosynthesis, Biosynthesis of nitrogenous compounds- Amino acid and proteins, Purine and pyrimidines, Nucleic acids.

UNIT III

Protein break down by microorganisms, Deamination, Transamination, Assimilation of complex carbohydrates- Cellulose, Hemicellulose, Starch, Pectin and Chitin, Nitrogen fixing micro-

organisms, Requirements of nitrogen fixation, Mechanism of nitrogen fixation , Nitrogenase enzyme, Biochemistry of hydrogenase enzyme and hydrogen assimilation.

UNIT IV

Secondary metabolism, Primary and secondary metabolites and their significance, Physiological response of microorganisms to salinity, Alkalinity, UV, Drought and heavy metals, Adaptive mechanisms employed to cope with stress, Pesticides: Types, Resistance to microbes and metabolism, Residual effects of pesticides.

Practicals

Study on enzyme kinetics, Tolerance and degradation of pesticides by microorganisms, Effect of salinity and alkalinity on microorganisms, Nitrogenase activity and nodulation pattern, Estimation of total soluble proteins, Protein profile through Poly-acrylamide Gel Electrophoresis, Ammonia liberation from nitrogenous compound and enzymatic conversion of ammonia to nitrates by microorganisms, Reduction of nitrates to nitrogen gas, Reducing sugars estimation, Separation of amino acids by TLC, Estimation of nitrate reductase and glutamine synthetase activity in prokaryotes.

Suggested Readings

Doelle, H.W. 1975. Bacterial Metabolism, Second Edition, Academic Press, NY.

Gottschalk, G. 1979. Bacterial Metabolism, Springer Verlag.

Moat, A.G. , Foster, J.W. and Michael, P. Spector 1979. Microbial Physiology, Wiley Student Edition, John Wiley & Sons (Asia), Pvt. Ltd.

Plummer, David T. 1987. An Introduction to Practical Biochemistry, Tata McGraw- Hill Publishing Company Limited, New Delhi.

Sokatch, J.R. 1969. Bacterial Physiology and Metabolism, Academic Press.

Schaechter, M. 2004. The Desk Encyclopedia of Microbiology, Elsevier , Academic Press.

MB 605 ALGAE IN AGRICULTURE AND INDUSTRY

(3L+0P) III

Objective

To familiarize the students with the economic use of algae in agriculture and industry

Theory

UNIT I

Role of algae in fertility and productivity of soil, Production of growth promoting substances, P-solubilisation, Blue green algal biofertilizer: Production and quality control, BGA in reclamation of saline/sodic soils, *Azolla*: Production, utilization and economic importance.

UNIT II

Algae in aquatic environment, Sewage treatment, Bioindicators of pollution, Metal detoxification, Controlled photosynthesis and its application, Use of algae as food, feed, manure and energy, Therapeutic uses of algae, Phycocolloids: Production and use, Carrageenan, Agar-agar, Alginic acid and alginates.

UNIT III

Production of vitamins and fine chemicals, Pigments, Antibiotics, Source of single cell protein (SCP), Economic importance of *Spirulina*, *Dunaliella*, *Chlorella*, *Scenedesmus*, *Haematococcus*, Mass cultivation of algae, Harvesting and drying methods in algae, Microalgae and biofuels.

Suggested Reading

Ahluwalia, A.S. 2003. Phycology: Principles, Processes and Applications, Daya Publishers.

Becker, E.W. 1994. Microalgae: Biotechnology and Microbiology, Cambridge Univ. Press, Cambridge, UK.

Borowitzka, M.A. and Borowitzka, L.A. 1988. Microalgal Biotechnology, Cambridge Univ. Press, Cambridge, UK.

Pabbi, Sunil 2008. Cyanobacterial Biofertilizers, Journal of Eco-friendly Agriculture. 3: 95- 111.

Seaweed Research and Utilization in India, CMFRI Bulletin 41.

Seshadri, C.V. and Jeeji, Bai N. 1993. Spirulina- Etta.

Venkataraman, L.V. and Becker, E.W. 1985. Biotechnology and Utilization of Algae. The Indian Experience, DST.

MB 606 APPLICATIONS OF MICROORGANISMS IN AGRICULTURE

(1L+2P) III

Objective

To familiarize the students with the basic concepts and applied aspects regarding the use of microorganisms in agriculture

Theory

UNIT I

Principles of crop inoculation with microbial agents, Overview of microbial inoculants and their production, Carriers for inoculants: Types and their characteristics, Strain selection of bacteria and cyanobacteria for biofertilizer production and quality control, Mass multiplication: Methodology and constraints/benefits, Bulk production (small scale and commercial scale), Setting up of pilot scale inoculant production plants.

UNIT II

Rhizobium: Evaluation as biofertilizer, *Azotobacter*: Evaluation as biofertilizer, Phosphate solubilising microorganisms: Methods for their identification, AM fungi, Ecology of inoculants/ microorganisms in soil, Biocontrol agents.

UNIT III

Biogas production technology, Methanogens, Methanotrophs and their applications. Silage production, Techniques of composting and vermi-compost and its evaluation.

Practicals

Isolation, purification and characterization of bacteria / cyanobacteria from soil, Isolation and identification of Phosphate Solubilizing Micro-organisms (PSMs), Qualitative and quantitative evaluation of phosphate solubilization, Hyphal/spore staining for AM fungi, Calculation of root infection, Mass production protocols for PSMs and AM fungi, Pretreatment, sterilization and

evaluation of carriers for inoculants; Preparation of bacterial biofertilizers, Testing of quality of prepared bacterial biofertilizers, Production technology of BGA biofertilizer, Microcosm studies to evaluate establishment of cyanobacterial strains, Testing of quality of prepared BGA biofertilizers; IAA production and seed germination test using the bacterial/cyanobacterial strains used as inoculants, Nitrogen fixation studies with inoculant organisms/ inoculants, Composting and silage production technology; Biogas production technology.

Suggested Readings

- Insam, H., Riddech, N. and Klammer, S. 2002. *Microbiology of Composting*, Springer-Verlag, Berlin-Heidelberg, Germany.
- Kannaiyan, S. 2002. *Biotechnology of Biofertilizers*. Kluwer Academic Publishers, The Netherlands and Narosa Publishing House, New Delhi.
- National Institute of Industrial Research Board, 2004. *The Complete Technology Book on Biofertilizer and Organic Farming*. National Institute of Industrial Research, New Delhi.
- Subba Rao, N.S. 1988. *Biofertilizers in Agriculture and Forestry*. Oxford and IBH, New Delhi.
- Tilak, K.V.B.R., Pal, K.K. and De, R. 2010. *Microbes for Sustainable Agriculture*. I.K. International Publishing House Private Ltd., New Delhi.
- Vincent, J.M. 1970. *A Manual for the Practical Study of Root Nodule Bacteria*, IBP Handbook, Blackwell, Oxford.

MB 607 MICROBIAL GENETICS

(3L+1P) II

Objective

To teach the concepts related to the genetics of micro-organisms.

Theory

UNIT I

Principles of microbial genetics, Basic procedures and terminology, Cis-trans complementation, Genome organization in bacteria and viruses, Gene transfer, Transformation, Conjugation, Transduction and methods of gene mapping, Transposons and insertion sequences, Extra-chromosomal genetic elements, Plasmids and their inheritance, Genetic analysis of bacteriophages and cyanophages.

UNIT II

Gene, Genetic code, Operon concept and its regulation, Gene regulation and expression, Genetic engineering, Restriction enzymes, Vectors, Cloning genomic library.

UNIT III

Recombinant DNA and mechanisms of recombination, Applications of rDNA, Safety issues and ethics in using rDNA, DNA replication, DNA Polymerases, Type of replication, Mutation and repair mechanisms, Protein synthesis and central dogma, Nucleic acid synthesis and sequencing.

Practicals

Isolation of genomic DNA and plasmid DNA, Curing of plasmid, Inducing mutation using chemical/UV rays (mutagenesis and isolation of mutants), Isolation of bacteriophage, One step growth experiment with λ phage, Preparation of genomic library and competent cells, PCR amplification and cloning of the PCR product, Conjugation and transformation experiments.

Suggested Readings

- Winfrey, M., Rott, M.A., Wortman, A.T. 1997. Unraveling DNA: Molecular Biology for the Laboratory, Prentice Hall.
- Lewin, Benjamin 1999. Genes, Vols.VI-IX, John Wiley and Sons.
- Syncler, Larry and Champness, Wendy 2003. Molecular Genetics of Bacteria, II Edition, ASM Press, Washington, DC.
- David, Friedfelder 1987. Microbial Genetics, Jones and Barlett Publishers, Inc. Boston.
- Birge, E.A. 2000. Bacterial and Bacteriophage Genetics, Springer-Verlag.
- Gardner, J.E., Simmons, M.J. and Snustad, D.P. 1991. Principles of Genetics, John Wiley and Sons.
- Maloy, A. and Friedfelder, D. 1994. Microbial Genetics, Narosa.
- Mathew, C.K., Kutter, E.M., Mosig, G. and Berget, P. 1988. Bacteriophage T4, Plenum Press.
- Nancy, T. and Trempy, J. 2004. Fundamental Bacterial Genetics, Blackwell Publishers.
- Scaife, J., Leach, D. and Galizzi, A. 1985. Genetics of Bacteria, Academic Press.
- Hayes, William 1981. Genetics of Bacteria, Academic Press.
- Winkler, J., Ruger, W. and Wackernagel, W. 1979. Bacterial, Phage and Molecular Genetics: An Experimental Course, Narosa.

MB 608 IMMUNOLOGY-IMMUNODIAGNOSTICS IN AGRICULTURE

(3L+1P) I

Objective

To teach the basic concepts in immunology and its application in microbiological science

Theory

UNIT I

Historical perspective, Innate and acquired immunity, Specific and nonspecific immunity,

UNIT II

Cells and organs of immune system, Cellular and humoral immune response, Antigens, Antibodies, Immunoglobulin structure and function.

UNIT III

Antigen-antibody reactions, Complement system, Hybridoma and monoclonal antibodies, Organization and expression of immunoglobulin genes, Immune dysfunction, Auto-immunity, Immunodeficiency and hyper sensitivity, Vaccines, Serology in agriculture, Immunodiagnostic tests, Transplantation immunology.

Practicals

Ag-Ab reactions, Agglutination (blood grouping), Precipitation, Immunodiffusion, Western blotting, ELISA

Suggested Readings

- Marcus, David A., Goldsby Richard A, Osborne Barbara A. 2003. W.H. Freeman and company publishers.

Tizar, Ian R. 2006. Immunology, An Introduction, Cengage Learning (Thompson) publishers.
Joshi, K.R. 2007. Immunology: Agrobios (India) publisher.

MB 609 RECENT ADVANCES IN MICROBIAL BIOTECHNOLOGY

(3L+1P) II

Objective

To expose the students to the advances in microbiology and to improve the understanding and expertise.

Theory

UNIT I

Role of microbes in bioindustries, Value addition, Production of recombinant vaccines and hormones, Biosensors, Bioflavours, Biowarfare, Bioremediation.

UNIT II

Microbial ore leaching (biomining), Microbial enzymes in clinical diagnostics, Metabolic pathway engineering, Yeast technology, Genetics and strain improvement for brewing, baking and distilleries.

UNIT III

Bioinformatics, Bioprospecting, Microbial diversity and global environment issue, IPR and biosafety, Genomics and Proteomics, Metagenomics for improvement of industrial fermentation.

Practicals

Isolation of metagenome from environmental sources, Development of environmental libraries, DGEE, 16S rDNA community analysis, Functional and sequence based analysis of clones, Bioremediation of recalcitrant compounds.

Suggested Reading

Peppler, H.J. and Perlman, D. 1979. Microbial Technology, 2nd Edition, Academic Press.

Pommerville, Jeffrey C. 2011. Alcamo's Fundamentals of Microbiology, Jones and Bartlett International student Edition, Jones and Bartlett Publishers, Boston, p 805.

Wiseman, A. 1983. Principles of Biotechnology, Chapman and Hall Publishers.

Advances in Applied Microbiology- Latest issues.

Advances in Biochemical Engineering and Biotechnology- Latest issues.

Nature Reviews in Microbiology.

Advances in Biotechnology.

Annual Review in Microbiology.