

# **Course outcomes of Department of** **Microbiology (M.Sc.)**

**Semester:** Semester I

**Title of the paper:** Microbial Biochemistry (MIC 101)

**Class:** M.Sc

**No. of Credits:** 3 (Theory) + 1 (Practical)

**Objectives:** This course deals with characteristics, properties and biological significance of the biomolecules of life. In depth knowledge of the energetic and regulation of different metabolic processes in microorganisms.

**Course content** (Syllabus in brief):

1. Biological Molecules
2. Bioenergetics and Carbohydrate Metabolism
3. Lipids, Amino Acids, Nucleotides and other Metabolic Paths

**Course level learning outcomes:**

1. Apply the knowledge to understand the microbial physiology and to identify the microorganisms.
2. Understand the regulation of biochemical pathway and possible process modifications for improved control over microorganisms for microbial product synthesis.

**Reference Books (Composite list for theory and practicals):**

1. Lehninger, A., Cox, M. and Nelson, D. L., Principles of Biochemistry, W. H. Freeman & Company.
2. Moat, A. G., Foster, J. W. and Spector, M. P., Microbial Physiology, A. John Wiley & Sons Inc. Publication.
3. Bull, A. T. and Meadow, P., Companion to Microbiology, Longman Group Limited, New York.
4. Voet, D., Voet, J. G. and Pratt, C. W., Principles of Biochemistry, John Wiley and Sons Inc.
5. Murray, R. K., Bender, D. A., Botham, K. M., Kennelly, P. J., Rodwell, V. W. and Weil, P. A., Harper's Illustrated Biochemistry, The McGraw-Hill Companies, Inc.
6. Plummer, D. T., An Introduction to Practical Biochemistry, Tata McGraw Hill Publishing Company.
7. Sadasivam, S., Manickam, A., Biochemical Methods, New Age International (P) Limited.

8. Jayaraman, J., Laboratory Manual in Biochemistry, John Wiley & Sons, Limited, Australia.

**Semester:** Semester I

**Title of the paper:** Microbial Genetics (MIC 102)

**Class:** M.Sc

**No. of Credits:** 3 (Theory) + 1 (Practical)

**Objectives:** This course develops concept of Classical Mendelian genetics and deviation from Mendelian principles, Microbial genome organization (Prokaryotic and Eukaryotic), Viral Genetics, Mutagenesis, Bacterial plasmids as research tools, transcription and translation in prokaryotes and eukaryotes and application of microbial genetics.

**Course content** (Syllabus in brief):

1. Genetics
2. Genomic DNA Rearrangements
3. Fungal and bacterial genetics

**Course level learning outcomes:**

1. Explain principles/concept of Prokaryotic and Eukaryotic genetics, Viral genetics and application in research.
2. Mutagenesis, Mutation and mutants and their significance in microbial evolution.
3. Application of bacterial and eukaryotic plasmids in research.

**Reference Books (Composite list for theory and practicals):**

1. Gardner, E. J., Simmons, M. J. and Snustad, D. P., Principles of Genetics, John Wiley & Sons.
2. Krebs J. E., Lewin B., Goldstein E. S. and Kilpatrick, S.T., LEWIS Genes XI, Jones and Bartlett Publishers.
3. Maloy, S. R., Cronan, J. E. and Freifelder, D., Microbial Genetics, Jones and Bartlett Publishers.
4. Streips, U. N. and Yasbin, R. E., Modern Microbial Genetics, John Wiley.
5. Synder, L., Peters, J. E., Henkin, T. M. and Champness, W., Molecular Genetics of Bacteria, ASM Press.
6. Dale, J. W. and Park, S. F., Molecular Genetics of Bacteria, John Wiley.
7. Trun, N. and Trempy, J., Fundamental Bacterial Genetics, John Wiley & Sons.
8. Peter, J. R., iGenetics: A Molecular Approach, Pearson Education. 9. Birnboim, H. C. and Doly, J., (1979) A rapid alkaline extraction procedure for screening recombinant plasmid DNA. Nucleic Acid Research, 7: 1513-1523.

10. Holmes, D. S. and Quigley, M., (1981) A rapid boiling method for the preparation of bacterial plasmids. *Anal Biochem.*, 114(1): 193-197.
11. Sambrook, J., Fritsch, E. F. and Maniatis, T., *Molecular Cloning: A Laboratory Manual*, Cold Spring Harbor Laboratory, New York.
12. Green, M. R. and Sambrook, J., *Molecular Cloning: A laboratory manual*, Cold Spring Harbour Laboratory Press, New York.

**Semester:** Semester I

**Title of the paper:** Microbial Taxonomy and Systematics (MIC 103)

**Class:** M.Sc

**No. of Credits: 3 (Theory) + 1 (Practical)**

**Objectives:** This course introduces the development of taxonomy and systematic, the various characters used for this purpose, the rules governing the different taxonomy and classification systems and the salient features of the different microbial groups. It also focuses on the rapidly evolving nature of taxonomy and systematic.

**Course content** (Syllabus in brief):

1. Microbial taxonomy
2. Salient features of phylum

**Course level learning outcomes:**

1. Apply knowledge of the standard rules of classification systems to categorise microorganisms.
2. Appreciate and explain the dynamic and ever developing nature of the field of microbial taxonomy and systematic.

**Reference Books (Composite list for theory and practicals):**

1. Sneath, A. H. P., Mair, S. N. and Sharpe, E. M., *Bergey's Manual of Systematic Bacteriology Vol. 2*. Williams & Wilkins Bacteriology Symposium, Series No 2, Academic Press, London/New York.
2. Goodfellow, M., Mordarski, M. and Williams, S. T., *The biology of the actinomycetes*, Academic Press.
3. Goodfellow, M. and Minnikin, D. E., *Chemical Methods in Bacterial Systematics*, The Society for Applied Bacteriology. Technical Series No. 20, Academic Press.

4. Barlow, A., The prokaryotes: A Handbook on the Biology of Bacteria: Ecophysiology, Isolation, Identification, Applications, Volume 1, Springer-Verlag.
5. Kurtzman, C. P., Fell, J. W. and Boekhout, T., The Yeasts - A Taxonomic Study, Elsevier.
6. Prescott, L. M., Harley, J. P. and Klein, D.A., Microbiology. McGraw Hill, New York.
7. Norris, J. R. and Ribbons, D. W., Methods in Microbiology, Vol. 18 & 19, Academic Press.
8. Reddy, C. A., Methods for General and Molecular Microbiology, ASM Press.

**Semester:** Semester I

**Title of the paper:** Biostatistics (MIC 104)

**Class:** M.Sc.

**No. of Credits:** 3 (Theory) + 1 (Practical)

**Objectives:** This paper develops concepts about types of data observed in biological experiments, its handling and processing. It develops concepts of hypothesis and formulation of experiments. It gives understanding of various statistical operations needed to carryout and process the biological data.

**Course content** (Syllabus in brief):

1. Data analysis
2. Measures of central tendency
3. Probability

**Course level learning outcomes:**

1. Able to collect, handle, process and present the biological data
2. Apply the principles of statistics on biological experiments.

**Reference Books (Composite list for theory and practicals):**

1. Kothari, C. R., Quantitative Techniques, Vikas Publishing House.
2. Arora, P. N. and Malhan, P. K., Biostatistics, Himalaya Publishing House.
3. Danilina, N.I., Computational Mathematics, Mir Publishers.
4. Surya, R. K., Biostatistics, Himalaya Publishing House.

**Semester:** Semester II

**Title of the paper:** Techniques and Instrumentation in Microbiology (MIC 201)

**Class:** M.Sc

**No. of Credits: 3 (Theory) + 1 (Practical)**

**Objectives:** This course develops the concepts of methodology involved in studying the different components of microbial cell and various techniques and instruments involved in product analysis.

**Course content (Syllabus in brief):**

1. Instrumentation
2. Microscopy
3. Electrophoretic techniques

**Course level learning outcomes:**

1. Ability to use techniques and instruments involved in the study of microorganisms and their products.

**Reference Books (Composite list for theory and practicals):**

1. Wilson, K. and Walker, J., Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press, N.Y., USA.
2. Cooper, T. G., The Tools of Biochemistry, Wiley India Pvt. Ltd.
3. Goswami, C., Paintal, A. and Narain, R., Handbook of Bioinstrumentation, Wisdom Press, New Delhi.
4. Norris, J. R. and Ribbons, D. W., Methods in Microbiology, Volume 5, Part B, Academic Press.
5. Colowick, S. P. and Kaplan, N. O., Methods in Enzymology, Vol. VI, Academic Press, N.Y.
6. Parakhia, M. V., Tomar, R. S., Patel, S. and Golakiya, B. A., Molecular Biology and Biotechnology: Microbial Methods, New India, Pitampura.
7. Sambrook, J., Fritsch, E. F. and Maniatis, T., Molecular Cloning: A Laboratory Manual, Cold Spring Harbor Laboratory Press, USA.
8. Jayaraman, J., Laboratory Manual in Biochemistry, John Wiley & Sons Limited, Australia.

**Semester:** Semester II

**Title of the paper:** Industrial Microbiology (MIC 202)

**Class:** M.Sc

**No. of Credits:** 3 (Theory) + 1 (Practical)

**Objectives:** Development of concepts in the processes, instruments, management, quality etc being used in industries to produce the products using microorganisms.

**Course content (Syllabus in brief):**

1. Industrial Microbiology and fermentation
2. Bioreactor
3. Solid Substrate Fermentation

**Course level learning outcomes:**

1. Ability the principle of management and controls on the microbial processes in industrial settings.
2. Ability the principles of physiological understanding in improvement of industrial processes.

**Reference Books (Composite list for theory and practicals):**

1. Demain, A. L., Davies, J. E. and Atlas, R. M. Manual of Industrial Microbiology and Biotechnology, ASM Press.
2. Vogel, H. C. and Tadaro, C. M., Fermentation and Biochemical Engineering Handbook: Principles, Process Design and Equipment, William Andrew Publisher.
3. Atkinson, B. and Mavituna, F., Biochemical Engineering and Biotechnology Handbook, Stockton Press.
4. Flickinger, M. C. and Drew S. W., The Encyclopedia of Bioprocess Technology: Fermentation, Biocatalysis and Bioseparation, Volumes 1 - 5, John Wiley Publisher.
5. Stanbury, P. F., Whitaker, A. and Hall, S.J., Principles of Fermentation Technology, Butterworth-Heinemann Publishers.

**Semester:** Semester II

**Title of the paper:** Molecular Biology (MIC 203)

**Class:** M.Sc

**No. of Credits:** 3 (Theory) + 1 (Practical)

**Objectives:** This course develops concepts in molecular biology: DNA packaging, DNA damage and repair, gene structure, expression and regulation in both prokaryotes and eukaryotes.

**Course content** (Syllabus in brief):

1. Nucleic Acids, bonds, types of DNAs, DNA packaging and model organisms
2. DNA Damage, DNA Repair and Recombination
3. How cells read the Genome

**Course level learning outcomes:**

1. Understanding of gene structure, expression and regulation of gene expression in both prokaryotes and eukaryotes for application in molecular research.

**Reference Books (Composite list for theory and practicals):**

1. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K. and Walter, P., Molecular Biology of the Cell, Garland Science.
2. Darnell, J. E., Lodish, H. F. and Baltimore, D., Molecular Cell Biology, Scientific American Books, Spektrum Akademischer Verlag.
3. Watson, J. D., Molecular Biology of the Gene, Pearson/Benjamin Cummings.
4. Malacinski, G.M., Freifelder's Essentials of Molecular Biology, Narosa Book Distributors Private Limited.
5. Krebs J. E., Lewin, B., Goldstein, E. S. and Kilpatrick S.T., LEWIS Genes XI, Jones and Bartlett Publishers.
6. Gardner, E. J., Simmons, M. J. and Snustad, D. P. Principles of Genetics, John Wiley & Sons.
7. Tamarin, R. H., Principles of Genetics, McGraw-Hill Higher Education.
8. Twyman, R. M. and Wisden, W., Advanced Molecular Biology: A Concise Reference, BIOS Scientific Publishers.
9. Green, M. R. and Sambrook, J., Molecular Cloning: A Laboratory Manual, Cold Spring Harbor Laboratory, New York.
10. Davis, L. G., Dibner, M. D. and Battey, J. F., Basic Methods in Molecular Biology, Elsevier.
11. Gerhardt, P., Methods for General and Molecular Bacteriology, Elsevier

**Semester:** Semester II

**Title of the paper:** Mycology (MIC 204)

**Class:** M.Sc

**No. of Credits:** 3 (Theory) + 1 (Practical)

**Objectives:** This course deals with detailed classification and identification of fungi, fungal ecology in terrestrial, aquatic and extreme habitats, fungal genetics and applications of fungal enzymes and various primary and secondary metabolites.

**Course content** (Syllabus in brief):

1. Fungal diversity and distribution
2. Physiology and Genetics
3. Pathogenesis - Antifungal Therapy
4. Applications

**Course level learning outcomes:**

1. Apply the knowledge in fungal taxonomy, bioremediation and bioprospecting of secondary metabolites and industrially important fungal enzymes.

**Reference Books (Composite list for theory and practicals):**

1. Alexopoulos, C. J., Mims, C. W. and Blackwell, M., Introductory Mycology, John Wiley & Sons (Asia) Pvt. Ltd.
2. Mehrotra, R. S. and Aneja, K. R., An Introduction to Mycology, Wiley Eastern Limited.
3. Cooke, R. C. and Whipps, J. M., Ecophysiology of fungi, Blackwell Scientific Publications, Oxford.
4. Deacon, J. W., Introduction to Modern Mycology, Volume 7 of Basic Microbiology, Blackwell Scientific Publications.
5. Kendrick, B., The Fifth Kingdom, Focus Publishers.
6. Davis, B. D., Dulbecco, R., Eisen, H. N. and Ginsberg, H. S., Microbiology, Harper and Row.
7. Strickberger, M. W., Genetic, The MacMillan Company, New York.
8. Domsch, K. H., Gams, W. and Anderson, T-H., Compendium of Soil Fungi, IHWVerlag.
9. Gilman, J. C. and Joseph, C., A Manual of Soil Fungi, Daya Books.
10. Onions, A. H. S., Allsop, D. and Eggins, M. O. W., Smith's Introduction to Industrial Mycology, Edward Arnold, London.



**Semester:** Semester III & IV

**Title of the paper:** Medical Virology (MIO 101)

**Class:** M.Sc

**No. of Credits:** 3 (Theory)

**Objectives:** This course develops concepts in structure, classification, cultivation, assay and pathogenesis of disease-causing viruses.

**Course content** (Syllabus in brief):

1. Virus: Structure, Cultivation and Assay
2. Viral Diseases
3. Oncogenic and Emerging Viruses and Antiviral Combat

**Course level learning outcomes:**

Explain morphology, mode of infection, multiplication of medically important viruses and their treatment.

**Reference Books (Composite list for theory and practicals):**

1. Davis, B. D., Dulbecco, R., Eisen, H. N. and Ginsberg, H. S., Microbiology, Harper and Row Publishers.
2. Microbiology and Immunology - Online, Department of Pathology, Microbiology and Immunology, University of South Carolina School of Medicine.
3. White, D. O., Fenner, F., Medical Virology, Gulf Professional Publishing.
4. Cohen, A., Medical Virology, John Wiley & Sons, Incorporated.
5. Evans, B., Perspectives in Medical Virology, Volume 1, Elsevier.
6. De La Maza, L. M., Peterson, E. M., Springer Science & Business Media.

**Semester:** Semester III & IV

**Title of the paper:** Archaea (MIO 102)

**Class:** M.Sc

**No. of Credits:** 3 (Theory) + 1 (Practical)

**Objectives:** This course develops concepts of three domains of life, Ecology, physiology and diversity of Archaea, cell structure and architecture of archaea, metabolism and energetic of Archaea and genetics of domain Archaea

**Course content** (Syllabus in brief):

1. Emergence of Archaeobacteria
2. Metabolism and energetics of Archaea
3. Genome of Archaea

**Course level learning outcomes:**

1. Explain concept of third domain of Life Archaea.
2. Explain Ecology, Physiology and Biochemistry of domain Archaea.
3. Principles of Archaeal Genetics and application.
4. Application of Archaea and Archaeal bioactive compounds in Industry.

**Reference Books (Composite list for theory and practicals):**

1. Woese, C. R., Fox, G. E., (1977) Phylogenetic structure of the prokaryotic domain: the primary kingdoms. Proc Natl Acad Sci USA. 74: 5088–5090.
2. Blum, P., Archaea: New Models for Prokaryotic Biology, Academic Press.
3. Cavicchioli, R., Archaea: Molecular and Cellular Biology, ASM Press.
4. Garrett, R. A. and Hans-Peter, K., Archaea: Evolution, Physiology and Molecular Biology, John Wiley and Sons.
5. Howland, J. L., The Surprising Archaea: Discovering Another Domain of Life, Oxford University Press.
6. Barker, D. M., Archaea: Salt-lovers, Methane-makers, Thermophiles and Other Archaeans, Crabtree Publishing Company.
7. Munn, C., Marine Microbiology: Ecology and Applications, Garland Science, Taylor and Francis Group, N.Y.
8. Boone, D. R. and Castenholz, R. W., Bergey's Manual of Systematic Bacteriology: The Archaea and The Deeply Branching and Phototrophic Bacteria, Springer Science and Business Media.
9. Corcelli, A. and Lobasso, S., (2006) Characterization of Lipids of Halophilic Archaea. Methods in Microbiology, 35: 585-613.
10. Rothe, O. and Thomm, M., (2000) A simplified method for the cultivation of extreme anaerobic archaea based on the use of sodium sulfite as reducing agent, Extremophiles. 4: 247-252.

**Semester:** Semester III & IV

**Title of the paper:** Marine Microbiology (MIO 104)

**Class:** M.Sc

**No. of Credits:** 3 (Theory) + 1 (Practical)

**Objectives:** This course focuses on the various characteristics of marine environments including the physic-chemical variables, climate events, microbial habitats, the different marine microorganisms found in seawater and their metabolic diversity, detection and enumeration methods.

**Course content (Syllabus in brief):**

1. Introduction to oceanography

2. Marine microbes – bacteria, fungi, phytoplankton, zooplankton, viruses: their growth, physiology and contribution to ocean processes.
3. Methods in marine microbiology

**Course level learning outcomes:**

1. Explain the concept of marine environments and the factors governing them.
2. Apply the principles of marine microbiology to understand the biological phenomena occurring in marine environments.

**Reference Books (Composite list for theory and practicals):**

1. Belkin, S. and Colwell, R. R., Ocean & Health: Pathogens in the Marine Environment, Springer.
2. Grasshoff, K., Ehrhardt, M. and Kremling, K., Methods of Seawater Analysis, Verlag Chem., Weinheim.
3. Hunter-Cevera, J., Karl, D. and Buckley, M., Marine Microbial Diversity: the Key to Earth's Habitability, American Academy of Microbiology.
4. Meller, C. B., Wheeler, P. A., Biological Oceanography, Wiley-Blackwell Publishers.
5. Mitchell, R. and Kirchman, D. L., Microbial Ecology of the Oceans, Wiley-Blackwell Publishers.
6. Munn, C., Marine Microbiology: Ecology and Applications, Garland Science, Taylor and Francis, N.Y.
7. Nybakken, J. W. and Bertness, M. D., Marine Biology: an Ecological Approach, Benjamin Cummings, San Francisco.
8. Parsons, T. R., Maita, Y. and Lalli, C. M., Manual of Chemical and Biological Methods for Seawater Analysis, Pergamon Press, New York.
9. Strickland, J. D. H. and Parsons, T. R., A Manual of Seawater Analysis, Queen's Printer and Controller of Stationery, Ottawa.
10. Sournia, A., UNESCO Monographs on Oceanographic Methodology, Vol. 6, Phytoplankton Manual, UNESCO Publishing, Paris.
11. Tomas, C. R., Identifying Marine Phytoplankton, Academic Press, San Diego, CA.

**Semester:** Semester III & IV

**Title of the paper:** Environmental Microbiology and Bioremediation (MIO 106)

**Class:** M.Sc

**No. of Credits:** 3 (Theory) + 1 (Practical)

**Objectives:** This course develops concepts in Environmental Microbiology (microbial diversity, community structure and role of microorganisms in biogeochemical cycles, role of microorganisms in sustainable development and bioremediation of pollutants using microorganisms. )

**Course content** (Syllabus in brief):

1. Microbial Ecology
2. Biogeochemical processes
3. Concepts of sustainable and holistic development
4. Microbes on surface
5. Microbiological bioremediation

**Course level learning outcomes:**

1. Understanding the significance of microorganisms in biogeochemical cycling of nutrients, sustainable development and bioremediation of pollutants for developing strategies of environmental conservation and remediation.

**Reference Books (Composite list for theory and practicals):**

1. Scragg, A. H., Environmental Biotechnology, Longman Publishers.
2. Sharma, P. D., Environmental Microbiology, Alpha Science International.
3. Osborn, A. M. and Smith, C. J., Molecular Microbial Ecology, Taylor and Francis.
4. Liu, W-T. and Jansson, J. K., Environmental Molecular Microbiology, Caister Academic Press.
5. Norris, J. R. and Ribbons, D.W., Methods in Microbiology, Vol. 18 & 19, Academic Press
6. Murugesan, A. G. and Rajakumari, C., Environmental Science and Biotechnology: Theory and Techniques, MUP Publishers.

**Semester:** Semester III & IV

**Title of the paper:** Genetic Engineering (MIO 108)

**Class:** M.Sc

**No. of Credits:** 3 (Theory) + 1 (Practical)

**Objectives:** This course aims to introduce the fundamental tools and techniques required for molecular cloning, with emphasis on DNA editing to protein expression in wide variety of hosts. Application of genetic engineering in agriculture, therapeutics and industry will be covered.

**Course content (Syllabus in brief):**

1. Introduction to genetic engineering and tools involved in genetic and manipulation.
2. Application of Genetic Engineering in Biology, forensics and medicine
3. Application of Genetic Engineering in Agriculture
4. Application of Genetic Engineering in Industry
5. Application of Genetic engineering in Bioremediation, Biorecovery and Biomonitoring of xenobiotics, metals and organometals

**Course level learning outcomes:**

1. Understanding of tools and techniques involved in molecular cloning.
2. Overall understanding about the importance of GMOs, GMPs and other engineered products in science and industry.

**Reference Books (Composite list for theory and practicals):**

1. Old, R. W. and Primrose, S. B., Principles of Gene Manipulation: An Introduction to Genetic Engineering, University of California Press.
2. Glick, B. R., Pasternak, J. J. and Patten, C. L., Molecular Biotechnology: Principles and Applications of Recombinant DNA, ASM Press.
3. Williamson, R., Genetic Engineering, Volumes 4-7, Academic Press.
4. Glover, D. M., Gene Cloning: The Mechanics of DNA Manipulation, Springer-Science+Business Media, B. V.
5. Green, M. R. and Sambrook, J., Molecular Cloning: A Laboratory Manual, Cold Spring Harbor Laboratory, New York.
6. Davis, L. G., Dibner, M. D. and Battey, J. F., Basic Methods in Molecular Biology, Elsevier.
7. Gerhardt, P., Methods for General and Molecular Bacteriology, Elsevier.
8. Grinsted, J. and Bennett, P. M., Methods in Microbiology, Vol. 21, Plasmid Technology, Academic Press.

**Semester:** Semester III & IV

**Title of the paper:** Immunology (MIO 110)

**Class:** M.Sc

**No. of Credits:** 3 (Theory) + 1 (Practical)

**Objectives:** It is to develop concepts in role and the underlying mechanisms for the functioning of immunological cells and their interactions. The regulation of molecular synthesis, signalling, immune responses and allied activities of immune system at the molecular level.

**Course content (Syllabus in brief):**

1. Phagocytosis
2. Immunocompetent T and B cells
3. Immuno-technique

**Course level learning outcomes:**

1. Explains the mechanisms of immunological responses.
2. Apply the principles of cellular ontogeny and the gene rearrangement to understand the novel and complex immune system.

**Reference Books (Composite list for theory and practicals):**

1. Goldsby, R. A., Kindt, T. J. and Osborne, B. A., Kuby Immunology. W.H. Freeman
2. Bona, C. A. and Bonilla, F. A., Textbook of Immunology, Fine Arts Press
3. Janeway, C. A., Travers, P., Walport, M. and Shlomchik, M. J., Immunobiology, Garland Science.
4. Delves, P., Martin, S., Burton, D. and Roitt, I., Roitt's Essential Immunology. Wiley-Blackwell.
5. Chakraborty, P. and Pal, N. K., Manual of Practical Microbiology and Parasitology, New Central Book Agency (P) Ltd, Delhi, India.

**Semester:** Semester III & IV

**Title of the paper:** Extremophilic Microorganisms (MIO 112)

**Class:** M.Sc

**No. of Credits:** 3 (Theory) + 1 (Practical)

**Objectives:** This course gives insights about the extreme habitats, extremophilic microorganisms, their adaptations and biotechnological potentials.

**Course content (Syllabus in brief):**

1. Concept of extremophiles v/s conventional microbial forms.
2. Extreme habitats in universe.
3. Significance in biogeochemical cycling, industry, pharma and degradation of xenobiotics.
4. Key Molecular components, Unique : physiological features, adaptation strategies , growth kinetics and enzymes of various extremophilic types.

**Course level learning outcomes:**

1. Apply the knowledge to study the extremophilic microorganisms and tap their unique properties for ecological and industrial applications.

**References (Composite list for theory and practicals):**

1. Brock, T. D., Thermophilic Microorganisms and Life at High Temperatures, Springer, New York.
2. Horikoshi, K. and Grant, W. D., Extremophiles-Microbial Life in Extreme Environments, Wiley, New York.
3. Ventosa, A., Nieto, J. J. and Oren, A. (1998) Biology of moderately halophilic aerobic bacteria. Microbiology and Molecular Biology Reviews, 62, 504–544.
4. Rainey, F. A. and Oren, A., Extremophile Microorganisms and The Methods to Handle Them. In: Extremophiles, Methods in Microbiology, Vol. 35, Elsevier, Amsterdam.

**Semester:** Semester III & IV

**Title of the paper:** Research Methodology (MIO 114)

**Class:** M.Sc

**No. of Credits:** 1 (Theory) + 1 (Practical)

**Objectives:** This course develops the concepts of research and covers all aspects ranging from biosafety in the laboratory, experimental protocol, presentation of data and viva voce

**Course content (Syllabus in brief):**

1. Biosafety in the laboratory
2. Ethics in research
3. Defining the problem
4. Literature survey
5. Defining the Aims and Objectives
6. Work Plan – Time-bound Frame
7. Research design
8. Experimental protocol
9. Presentation of data
10. Analysis and Conclusions
11. Presentations
12. Research manuscript writing
13. Thesis Writing
14. Viva Voce

**Course level learning outcomes:**

1. Skills to design, conduct an experiment and successfully process and report the observations in the form of a scientific report/manuscript/thesis.

**Reference Books (Composite list for theory and practicals)**

1. Kothari C. R., Research Methodology Methods and Techniques, New Age International.
2. Kumar, R. C., Research Methodology. APH Publ Corporation, New Delhi.
3. Good C. V., Scates, D. E., Methods of Research, Appleton-Century-Crofts.
4. Day R.A. How to write and publish a scientific paper, Part 274, Volume 994, Oryx Press.
5. Alley, M., The Craft of Scientific Writing, Springer Science and Business Media.
6. Cooray P.G. Guide to Scientific and Technical Writing.

**Semester:** Semester III & IV

**Title of the paper:** Microbial Technology (MIO 116)

**Class:** M.Sc

**No. of Credits: 3 (Theory) + 1 (Practical)**

**Objectives:** This course develops concepts in technologies used in agriculture, mining, energy production and human health with respect to microorganisms and genetically engineered microorganisms. Introduces concepts of nanotechnology.

**Course content (Syllabus in brief):**

1. Biotechnology and prospecting with microbes.
2. Microbial technology in agriculture
3. Microbial technology in mining
4. Microbial technology for energy production
5. Microbial technology in Human health & aquaculture

**Course level learning outcomes:**

1. Apply the knowledge of various techniques in developing technology for sustainable development.
2. Explain commercialisation of a technology.

**Reference Books (Composite list for theory and practicals)**

1. Arora, R., Microbial Biotechnology: Energy and Environment, CABI Publishing.



2. Ahmad, I., Ahmad, F. and Pichtel, J. Microbes and Microbial Technology: Agriculture and Environmental Applications, Springer.
3. Peppler, H.J., Microbial Technology: Microbial Processes, Academic Press.
4. Sukla, L. B., Pradhan, N., Panda, S. and Mishra, B. K. Environmental Microbial Biotechnology, Springer.
5. Bull, A. T., Microbial Diversity and Bioprospecting, American Society for Microbiology.

**Semester:** Semester III & IV

**Title of the paper:** Food Microbiology (MIO 118)

**Class:** M.Sc

**No. of Credits:** 3 (Theory) + 1 (Practical)

**Objectives:** This course deals with the beneficial and harmful association of microorganisms with the food and prospective application of the microorganisms in the food industry. Teaches the methods of controlling the type and number of microorganisms in the food as per requirement. Teaches about the role of food regulatory bodies and measures of food safety and quality control.

**Course content** (Syllabus in brief):

1. Microbial Food Spoilage and Food Preservation
2. Microbiology in Food Processes
3. Food Safety and Quality Assurance

**Course level learning outcomes:**

1. Apply the knowledge about the food preservation, food fermentation, food safety, quality control and validation.

**Reference Books (Composite list for theory and practicals):**

1. Adams, M. R. and Moss, M. O., Food Microbiology, New Age International (P) Limited Publishers, New Delhi.
2. Frazier, W. C. and Westhoff, D. C., Food Microbiology, M. C. Graw-Hill Companies, Inc., New York.
3. Jay, M. J., Loessner, M. J. and Golden, D. A., Modern Food Microbiology, Springer Science + Business Media Inc., New York.
4. Da Silva, N., Taniwaki, M. H., Junqueira, V. C. A., Silveira, N. F. A., Nascimento, M. S. do. and Gomes, R. A. R., Microbiological Examination Methods of Food and Water: A Laboratory Manual, CRC Press, Taylor & Francis Group, U.K.

5. Ramesh, K. V., Food Microbiology, MJP Publishers, Chennai.
6. Harrigan, W. F., Laboratory Methods in food Microbiology, CRC Press, Taylor & Francis Group.
7. Doyle, M. P. and Buchanan, R. L., Food Microbiology: Fundamentals and Frontiers, ASM Press.

**Semester:** Semester III & IV

**Title of the paper:** Agricultural Microbiology (MIO 120)

**Class:** M.Sc

**No. of Credits:** 3 (Theory) + 1 (Practical)

**Objectives:** This course deals with the information about Inter-relationship of soil and microorganisms, different group of beneficial microorganisms in agriculture, microbes as a biofertilizer, plant pathogen and biocontrol agent.

**Course content** (Syllabus in brief):

1. Soil Microbiology
2. Beneficiary Microorganisms to plants
3. Plant Pathogens

**Course level learning outcomes:**

1. Apply the knowledge of soil chemistry and significant biochemical processes of microbes to improve agricultural practises.
2. Apply the understanding about genetics of advantageous microorganisms to genetically modified and develop improved crops.

**References (Composite list for theory and practicals):**

1. Alexander, M., Introduction to Soil Microbiology, Wiley.
2. Dadarwal, K. R., Biotechnological Approaches in Soil microorganisms for sustainable crop production, Scientific Publishers.
3. Subba Rao, N. S., Advances in Agricultural Microbiology, Oxford & IBH Publishers.
4. Carr, N. G. and Whitton, B. A., The Biology of Blue-green algae, University of California Press.
5. Mahanta, K. C., Fundamentals of Agricultural Microbiology, Oxford & IBH Publishers.
6. Veeresh, G. K. and Rajagopal, D., Applied Soil Biology and Ecology, Oxford & IBH Publishing Company Pvt. Limited.
7. Somani, L. L., Biofertilizers in Indian Agriculture, Concept Publishing Company.

8. Subba Rao, N. S., Biofertilizers in Agriculture and Forestry, International Science Publishers.
9. Bilgrami K. S. (1987) Plant Microbe Interactions, Proceedings of Focal Theme Symposium, Indian Science Congress Association, Narendra Publishing House.
10. Madigan, M. T., Martinko, J. M., Bender, K. S., Buckley, D. H. and Stahl, D. A., Brock Biology of Microorganisms, Pearson Education Limited.
11. Kumar, H. D., Modern Concepts of Microbiology, Vikas Publishing House Pvt. Ltd.

**Semester:** Semester III & IV

**Title of the paper:** Medical Microbiology and Epidemiology (MIO 122)

**Class:** M.Sc

**No. of Credits:** 3 (Theory) + 1 (Practical)

**Objectives:** Develops concepts in pathogenesis of various pathogens, its underlying mechanisms along with molecular interactions, leading to development of disease in the host. Develops principles of pathogen, host and environment in terms of its varied existence and interactions, leading to epidemiological events

**Course content** (Syllabus in brief):

1. Pathogenicity
2. Exotoxins
3. Communicable diseases

**Course level learning outcomes:**

1. Explain the various pathological events during the progression of an infectious disease.
2. Apply the principle of epidemiological sciences in studying the underlying mechanisms of spread of disease and controls required thereof to combat the spread of pathogens.

**References (Composite list for theory and practicals):**

1. Davis, B.D. et al., Microbiology. Harper and Row.
2. Gillespie, S.H. and Hawkey, P.M., Principles and Practice of Clinical Bacteriology. Wiley.
3. Struthers, J.K. and Westran, R.P., Clinical Bacteriology. CRC Press.

4. Chakraborty, P. and Pal, N.K., Manual of Practical Microbiology and Parasitology. Calcutta New Central Book Agency.

**Semester:** Semester III & IV

**Title of the paper:** Marine Microbial Interactions (MIO 124)

**Class:** M.Sc

**No. of Credits: 3 (Theory) + 1 (Practical)**

**Objectives:** The focus of this course is to advance the understanding of the students of marine microbiology with special emphasis on the intricate associations between microorganisms and marine organisms, diseases of microbial origin in fish and invertebrates, and other beneficial and harmful aspects like bioremediation and HABs respectively.

**Course content** (Syllabus in brief):

1. Symbiotic associations
2. Microbial diseases of fish and invertebrates
3. Marine microbes - Beneficial and harmful

**Course level learning outcomes:**

1. Explain the underlying marine microbial communities and how they impact the environment.

**Reference Books (Composite list for theory and practicals):**

1. Grasshoff, K., Ehrhardt, M. and Kremling, K., Methods of Seawater Analysis, Verlag Chem., Weinheim.
2. Gatesoupe, F. J., (1999) The use of probiotics in aquaculture, Aquaculture, 180:147-165.
3. Maier, R., Pepper, I. and Gerba, C., Environmental Microbiology, Academic Press.
4. Munn, C., Marine Microbiology: Ecology and Applications, Garland Science, Taylor and Francis, N.Y.
5. Nybakken, J. W. and Bertness, M. D., Marine Biology: an Ecological Approach, Benjamin Cummings, San Francisco, N.Y.
6. Parsons, T. R., Maita, Y. and Lalli, C. M., Manual of Chemical and Biological Methods for Seawater Analysis, Pergamon Press, New York.
7. Sharma, P. D., Environmental Microbiology, Alpha Science.
8. Sindermann, C. J., Principal Diseases of Marine Fish and Shellfish: Diseases of Marine Fish, Vol. 1, Gulf Professional Publishing.
9. Strickland, J. D. H. and Parsons, T. R., A Manual of Seawater Analysis, Queen's Printer and Controller of Stationery, Ottawa.

10. Toranzo, A. E., Magarinos, B. and Romalde, J. L., (2005) A review of the main bacterial fish diseases in mariculture systems, *Aquaculture*, 246(1): 37-61.

**Semester:** Semester III & IV

**Title of the paper:** Study tour/Field trip (MIO 201)

**Class:** M.Sc

**No. of Credits:** 1

**Objectives:** To provide knowledge about the ongoing research in various national research institutes and functioning of microbiology- related industries and industrial processes.

**Course content**

1. Visit to National Research Institutes
2. Visit to industries
3. Report writing
4. Presentation and group discussion

**Course level learning outcomes:**

1. Exposure to the various research being carried out in the field of microbiology.
2. Exposure to the various activities being carried out in industries using/or related to the applications of microbial principles.

**Semester:** Semester III & IV

**Title of the paper:** Study tour/Field trip (MIO 202)

**Class:** M.Sc

**No. of Credits:** 1

**Objectives:** To provide hands-on experience in the application of microbiological techniques in research institutes/industries/universities. To experience the workings of microbiology-related departments in commercial industries.

**Course content**

1. Undertake training for a minimum period of 10 working days or its equivalent.
2. Submit to the Department of Microbiology, Goa University, a certificate of attendance signed by the Training Coordinator of the respective Institute/Industry/University.
3. Submit to the Department a Report of the work undertaken.
4. Make a presentation of the work carried out to the Department Council for evaluation.

**Course level learning outcomes:**

Apply the tools and techniques of microbiology to a range of situations.

**Semester:** Semester III & IV

**Title of the paper:** Dissertation (MID)

**Class:** M.Sc

**No. of Credits:** 8

**Objectives:** Develop the skills of preparing and conducting independent research.

**Course content**

1. Research to be carried out under the guidance of an assigned guide.
2. Periodic reports (as determined at the initiation of the research work).
3. Dissertation.
4. Viva- Voce.

**Course level learning outcomes:**

Ability to apply the tools and techniques of microbiology in conducting independent research.