Goa University
P.O. Goa University, Taleigao Plateau, Goa 403 206, India

Syllabus of M.Sc. (Microbiology) Programme

The Programme is meant for students of B.Sc. (Microbiology) to pursue higher studies in Microbiology. It serves to impart advanced training to the students in the field of Microbiology with focus on microbial diversity, bioprospecting and applications of microbes for obtaining various biologically significant metabolites and in bioremediation of polluted environments. Students undergo hands-on training with state-of-the art technologies and are trained so as to develop an aptitude for independent research. The Programme equips students for higher research leading to the Ph.D. Degree in India or in International Universities overseas, or for employment in Research Institutes, in teaching, and in Industry.

Prerequisites: B. Sc. (Microbiology)

M.Sc. MICROBIOLOGY : COURSE STRUCTURE

CORE COURSES

CODE	COURSE	CREDIT(S) Theory	CREDIT(S) Practical	Contact Hours	Page No.
MIC 101-T	Microbial Biochemistry [T]	3	-	45	4
MIC 101-P	Microbial Biochemistry [P]	-	1	30	5
MIC 102-T	Microbial Genetics [T]	3	-	45	6
MIC 102-P	Microbial Genetics [P]	-	1	30	7
MIC 103-T	Microbial Taxonomy and Systematics [T]	3	-	45	8
MIC 103-P	Microbial Taxonomy and Systematics [P]	-	1	30	8
MIC 104-T	Techniques and Instrumentation in Microbiology [T]	3	-	45	9
MIC 104-P	Techniques and Instrumentation in Microbiology [P]	-	1	30	10
MIC 105-T	Biostatistics [T]	3	-	45	11
MIC 105-P	Biostatistics [P]	-	1	30	12
MIC 201-T	Industrial Microbiology [T]	3	-	45	13
MIC 201-P	Industrial Microbiology [P]	-	1	30	14
MIC 202-T	Archaea – Ecology, Physiology, Biochemistry, Genetics [T]	3	-	45	15
MIC 202-P	Archaea – Ecology, Physiology, Biochemistry, Genetics [P]	-	1	30	16
MIC 203-T	Molecular Biology [T]	3	-	45	17
MIC 203-P	Molecular Biology [P]	-	1	30	18
MIC 204-T	Marine Microbiology [T]	3	-	45	19
MIC 204-P	Marine Microbiology [P]	-	1	30	20
MIC 205-T	Mycology [T]	3	-	45	21
MIC 205-P	Mycology [P]	-	1	30	22

OPTIONAL COURSES

CODE	COURSE	CREDIT(S)		Contact Hours	Page No.
		Theory	Practical		
MIO 101-T	Medical Virology [T]	3	-	45	23
MIO 102-T	Environmental Microbiology and Bioremediation [T]	3	-	45	24
MIO 102-P	Environmental Microbiology and Bioremediation [P]	-	1	30	25
MIO 103-T	Genetic Engineering [T]	3	-	45	26
MIO 103-P	Genetic Engineering [P]	-	1	30	28
MIO 104-T	Immunology [T]	3	-	45	29
MIO 104-P	Immunology [P]	-	1	30	30
MIO 105-T	Extremophilic Microorganisms [T]	3	-	45	31
MIO 105-P	Extremophilic Microorganisms [P]	-	1	30	31
MIO 106-T	Research Methodology [T]	1	-	15	32
MIO 107-T	Microbial Technology [T]	3	-	45	33
MIO 107-P	Microbial Technology [P]	-	1	30	33
MIO 108-T	Food Microbiology [T]	3	-	45	34
MIO 108-P	Food Microbiology [P]	-	1	30	35
MIO 109-T	Agriculture Microbiology [T]	3	-	45	36
MIO 109-P	Agriculture Microbiology [P]	-	1	30	37
MIO 110-T	Medical Microbiology and Epidemiology [T]	3	-	45	38
MIO 110-P	Medical Microbiology and Epidemiology [P]	-	1	30	39
MIO 111-T	Marine Microbial Interactions [T]	3	-	45	40
MIO 111-P	Marine Microbial Interactions [P]	-	1	30	40
MIO 201-P	Field Trip/Study Tour	-	1	30	42
MIO 202	Training in an Institute/ Industry/ University	-	1	-	43
MID 301	Dissertation	-	8	-	44

Under Optional Courses:

- The theory course is a prerequisite for any practical course.
- Students of Microbiology and Marine Microbiology Programmes shall be required to take both Theory and Practical Courses under a given Course Title.

MIC 101-T MICROBIAL BIOCHEMISTRY [T]
Theory Course Credit : 3
Contact Hours : 45

1. Biological Molecules **(15)**

1.1 Protein

A. Amino acids: features and properties.

B. Protein: structure, principles of separation and purification, molecular weight determination; sequencing and synthesis.

C. Enzymes: activity, inhibition, mechanism of action; regulatory – allosteric and covalently modulated enzymes and their significance in metabolism.

1.2 Carbohydrate

A. Monosaccharides: types, characteristics and properties.

B. Disaccharides, oligosaccharides, polysaccharides – biological significance.

1.3 Lipid

A. Fatty acids: saturated and unsaturated, structure and properties.

B. Lipids: classification, structure, properties; biological significance; lipid composition of microorganisms.

2. Bioenergetics and Carbohydrate Metabolism **(15)**

2.1 Bioenergetics

Thermodynamics, exergonic and endergonic reactions, redox potential, high energy compounds, ATP structure and significance.

2.2 Oxidative Phosphorylation

Redox enzymes, aerobic electron transport and oxidative phosphorylation.

2.3 Carbohydrate metabolism

A. Carbohydrates: Central pathways of metabolism – regulatory mechanisms, bioenergetics and significance – EMP, TCA cycle (glucose aerobic and anaerobic metabolism, malate metabolism), Glyoxylate cycle.

Utilization of sugars such as lactose, galactose, maltose and of polysaccharides such as starch, glycogen, cellulose, pectin.

B. Gluconeogenesis from TCA intermediates / amino acids / acetyl-CoA; biosynthesis of polysaccharides and sugar interconversions.

3. Lipids, Amino Acids, Nucleotides and other Metabolic Paths **(15)**

3.1 Lipid Metabolism

A. Catabolism: Oxidation of fatty acids and the bioenergetics involved.

B. Anabolism: Biosynthesis of fatty acids: saturated and unsaturated, triglycerides, phospholipids, sterol.

3.2 Amino Acid and Nucleotide Biosynthesis

A. Amino acid biosynthethic pathways and their regulation.

B. Purine and pyrimidine nucleotides, Deoxyribo nucleotides: biosynthesis and regulation.

C. Biosynthesis of nucleotide coenzymes.

3.3 Photosynthetic Metabolism

A. Organisms and photosynthetic pigments, fundamental processes in Photosynthesis.

B. Photosynthetic electron transcript and photophosphorylation.

3.4 Chemolithotrophy

Organisms, substrates, bioenergetics of metabolism.

3.5 Antimicrobials

Bacteriocins and antibiotics - mode of action and resistance.

MIC 101-P MICROBIAL BIOCHEMISTRY [P]

Practical Course Credit : 1

Contact Hours : 30

1. Standard curve for sugar.
2. Standard curve for protein.
3. Enzyme assay.
4. Precipitation of protein from solution by salting out.
5. Dialysis.
6. Molecular exclusion chromatography.
7. Specific activity, fold purification, percentage yield of enzyme.
8. Molecular weight determination by SDS-PAGE.

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.

MIC 102-T MICROBIAL GENETICS [T]
Theory Course Credit : 3
Contact Hours : 45

1.

1.1 **Classical Mendelian genetics and deviation from Mendelian principles:** Origin of mitochondria and plastids – Endosymbiotic theory, DNA in Mitochondria and plastids, Mitochondrial and plastids genes have been inherited by Non-Mendelian mechanism, Maternal effect and epigenetic inheritance. **(03)**

1.2 **Microbial genome organization:** 3 Domains of Life based on 16S rRNA and 18S rRNA; Prokaryotic and Eukaryotic; replication, transcription and regulation. **(07)**

Structure of Prokaryotic genes (lac and trp operon) and Eukaryotic Genes (interrupted Genes), Prokaryotic genes are collinear with their proteins, Prokaryotic & Eukaryotic genome size, Gene numbers, types and families of genes, pseudogenes and their significance.

Microbial gene transfer (Conjugation, transformation, transduction).

Structural chromosomal aberrations and their significance: Deletion, duplication, inversion, translocation. Aneuploidy and polyploidy.

1.3 **Viral Genetics :** Genomic organization and Replication of viruses:-T4, Lambda Phage and its strategies-Lytic and Lysogenic cycles, TMV, M13, SV40, Hepatitis B, Poliomyeletis, HIV, H1N1 (Swine Flu). Retroviruses and retroposons-introduction and genetic significance. Viroids and plant diseases, virusoids. **(05)**

2.

2.1 **Genomic (DNA) Rearrangements:** Mechanism of General and programmed DNA rearrangements, Antigenic and phase variation in bacteria, rearrangement of immunoglobulin genes. **(05)**

Transposons: IS elements – Composite transposons (Tn3, Tn5, Tn7, Tn10), Ty, Copia and P type, Mechanism of transposition, transposons as research tools. Role of transposons in DNA rearrangements and microbial genome evolution.

2.2 **Mutagenesis, mutation and mutants**: Somatic and germinal mutation, spontaneous and induced mutations, different types of mutants, molecular basis of mutagenesis, site specific using PCR/ cassette mutagenesis/ M13 phage, and random mutagenesis.Tn mutagenesis; transition, transversion, tautomeric shift. **(10)**

DNA Damage: Thymine dimer, apyrimidinic site and apurinic site, cross linking, deamination of base, base mismatch.

Types of mutation: silent mutation, missense mutation, nonsense mutation, Read through mutation, frameshift- insertion and deletion mutation, translocation, Inversion, suppressor mutation.

Mutagenic chemicals and radiations and their mechanism of action: Base analogues (5-Bromouracil and 2-amino purines), EMS, MMS, acridines, Acriflavins, NTG, Hydroxylamine; mutagenic radiations- UV, X-rays and gamma rays. Ames test; Auxotrophy. Importance of mutations.

3.

3.1 **Fungal Genetics**: Yeast -*Saccharomyces cerevisiae/ S. pombe* and *Neurospora* genomes as model genetic systems; Chromosome replication, yeast artificial chromosomes, Crosses, tetrad analysis, genetic compatibility and non-compatibility genes, heterokaryosis, Parasexuality, Parthenogenesis, Gene conversion, Petite mutants of yeast, Killer yeast. **(08)**

3.2 **Bacterial plasmids**: Types of plasmids, F plasmids and their use in genetic analysis-$F^{+,}$Hfr cells/ F'cells, colicin and col plasmids, R plasmids and plasmids with genes encoding metal resistance, degradation of organic recalcitrants – PAH/PCB's and antibiotic resistance - efflux pump/MDR bacteria, Ti plasmid, 2µ plasmid. Replication in plasmids. Regulation of copy number and compatibility; Bacterial plasmids as research tools. Integrons and Genomic islands - pathogenicity islands. **(07)**

MIC 102-P MICROBIAL GENETICS [P]
Practical Course Credit : 1
Contact Hours : 30

1. Isolation of plasmid DNA from bacterial cells by Alkaline Lysis method (Birnboim and Doly, 1979).
2. Isolation of plasmid DNA from recombinant *E. coli* cells by Boil prep method (Holmes and Quigley, 1981).
3. Agarose gel electrophoresis, visualization and documentation of plasmid and genomic DNA using Gel Doc system.
4. Spectrophotometric quantification and purity of bacterial plasmid DNA.
5. UV mutagenesis and screening of pigment deficient mutants of *Serratia marcescens*.

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., *i*Genetics: 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.

MIC 103-T MICROBIAL TAXONOMY AND SYSTEMATICS [T]

Theory Course Credit : 3

Contact Hours : 45

1.

1.1 **Microbial taxonomy and systematics** **(03)**

Concepts of taxonomy (characterization, classification and nomenclature) and systematics; classification of microorganisms, three domain, six-kingdom, 8-kingdom systems, Endosymbiotic theory.

1.2 **Phenotypic characters** - Morphology, Biochemical tests (e.g. API, BIOLOG), Bacteriophage typing, Serotyping. **(04)**

1.3 **Chemotaxonomic markers** - Cell wall components, lipid composition, cellular fatty acid (FAME analysis), isoprenoid quinones, protein profiles (e.g. MALDI-TOF), cytochrome composition, polyamines. **(08)**

1.4 **Nucleic acid based techniques** – G+C content (T_m and HPLC); 16S rRNA gene sequencing; phylogenetic analysis; DNA-DNA hybridization. **(09)**

1.5 Concepts of species, numerical taxonomy and polyphasic taxonomy. **(06)**

2. Salient features of phylum, class and orders with representative examples of the following – Archaea, Eubacteria (bacteria, cyanobacteria, actinomycetes), Mycota, Protista (algae, protozoa, diatoms); and viruses. **(15)**

MIC 103-P MICROBIAL TAXONOMY AND SYSTEMATICS [P]

Practical Course Credit : 1

Contact Hours : 30

1. Morphological, physiological and biochemical characterization of bacteria.
2. Chemotaxonomic analysis - cell wall, cell lipid, quinones.
3. Characterization of actinomycetes (*Streptomyces* sp.).
4. Characterization of yeast (*Saccharomyces cerevisiae, Schizosaccharomyces pombe*).
5. Characterization of cyanobacteria.

References (Composite list for theory and practical):

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.

MIC 104-T TECHNIQUES AND INSTRUMENTATION IN MICROBIOLOGY [T]

Theory Course Credit : 3

Contact Hours : 45

1. **(15)**

1.1 Chromatographic techniques:

GC, HPLC, detectors, column/s matrix- Ion-exchange, affinity and molecular exclusion. (using examples for separation of microbial lipids, pigments, nucleic acids and proteins/enzymes).

1.2 Centrifugation:

Principles, methodology, application; Density gradient centrifugation; Ultracentrifugation (Separation of ribosomal subunits of bacteria).

1.3 Spectrophotometry:

Atomic Absorption Spectrophotometry (AAS), UV-Visible, fluorimetry, Fourier transformation infra-red spectroscopy (FTIR), MALDI-TOF, IR, NMR, MS.

2. **(15)**

2.1 Microscopy:

Epifluorescence filter technique (DEFT), SEM, TEM, Confocal and AFM.

2.2 Radio-isotope and tracer techniques:

Isotope and types of isotopes, Radio-activity counters, Autoradiography, Radiorespirometry.

2.3 Cell and tissue culture techniques:

Primary and secondary/established cell lines, Monolayer and suspension cultures, Fluorescence activated cell sorting (FACS), Biohazards and Biosafety cabinet.

3. **(15)**

3.1 Electrophoretic technique:

PAGE, IEF, Agarose gel electrophoresis, PFGE, DGGE, TGGE, Capillary electrophoresis, Single stranded conformation polymorphism (SSCP), Electroporator, Micro-array technique.

3.2 Isolation of cell organelles:

Different methods of cell lysis/ breakage and isolation and purification of various cell organelles - Cell surface structures, cell envelopes, plasma membranes, peptidoglycan, Outer membrane, ribosomes, protoplasts, vesicles, spheroplast, DNA, RNA.

3.3 Others:

X-ray diffraction, Oxygen analyser, Biosensors.

MIC 104-P TECHNIQUES AND INSTRUMENTATION IN MICROBIOLOGY [P]

Practical Course Credit : 1

Contact Hours : 30

1. Microscopy – compound, phase contrast – of bacterial cells.
2. Counting of bacterial cells using epifluorescence microscopy.
3. Density gradient separation of microbial cells.
4. Cell disruption by sonicator and efficacy of sonication.
5. Extraction of microbial pigments and profiling using UV-Vis spectrophotometer.
6. Polyacrylamide gel electrophoresis (PAGE), Zymogram.
7. Separation of pigments by column chromatography.

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.

MIC 105-T BIOSTATISTICS [T]
Theory Course Credit : 3
Contact Hours : 45

1.

1.1 **Characteristics of biological data:** Variables and constants, discrete and continuous variables, relationship and prediction, variable in biology (measurement, ranked, attributes), derived variables (ratio, index, rates), types of measurements of biological data (interval scale, ratio scale, ordinal scale, nominal scale, discrete and continuous data). **(03)**

Elementary theory of errors: exact and approximate numbers, source and classification of errors, decimal notation and rounding off numbers, absolute and relative errors, valid significant digits, relationship between number of valid digit and error, the error of sum, difference, product, quotient, power and root, rules of calculating digits. **(03)**

1.2 **Data handling:** Population and samples, random samples, parameter and statistics, accuracy and precision, accuracy in observations Tabulation and frequency distribution, relative frequency distribution, cumulative frequency distribution. **(05)**

Graphical representation: types of graphs, preparation and their applications.

1.3 Introduction to Bioinformatics **(04)**
Concepts and applications.

2.

2.1 **Measures of central tendency:** characteristics of ideal measure, Arithmetic mean – simple, weighted, combined, and corrected mean, limitations of arithmetic mean; Median – calculation for raw data, for grouped data, for continuous series, limitations of median; Mode – computation of mode for individual series, by grouping method, in a continuous frequency distribution, limitations of modes; Relationship between mean, median and mode; mid-range, geometric mean, harmonic mean, partition value, quartiles, deciles, percentiles. **(05)**

2.2 **Measure of dispersion:** variability, Range, mean deviation, coefficient of mean deviation, standard deviation (individual observations, grouped data, continuous series), variance, coefficient of variance, limitation. **(05)**
Skewness – definition, positive, negative, purpose, measure, relative measure, Karl Pearson's Coefficient, Bowley's Coefficient, Kelly's Measure, Moments.

2.3 **Correlation analysis** – Correlation, covariance, correlation coefficient for ungrouped data, Pearson's Rank Correlation coefficient, scatter and dot diagram (graphical method). **(05)**

Regression analysis - Linear and exponential function - DNSA conversion by reducing sugar, survival/growth of bacteria, regression coefficients, properties, standard error of estimates, prediction, regression analysis for linear equation.

3.

3.1	Probability: Probability, Combinatorial Techniques, Elementary Genetics, Conditional Probability, Bayes' Rule, Statistical Independence, Binomial, Poisson, Normal Distributions.	**(05)**
3.2	Hypothesis Testing – parameter and statistics, sampling theory, sampling and non-sampling error, estimation theory, confidence limits testing of hypothesis, test of significance; Students' T-test, t-distribution, computation, paired t-test.	**(05)**
3.3	Chi-square test, F-test and ANOVA.	**(05)**

MIC 105-P BIOSTATISTICS [P]

Practical Course Credit: 1

Contact Hours : 30

1. Excel spreadsheet and data analysis.
2. Linear equation analysis (regression analysis).
3. Normal distribution.
4. Hypothesis testing.
5. Application of other software (graphpad) for statistical analysis

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.

MIC 201-T INDUSTRIAL MICROBIOLOGY [T]
Theory Course Credit: 3
Contact Hours: 45

1.

1.1 History of Industrial Microbiology, fermentation processes, descriptive layout and components of fermentation process for extracellular and intracellular microbial products. **(05)**

1.2 Microbial growth kinetics: **(05)**
Batch kinetics – Monod's model (single substrate), deviations from Monod's model, dual substrates – sequential utilization, multiple substrates – simultaneous utilization, substrate inhibition, product synthesis (primary and secondary metabolite), toxic inhibition, death constant.

1.3 Microbial growth kinetics: **(05)**
Fed-batch kinetics – fixed volume, variable volume and cyclic fed-batch, applications and examples of fed-batch systems.
Continuous cultivation system – relationship between specific growth rate (μ) and dilution rate, multistage systems, feedback systems (internal and external feedback), applications and examples of continuous cultivation system; comparison between various cultivation systems.

2.

2.1 Optimization and modeling of fermentation process – single variable design, multivariate screening designs, critical factor analysis, optimization designs for two or more factor, singlet method; Metabolic and flux control analysis. **(05)**

2.2 Bioreactor design and operation: classification of reactors; Ideal mixed v/s plug flow reactor; designing parameters for reactors (stirred tank reactor, airlift reactor, plug flow reactor), rheology of fermentation broth. **(05)**

2.3 Bioreactor design and operation: gas-liquid mass transfer, heat transfer, analysis of dimension less parameters and their application (aeration number, power number and Reynold's number; Scale-up of bioprocesses: parameters used in scale-up and problems associated with scale-up. **(05)**

3.

3.1 Solid substrate fermentation (SSF): Principles and application; Surface fermentation Comparison between SSF, Surface fermentation and SmF. **(05)**
Problems in fermentation process and handling (foam, contamination, strain degeneration, etc), Immobilized enzymes and cell systems.

3.2 Fermentation monitor and control: Common measurement and control systems (speed, temperature, gas, pH, Dissolved oxygen, foam, redox, air flow, weight, pressure, biomass), On-line and off-line analysis, Digital controllers, control algorithm, flow charting, incubation control, advanced fermentation control and computer-based automation of process. **(05)**

3.3 Industrial scale Down-stream processing and product recovery: principle and general description of instrumentation, Recovery of particulates (cells and solid particles), recovery of intracellular products, primary isolation (extraction, sorption), precipitation, industrial processes for chromatography and fixed bed adsorption, membrane separations; Type Processes - Antibiotic (Penicillin including semi-synthetic). **(05)**

MIC 201-P INDUSTRIAL MICROBIOLOGY [P]
Practical Course Credit : 1
Contact Hours : 30

1. Fermentation kinetics – growth of *E.coli/S.cerevisiae* and determination of μ_{max}, Ks, Yx/s, m.
2. Rheology of substrate solutions.
3. Designing of fermentor – stirred tank reactor.
4. Immobilization using alginate.
5. Baker's yeast – ISI quality assurance.
6. Demonstration of AAS, HPLC, FTIR, MS/MS.

References (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.

MIC 202-T ARCHAEA - ECOLOGY, PHYSIOLOGY, BIOCHEMISTRY, GENETICS [T]
Theory Course Credit : 3
Contact Hours : 45

1. **(15)**

1.1 **Emergence of Archaeobacteria and the domain Archaea:** Three major domains of life – Archaea, Eubacteria, Eukarya. **(03)**
Carl Woese classification of archaea based on 16S rRNA analysis: Euryarchaeota, Crenarchaeota, Korarchaeota and Nanoarchaeota.
Similarities and dissimilarities - archaea, eubacteria and eukaryotes.
Uniqueness of archaea versus other extremophilic microorganisms.

1.2 **Significance of Archaea**: **(01)**
Biotechnology, Biogeochemical cycling, Evolutionary developments.

1.3 **Ecology, physiology and diversity of Archaea** **(06)**
Global econiches: Deep Sea, Hydrothermal vent, Dead Sea, solar salterns, geothermal vents, solfataras, Antarctica, soda lake, alkaline hot springs.
Study of archaeal biodiversity; unculturable archaea by metagenomics.
Archaeal culture retrieval methods, novel samplers. Preservation and maintainance of archaeal cultures.
Nutrition, growth and growth kinetics and physiological versatility, Stress response of Methanogens (*Methanobacterium thermoautotrophicum)*; Halophiles (*Halobacterium halobium, H. salinarum)*; Thermophiles (*Thermoplasma acidophilum* and *T. volcanium*); Thermoacidophiles (*Sulfolobus acidocaldarius)*; Alkalithermophilic chemolithoautotrophic crenarchaeota; Psychrophilic archaea (*Methanogenium frigidum, Methanococcoides burtonii*); Methanotrophs; radiation-tolerant archaea (*Thermococcus gammatolerans*).

1.4 **Cell structure and architecture of Archaea:** **5**
Cellular organization: cell morphotypes, cell envelopes -archaeal membrane lipids and cell wall, purple membrane, Archaeal ribosomes, appendages -pili, flagella, cannulae, hami.
Novel bio-molecules: Glycerol diether moieties and macrocyclic lipid, enzymes, co-enzymes: methanopterin, formaldehyde activation factor, Component B, Coenzyme M, F420, F430, corrinoids.

2. **Metabolism and energetics of Archaea** **(15)**

2.1 Modified anabolic pathways of carbohydrates and lipids; methanogenesis and acetoclastic reactions.

2.2 Modified central metabolic pathways: EMP, ED, incomplete TCA; reverse Kreb cycle, carbon dioxide reduction pathways: reductive acetyl-CoA pathway, 3-hydroxypropionate pathway.
Chemolithoautotrophy.

2.3 Bioenergetics: ATP synthesis (i) respiration-driven (ii) light-driven, involving bacteriorhodopsin (iii) chloride-driven, involving halorhodopsin (iv) cation-driven. Anaerobiosis.

2.4 Bacterioruberin pathway.

2.5 Lipid synthesis.

3. Genome of Archaea **(15)**

3.1 Size of genome, G + C content, associated proteins, archaeal histones and nucleosomes, introns in archaea, archaeal RNA polymerases, reverse DNA gyrase.

3.2 Plasmids, transposons -IS elements, AT-rich-islands, FI-DNA, FII-DNA. Modifications in tRNA and rRNA structure. Novel 7S rRNA. Signature sequences. DNA replication, translation and transcription in archaea, Recombination and DNA repair in archaea.

3.3 Gene organization in Archaea: (i) *fdh* operon (ii) *his* operon (iii) *bob* operon (iv) *mcr* operon.

MIC 202-P ARCHAEA - ECOLOGY, PHYSIOLOGY, BIOCHEMISTRY, GENETICS [P]

Course Credit: 1

Contact Hours: 30

1. Isolation and culturing of archaea.
2. Identification of isolate:

2.1 Biochemical tests for archaea.

2.2 Extraction of archaeal pigment and characterization using UV-Vis spectroscopy.

2.3 Cellular lipids - Extraction and chromatographic resolution of lipids.

3. Screening for hydrolytic enzymes.

References (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.

MIC 203-T MOLECULAR BIOLOGY [T]
Theory Course Credit: 3
Contact Hours: 45

1. Genetic material, bonds, types of DNAs, DNA packaging and model organisms (15)

1.1 Nucleic Acids, bonds, types of DNAs, DNA packaging and model organisms

A. Structure of DNA and RNA.
B. Bondings and different types of DNA (B-DNA & Z-DNA).
C. DNA packaging in bacteria (Nucleoid) and viruses.
D. Hybrid genome of Eucaryotes.
E. Yeast as a minimal model eukaryote.
F. *Arabidopsis* as a model of higher eukaryote.

1.2 Chromosomes, Genomes and it's evolution

A. Fundamental functions of DNA.
B. Chromosomal DNA and its packaging in the chromatin fibre.
C. Chromatin structure, structural features (Telomere, Centromere and Repetitive sequences) of chromosomes and their functions.
D. Evolution of Genomes, Gene duplication and mutations.

2. DNA Damage, DNA Repair and Recombination (15)

2.1 DNA damage elements/factors

A. Types of DNA damage (spontaneous and induced DNA damage).
B. Mechanisms/pathways to remove damaged DNA: Excision repair, mismatch repair, recombination repair in *E. coli* and SOS Repair.
C. Role of *RecA* in DNA damage repair, Photoreactivation repair in *E. coli* involving photolyase.

2.2 Mechanisms of Genetic Recombination

A. General and site specific recombination.
B. Heteroduplex DNA formation (Homologous recombination).
C. Synaptonemal Complex, Bacterial RecBCD system and its stimulation of chi sequences.
D. Role of RecA protein, homologous recombination, Holliday junctions.

3. How cells read the Genome (15)

3.1 From DNA to Proteins

A. From DNA to RNA.
B. From RNA to Protein.
C. The RNA world and origin of life.

3.2 Gene structure and control of gene expression in Prokaryotes and Eukaryotes

A. An overview of Gene expression control, DNA binding motifs in gene regulatory proteins, genetic switches and their role in control of gene expression.
B. Molecular Genetic mechanisms that create specialized cell types.
C. Post-transcriptional controls-transcriptional attenuation, Riboswitches, Alternate splicing, RNA editing, RNA Interference.
D. Translation of mRNA in Prokaryotes and Eukaryotes.
E. Role of Regulatory Switches, leader sequences and protein localization.

MIC 203-P MOLECULAR BIOLOGY [P]

Practical Course Credit : 1
Contact Hours : 30

1. Isolation of genomic DNA of bacterial cells, estimation of quantity and purity of DNA by spectrophotometry, and agarose gel electrophoresis.
2. Recovery of genomic DNA from agarose gel.
3. PCR amplification of a specific gene using genomic DNA as a template and agarose gel analysis of PCR product to determine amplicon size.
4. Demonstration of RT-PCR.

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.

MIC 204-T MARINE MICROBIOLOGY [T]
Theory Course Credit : 3
Contact Hours : 45

1. **(15)**

1.1 Introduction to oceanography: the world's oceans and seas, properties of seawater, physico-chemical factors in the marine environment such as temperature, density, nutrients, salinity, dissolved gases, waves, tides, oceanic currents, Ekman transport and upwelling; oceanic phenomena such as Coriolis effect, eddies, gyres, El Nino Southern Oscillation (ENSO), El Nino, La Nina.

1.2 Marine microbial habitats: estuaries, mangroves, salt marshes, beach and coastal ecosystems, reef and coral reefs, water column, sediments.

2. **Marine microbes – bacteria, fungi, phytoplankton, zooplankton, viruses: their growth, physiology and contribution to ocean processes** **(15)**

2.1 Modes of microbial growth: viable but non-culturable (VBNC) microorganisms, biofilms, microbial mats, epibiosis.

2.2 Physiology of marine microbes: metabolic diversity and energy-yielding processes: microbial loop; marine snow; phototrophy and primary productivity, fermentation, aerobic respiration, anaerobic respiration (denitrification, sulphate reduction, methanogenesis); nitrification, annamox, sulphur oxidation, methanotrophy; carbon dioxide fixation in autotrophs; the role of microorganisms in biogeochemical cyling: carbon, nitrogen, phosphorous, sulphur, iron, manganese.

3. **Methods in marine microbiology** **(15)**

3.1 Sampling equipment: water samplers such as Niskin sampler, Hydro-Bios sampler, Rosette samplers; sediment samplers such as van Veen grabs and corers.

3.2 Analysis of primary productivity: the radiocarbon method

3.3 Analysis of bacterial productivity: the thymidine uptake method

3.4 Measurement of respiration rates: light-dark bottle method

3.5 Tools to study marine microbial diversity: flow cytometry (bacteria, picoplankton, picoeukaryotes, viruses); molecular approaches such as metagenomics, community fingerprinting and Fluorescence *in situ* hybridization (FISH).

MIC 204-P MARINE MICROBIOLOGY [P]
Practical Course Credit : 1
Contact Hours : 30

1. Sampling methods for collection of water and sediment samples from coastal environments.
2. Analysis of physico-chemical parameters of seawater.
3. Isolation and enumeration of microbes from coastal environments.
4. Assessment of salt requirement of marine isolates from different ecosystems.
5. Nitrification and denitrification by marine bacterial isolates.
6. Study of biofilm formation by microorganisms.

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.

MIC 205-T MYCOLOGY [T]
Theory Course Credit: 3
Contact Hours : 45

1. Fungal diversity and distribution (15)

1.1 Origin and phylogeny; **classification**

1.2 Fungi – Terrestrial and Aquatic

A. Terrestrial.
B. Fresh water and Marine: Coastal– salt marsh, mangrove; Estuarine; Ocean.
C. Hypersaline waters – solar salterns, Salt Lake, Dead Sea.

1.3 Extremophilic Fungi

Oligotrophs, Alkaliphiles, Acidophiles, Barophiles, Psychrophiles, Thermophiles, Halophiles, Osmophiles, Xerophiles.

2. Physiology and Genetics (15)

2.1 Physiology of fungi

A. Growth and development.
B. Fungal hormones- attractants, morphogenesis and differentiation.
C. Adaptation to extreme environments.
D. Microbial interactions.
E. Secondary metabolites: antimicrobials, mycotoxin, pigments

2.2 Fungal genetics

Neurospora and *Saccharomyces*: Life-cycle, Cross over and tetrad analysis, gene conversion; Deuteromycotina: parasexuality, cytoplasmic inheritance; Karyotyping.

2.3 Identification of fungi

A. Colonial and morphological characteristics.
B. Molecular finger printing.

3. Pathogenesis - Antifungal Therapy (05)

3.1 Pathogenesis

Mycoses - Systemic, sub-cutaneous, cutaneous and superficial, opportunistic.
Plant pathogens.

3.2 Antifungal Therapy

Drugs acting on cell membrane, protein synthesis inhibitors; fungicides.

4. Applications (10)

A. Industrially important enzymes.
B. Bioprospecting of secondary metabolites: Pigments, nutraceuticals, antimicrobials, antitumour agents.
C. Biodegradation and bioremediation.
D. Biocontrol.

MIC 205-P MYCOLOGY [P]
Practical Course Credit : 1
Contact Hours : 30

1. **Study and Identification of fungi**

1.1 Study of standard cultures:

A. Colony characteristics

B. Morphological characteristics

1.2 Identification:

A. Observation of colonial and morphological characteristics

B. Reference to identification keys

2. **Fungal Genetics**
   Isolation of fungal DNA

3. **Application of fungi for bioremediation**
   Fungal degradation of a plant polymer.

References (Composite list for theory and practicals):

1. Alexopoulus, 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, IHW-Verlag.
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.

MIO 101-T MEDICAL VIROLOGY [T]
Theory Course Credit : 3
Contact Hours : 45

1. Virus: Structure, Cultivation and Assay **(10)**

1.1 Viruses

A. Introduction.
B. Visualization by electron microscopy.
C. Structure: envelope, capsid, nucleic acid.
D. Defective viruses.
E. Classification.

1.2 Viral genome

Genomic diversity - RNA or DNA, segmented or non-segmented.

1.3 Cultivation and assay of viruses

A. Cultivation
- *in vitro* using cell cultures: primary, secondary cultures, cell lines.
- *in ovo* using chick/duck egg embryo.
- *in vivo* using experimental animals

B. Viral multiplication and interference.
C. Assay by physical methods and by infectivity and cultivation methods
Detection by plaque, pock, polykaryocytes, haemadsorption, immunofluorescence, cytopathogenicity, tumor formation.

2. Viral Diseases **(20)**

Viral agents of disease: structure, mode of replication and pathogens
Picornavirus: Enteroviruses (polio) and rhinoviruses (upper respiratory tract); Herpes, HIV, Hepatitis (A, B, C, D, E), Orthomyxoviruses: Influenza. Paramyxoviruses: Mumps and Measles; Arboviruses: Togavirus - Rubella; Rhabdovirus: Rabies; Corona Virus: SARS.

3. Oncogenic and Emerging Viruses and Antiviral Combat **(15)**

3.1 Oncogenic - Papova and Adeno viruses, Herpes EBV and HCV, Retrovirus. Emerging viral agents of disease.

3.2 Virus-Host interactions.
Host specific and nonspecific defense mechanisms; neutralizing antibodies; role of interferon.

3.3 Viral vaccine development and viral chemotherapy.
Traditional vaccine preparations and newer methods - molecular approach
Drugs – nucleoside analogs, reverse transcriptase and protease inhibitors.

Reference Books:

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.

MIO 102-T ENVIRONMENTAL MICROBIOLOGY AND BIOREMEDIATION [T]
Theory Course Credit : 3
Contact Hours : 45

1. Microbial Ecology **(15)**

Microbial community structure, evolution of communities

Types of Ecosystems: components and functioning of ecosystem, concept of homeostasis, biotic and abiotic components in the environment and their interaction, characteristics and functions. Energy flow and material cycling. Food webs. Ecological succession. Ecological efficiency. Biodiversity. Overview of wetland, marine, forest, grassland and desert ecosystems. Concepts of microcosms and econiches

The expanse of microbial diversity, estimates of total number of species, measures and indices of diversity. Newer approaches for exploring unculturable bacteria from environmental samples like sewage, Culture independent molecular methods for understanding microbial community structure.

2. Biogeochemical processes **(10)**

Biogeochemical cycling of carbon, nitrogen, phosphorous, sulphur, Fe and Mn: physiological and biochemical aspects; role of microbes

3. Concepts of sustainable and holistic development **(05)**

Role of microorganisms in environment, Use of microorganisms towards sustainable development and specific pollution abatement programmes, need for environment impact assessment studies.

4. Microbes on surface **(05)**

Nature and significance, activity in surface films

Biofilm kinetics and its application to waste water treatment

5. Microbiological bioremediation **(10)**

Bioremediation technologies, bioreactors, microbial consortium. Combined biological treatment processes.

Overview of aerobic / anaerobic biodegradation and biotransformation of aliphatic, aromatic, xenobiotic and recalcitrant hydrocarbons, and of agricultural polymers such as cellulose, lignin, pectin and fossil fuels.

Methods of environmental monitoring and pollution control using nanotechnology.

MIO 102-P ENVIRONMENTAL MICROBIOLOGY AND BIOREMEDIATION [P]

Practical Course Credit : 1

Contact Hours : 30

1. Analysis of water samples - Physico-chemical: pH, temperature, COD, BOD, and microbiological
2. Studies on microbial adherence: BATH assay.
3. Study of biodegradation of aromatic compounds using TLC and ortho / meta mode of ring cleavage

References (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.

MIO 103-T GENETIC ENGINEERING [T]
Theory Course Credit : 3
Contact Hours : 45

1. Introduction to genetic engineering and tools involved in genetic manipulation (20)

1.1 Introduction to genetic engineering

1.2 Tools and techniques involved in genetic manipulation

A. DNA modifying enzymes: restriction endonucleases, exonucleases, DNA ligases (T4 DNA Ligase and *E.coli* DNA ligase), Terminal DNA transferase, DNA Polymerases (Taq, Amplitaq, vent, Exo-vent, Pfu, T4 etc), Reverse transcriptase, T4 polynucleotide kinases, Alkaline phosphatase, S-1 Nuclease, Mung bean nuclease, RNases.

B. Gene cloning systems/Hosts: Gene cloning in *E.coli* and other organisms such as *Bacillus subtilis*, *Saccharomyces cerevisiae* and other microbial eukaryotes

C. Cloning vectors: plasmid (pUC19, pBR 322 and their derivatives), λ phage based vectors, cosmid vectors, Phasmid vectors, shuttle vectors, High capacity Cloning vectors (BAC and YACs).

D. Sequencing Vectors: pUC 19 and M-13 Phage vector.

E. Expression vectors: Prokaryotic (pET, pGEX-2T and others).
Characteristics of expression vectors: strong bacterial and viral promoters (lac,trp,tac, SV 40,T7,T3) for induction of gene expression.

F. Construction of rDNA molecule and it's transfer to appropriate host (bacteria/yeast/plant cell/animal cell) using a suitable technique: transformation, electroporation, transfection, gene gun.

G. Gene Cloning strategies: Cohesive end cloning & Blunt end cloning, Shot gun cloning and directed cloning; Genomic DNA cloning and cDNA cloning, screening of Gene libraries for recombinant clones.

H. Other Recombinant DNA techniques: Use of radioactive and non- radioactive nucleotides for DNA probe preparation and detection of hybrids, Gel retardation assay, Restriction mapping, RFLP, PCR, RT-PCR, Real time PCR, Microarray, DNA sequencing using Sanger's Dideoxy chain termination method and automated sequencer; chromosome walking, Hybrid release and hybrid arrest translation to screen clones, site directed mutagenesis.

2. Application of Genetic Engineering in Biology, forensics and medicine (10)

2.1 Application of genetic engineering in DNA diagnostics and production of recombinant drugs, vaccines and hormones

A. Screening of Genetic diseases using DNA probes (DNA diagnostics).

B. Production of recombinant proteins and drugs(insulin, tissue plasminogen activator, erythropoietin, human growth hormones, Antibodies (including bispecific antibodies),vaccines, interferons, DNA vaccines: merits and demerits, Edible vaccines- merits and demerits.

C. Application of recombinant DNA technology in solving parental dispute and criminal cases (DNA finger printing).

2.2

A. Manipulation of gene expression in Prokaryotes; Strategies to isolate functional promoters, gene expression from strong and regulatable promoters, Developing fusion proteins and separation of cloned protein by protease induced cleavage.

B. Genetic manipulation to increase recombinant protein stability and secretion using signal sequences.

3. Application of Genetic Engineering in Agriculture (05)

A. Development of transgenic crops resistant to insect pests, bacterial, fungal and viral pathogens.

B. Strategies to develop transgenic crops and horticulture plants using various tools of recombinant DNA technology: Development of Bt Brinjal, Golden Rice and *flavr savr* tomato.

C. Importance of *Agrobacterium tumefaciens* in genetic manipulation of plants (Role of Ti plasmids), Role of *Bacillus thuringiensis* (*Bt* genes) to develop insect/pest resistant crops.

4. Application of Genetic Engineering in Industry (05)

Genetic engineering of microbes for production of enzymes, biomolecules and fermentation products

A. Genetic manipulation of microbes to over-produce industrially valuable enzymes.

B. Production of recombinant pharmaceuticals, nutraceuticals and other biomolecules.

C. Production of fermentation products using recombinant organisms.

D. Production of microbial SCPs.

5. Application of Genetic engineering in Bioremediation, Biorecovery and Biomonitoring of xenobiotics, metals and organometals. (05)

Genetic engineering of microbes for bioremediation and biomonitoring of toxic environmental pollutants, Biohydrometallurgy

A. Microbial bioremediation of xenobiotics by recombinant microbes.

B. Bioremediation of toxic heavy metals and organometals by recombinant microbes.

C. Biohydrometallurgy using recombinant microbes for recovery of precious metals.

D. Genetic manipulation of microbes to develop biosensors for monitoring toxic organic and inorganic pollutants.

MIO-103 P – GENETIC ENGINEERING [P]
Practical Course Credit : 1
Contact Hours : 30

1. Restriction mapping of bacterial plasmid and agarose gel analysis.
2. Preparation of competent cells and transformation of *E. coli* host with plasmid DNA using heat shock method and eporator; confirmation of positive transformants.
3. Demonstration of insertional inactivation of marker gene.
4. Assessment of DNA ligation activity of T4 DNA ligase.

References (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.

MIO 104-T: IMMUNOLOGY [T]
Theory Course Credit : 3
Contact Hours : 45

1.

1.1 Phagocytosis – Cell surface receptors/markers and their role, killing mechanisms; NK cells – Cell to cell recognition for normal and modified cells, receptors, initiation of apoptosis and killing of target cells, malfunctioning of NK cells; role of mast cells in immunity. **(05)**

1.2 Concept of immunoglobulin domain, distribution of immunoglobulin domain, superfamily member, structure and function of TCR, diversity of antigen binding domain, concept of segmented gene, gene organisation of Ig and TCR, generation of gene during differentiation and development of B and T Cells, expression of Ig and TCR Cistrons, class switch and regulation of expression, B and T Cell ontogeny. **(05)**

1.3 Major Histocompatibility Cluster – Introduction to MHC I, II and III, structure and function of MHC I and II, distribution and recognition of MHC I and II, gene organisation and concept of polymorphism, expression and its regulation, processing of extracellular antigen by APC, presentation of intracellular antigen by nucleated cells, recognition of MHC I and II by TCR/CD3 complex; Members of MHC III and their roles (in brief). **(05)**

2.

2.1 Ontogeny of T- and B-cells, immunocompetent T and B cells, recognition, signalling and activation of T cells by APC, control and regulation of activated T-Cells, B-cell activation – Type 1 thymus-independent antigen, Type 2 thymus-independent antigen, thymus dependent antigen, co-operation with T-cells and activation of resting B-cells, antigen processing by B-cells, stimulation by cross-linking surface Ig. **(05)**

2.2 Cytokine as messengers, receptor for cytokine – gp130 subfamily, □c and □c receptor subfamily, signal transduction and effects, network interactions; TH1 and TH2 responses; Cytokine mediated chronic inflammatory response; Killer T Cell and its regulation; effect of antigen dose and maturation of affinity of antibodies; role of memory cells. **(05)**

2.3 Antigen as major factor in control, feedback control of antibody production, T cell regulation – T-helper cells, T-cell suppression; Idiotypic networks, influence of genetic factors, immune regulation through hormone; T-cell tolerance. **(05)**

3.

3.1 Concept of inflammation (self-revision), complement fixation (self-revision), defence against intracellular bacterial pathogen, immunity to viral infection, immunity to fungi, immunity to parasitic infections; Passively acquired immunity, vaccination – herd immunity, strategies, killed organisms as vaccines, live attenuated vaccines, subunit vaccine, epitope vaccines, vaccines in use and experimental vaccines, Adjuvant and new approaches in vaccine development. **(05)**

3.2 Immuno-techniques: Antigen antibody interactions in solution (self revision), identification and measurement of antigen (self revision), epitope mapping, hybridoma technology and monoclonal antibody revolution, catalytic antibodies, engineering antibodies, antigen-antibody based affinity chromatography (revision if done in techniques), isolation of leukocyte and subpopulations, localization of antigen *in cyto* and *in tissue*, assessment of functional activity, genetic engineering of experimental animal for immune response investigation. **(05)**

3.3 Clinical immunology (Immunodeficiency): phagocytic cell defects, complement system deficiency, primary B-call deficiency, primary T-cell deficiency, combined immunodeficiency, secondary immunodeficiency, comparison between SCID and AIDS, recognition of immunodeficiency. **(05)**

MIO 104-P IMMUNOLOGY [P]
Practical Course Credit : 1
Contact Hours : 30

1. Haemagglutination for Blood grouping ABO and Rh system
2. Immunodiffusion slide technique
3. Agglutination tests for *Salmonella*-antigens
4. Complement fixation test
5. C-reactive protein determination
6. ELISA
7. Rapid tests – Malaria antigens Pv/Pf, IgM/IgG antibodies for Dengue, Hepatitis HBsAg
8. Rheumatoid Arthritis Factor determination

References (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.

MIO 105-T EXTREMOPHILIC MICROORGANISMS [T]

Theory Course Credit : 3

Contact Hours : 45

1. Concept of extremophiles v/s conventional microbial forms **(01)**

2. Extreme habitats in universe, extreme communities in following econiches: deserts, rhizospheres, ore deposits/ mining areas (Fe, Mn, Cu), animal systems, deep biosphere (terrestrial and marine), hydrothermal vents. **(02)**

3. Significance in biogeochemical cycling, industry, pharma and degradation of xenobiotics **(02)**

4. Key Molecular components, Unique : physiological features, adaptation strategies , growth kinetics and enzymes of various extremophilic types:

A. Anaerobes: oxygen toxicity and regulation in *Clostridium, Moorella thermoacetica,* Wood Ljungdahl pathway **(15)**

B. Barophiles/Peizophiles: mechanism in barophily, alpha proteobacteria

C. Cryophiles, Psychrophiles: (cold shock proteins and regulation) *Polaromonas, Pseudomonas*

D. Thermophiles: heat shock proteins, rho factors and regulation, *Aquifex, Tepidomonas, Rhodothermus*

E. Alkaliphiles/ basophiles: *Alkalimonas, Nesterenconia* **(15)**

F. Acidophiles: *Picrophilus, Ferroplasma*

G. Halophiles: *Halomonas*

H. Osmophiles: Osmophilic *Lactobacilli, Schizosaccharomyces pombe*

I. Oligotrophs: *Pelagibacter*

J. Xerophiles: *Wallemia*, extreme cyanobacteria, *Frankia* **(10)**

K. Radiophiles: Mn, Fe regulation *Deinococcus radiodurans*

L. Metallophiles: *Geobacillus*

M. Xenobiotic users: *Pseudomonas*

N. Endoliths: *Chroococcidiopsis, Halothece*, Stromatolites

MIO 105-P EXTREMOPHILIC MICROORGANISMS [P]

Practical Course Credit : 1

Contact Hours : 30

1. Isolation of thermophiles, halophiles, alkaliphiles, and anaerobes.
2. Tolerance of bacterial culture to temperature.
3. Detection of osmolytes from halophilic culture.
4. Buffering capacity of alkaliphiles.

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.

MIO 106-T RESEARCH METHODOLOGY [T]

Theory Course Credit : 1

Contact Hours : 15

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

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.

MIO 107-T MICROBIAL TECHNOLOGY [T]

Theory Course Credit : 3

Contact Hours : 45

1. Biotechnology and prospecting with microbes. (06)

A. Advantages of using microbial technology over chemical and physical technology.
B. Increasing relevance of microbiology in all biotechnologies.
C. Ethics in the use of GEMs.
D. Commercialization of Microbial Biotechnology.
E. Introduction to Nanotechnology.

2. Microbial technology in agriculture (09)

Production of microbial biofertilizers, biopesticides, soil conditioners to enhance crop yields.

3. Microbial technology in mining (15)

A. Bioleaching.
B. Biomining.
C. Recovery of oil. MEOR
D. Microbial technology in waste and pollution management in mining: Bioconversions, Bioremediation, Biosedimentation, Bio-beneficiation, Aquifer cleaning.

4. Microbial technology for energy production (07)

A. Microbial fuel cell.
B. Biogas.
C. Microbial cell mass.

5. Microbial technology in Human health & aquaculture (08)

Pigments, Nutraceuticals, Probiotics, Bioactives, Bioplastics, Microbes as bio-weapons.

MIO 107-P MICROBIAL TECHNOLOGY [P]

Practical Course Credit: 1

Contact Hours : 30

1. Determination of stability of microbial fertilizer.
2. Effect of microbes on sedimentation and clarification of water.
3. Screening of isolates for production of pigments, probiotics, bioactives.

References (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.

MIO 108-T FOOD MICROBIOLOGY [T]
Theory Course Credit : 3
Contact Hours : 45

1. Microbial Food Spoilage and Food Preservation **(15)**

A. Predictive food microbiology - Types of foods and their spoilage.
B. Factors affecting the growth and survival of microorganisms in foods: Intrinsic, Extrinsic.
C. Preservation methods: Heat processing, low temperature storage, control of water activity, irradiation, high pressure processing, modified atmospheres, preservatives: chemicals, natural organic molecules (nisin).

2. Microbiology in Food Processes **(15)**

2.1 Fermented and processed foods

A. Indian fermented foods.
B. Oriental mold modified foods.
C. Fermented meats and fish: - sausage, fish sauce.
D. Fermentations: wine, vinegar.

2.2 Genetically engineered microorganisms in the Food Industry

A. Concept, advancements, principles.
B. Role of genetically engineered microbes in the food industry.

3. Food Safety and Quality Assurance **(15)**

3.1 Food borne diseases

Bacterial, with emphasis on emerging pathogens such as *E. coli* EHEC O157:H7 and other strains; *L. monocytogenes*, *H. pylori*; Fungal, Algal, Viral, Prions and other non-bacterial forms.

3.2 Quality control and Validation

A. Microbiological examination of foods – sampling, culturing/analysis including newer methods such as PCR, magnetic separation.
B. Plant sanitation.
C. Hazard Analysis and Critical Control Point (HACCP) concept.
D. Food Safety Act and Trade Regulations.
E. Good Manufacturing Practice (GMP) and Quality Systems.

MIO 108-P FOOD MICROBIOLOGY [P]
Practical Course Credit : 1
Contact Hours : 30

1. Determination of the D value in heat treatment of foods.
2. Fermentation: Production of wine, monitoring of sugar reduction and alcohol production.
3. Isolation of probiotic culture (*Lactobacillus*).
4. Assessment of sanitary status of an eatery – Examination of microflora from table surface; utensils; drinking water.

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.

MIO 109-T AGRICULTURE MICROBIOLOGY [T]
Theory Course Credit : 3
Contact Hours : 45

1. Soil Microbiology **(15)**

A. Terrestrial Ecosystem, Pyramids and Econiches.
B. Types of Soil, soil Profile, Physico-Chemical Characteristics.
C. Suitability of soil for agriculture.
D. Soil Enzymes and significance.
E. Inter-relationship of soil and microorganisms.
F. Influence of microbial metabolism on soil chemistry & humus formation.
G. Importance of humic & fulvic acids in soil mineralization.
H. Effect of soil on microorganisms; fate of microbes introduced into soil.
I. Factors influencing bacterial survival in soils: Biotic & Abiotic.
J. Establishment of microbial inoculant.
K. Rhizosphere and Rhizoplane Microflora.

2. Beneficiary Microorganisms to plants **(15)**

A. Plant growth promoting Rhizobacteria, nitrogen fixation, phosphate mobilization and biocontrol of plant pathogens.
B. Mycorrhiza – Ectomycorrhiza, Endomycorrhiza , VAM structure & significance.
C. Plant growth promoting hormones from microbes viz. bacteria and fungi & their significance.
D. Nitrogen Fixing Microbes – Free living nitrogen-fixing bacteria, symbiotic N_2- fixers, *Azolla*, Cyanobacteria, *Frankia*.
E. Biochemistry and Genetics of Nitrogen fixation with reference to free living and symbiotic nitrogen fixers viz. *Azotobacter vinelandii, Rhizobium* and *Bradyrhizobium*. Significance of *nif* H, D, K, A, L, nod, nodulin and fix genes in the process of microbial nitrogen fixation.
F. Biofertilizers: An Overview.
(i) free living soil microbes fixing N_2 (*Azotobacter*, *Azospirillum*).
(ii) *Rhizobium, Azorhizobium, Bradyrhizobium* in symbiotic association with leguminous plants.
(iii) Free living cyanobacteria- N*ostoc, Anabaena, Plectonema, Anabaenopsis*, *Scytonema* present in rice fields.
(iv) Associative cyanobacteria (symbionts)-*Anabaena azollae, Anabaena cicadae*
(v) *Azolla* as Biofertilizer.
(vi) Compost as Biofertilizer.
G. Microbial Pesticides-(Biocontrol agents for agriculturally important crop plants)-Development and their significance; Source Organisms: Bacteria-*Bacillus thuringiensis*, Bt based commercial products, other Bacilli producing pesticides; Fungi—*Beauveria bassiana, Metarhizium anisopliae, Trichoderma,* Viruses-Baculoviruses for insect pest control.

3. **(15)**

A. Plant Pathogens and Genetic basis of pathogenesis.
(i) Common bacterial pathogens of crop plants and symptoms.
(ii) Common fungal pathogens of crop plants and their symptoms.
(iii) Virus and viroid diseases of crop plants and their symptoms.
B. Pathogenesis in plants and Defense response.
(i) Virulence in plant pathogens: biochemical and genetic basis of virulence.
(ii) Toxins as virulence factors.
(iii) Phytoalexins and their induction.
(iv) Plant defense responses or mechanisms of control (anatomical changes and biochemical synthesis of toxins, alkaloids and other biocontrol molecules).
C. Other means of pathogen control.
(i) Application of Viral proteins in controlling viral diseases.
(ii) Antisense RNA technology in disease control.
(iii) RNA in controlling plant pathogens.
(iv) Mycoviruses acting against fungal plant pathogens.

MIO 109-P AGRICULTURE MICROBIOLOGY [P]

Practical Course Credit : 1

Contact Hours : 30

1. Detection of enzymes – amylase, lipase, protease, catalase, urease from various soils such as sandy soil and garden soil.
2. Morphological characterization of cyanobacteria, extraction and estimation of cyanobacterial pigments (chlorophyll a, carotenoids, phycocyanin, allophycocyanin, phycoerythrin).
3. Isolation of microbial plant pathogen(s).

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.

MIO 110-T MEDICAL MICROBIOLOGY AND EPIDEMIOLOGY [T]

Theory Course Credit : 3

Contact Hours : 45

1.

1.1 Pathogenicity, virulence and virulence factor – historical perspective and definitions, course of infectious diseases, damage-response curve and classes of pathogen, growth of pathogen in host. **(05)**

1.2 Pili, flagella, biofilm, quorum-sensing, iron scavenging, aggressins/impedins against host defence. **(03)**

1.3 Host susceptibility, pre-disposing factor (nutritional, soci-economical, occupational, therapy, genetical), factors affecting immune systems; Receptors for pathogen – GalNacbeta1-4 gal moiety exposed on asialylated glycolipids, TLRs, regulation of host cell apoptosis; establishment of latent infection; TB, Streptococcal Pneumonia, Amoebic and Bacillary dysentery. **(07)**

2.

2.1 Exotoxins – Type III secretion system, AB – type toxins, examples (Tetanospasmin, diphtheria toxin, pertusis toxin), bifunctional toxins, cytotoxins and cytolysins. **(08)**

Endotoxin – structure, biosynthesis, assay, pathophysiological effects, excessive inflammatory response, endotoxin neutralizing compound, antagonists of LPS.

2.2 Diagnostics – Sample type and handling of samples, selective enrichment, classical methods (review) of culturing and identification of pathogens, staining methods for demonstration of pathogen in situ (direct staining, fluorescent antibody staining), Applications of Molecular diagnosis and Typing: LPS (chemotyping), phage, pyocin, antimicrobial, serotyping, Restriction mapping, RFLP, PFGE, PCR. **(03)**

2.3 Cystic fibrosis, Spongiform encephalopathy. **(04)**

3.

3.1 Spatial, temporal and social distributions of communicable diseases, transmissibility of infections, cross-sectional studies, case-control studies, cohort studies, Models for Developing Epidemiological Theory, modeling tools, Rates and risks, Population dynamics, Epidemiological Statistics Relating Exposure and Disease, Simple Epidemic Processes, Vaccine effect measures, Multistage chronic diseases, Joint effects of multiple exposure variables. **(09)**

3.2 Community acquired infection, infections in immunocompromised patients, Nosocomial infections, catheter associated infections, infections in patients with debilitating diseases, neo-natal infections; Vector borne diseases – vectors for transmission of infectious diseases, epidemiological cycles of vector borne diseases, control measures. **(06)**

MIO 110-P MEDICAL MICROBIOLOGY AND EPIDEMIOLOGY [P]

Practical Course Credit : 1

Contact Hours : 30

1. Demonstration of malaria parasite in blood film.
2. Isolation of bacteria from sputum/ mouth swab on chocolate agar and partial characterization.
3. Determination of sensitivity of bacteria to antibiotics (Disc method).
4. Enrichment, isolation and identification of Enteric pathogen.
5. Analysis of disease incidence using CDC/epidemiological data.

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., Principal 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.

MIO 111-T MARINE MICROBIAL INTERACTIONS [T]

Theory Course Credit : 3

Contact Hours : 45

1. Symbiotic associations **(15)**

Symbiosis of microalgae with animals; Symbiosis of chemoautotrophic prokaryotes with animal; Light organ symbiosis in fish and invertebrates; Microbial symbionts of sponges; Symbiosis and mixotrophy in protists; Metabolic consortia and mutualism between prokaryotes.

2. Microbial diseases of fish and invertebrates **(15)**

Diseases of fish, bivalve mollusks, crustaceans, corals in fresh water/ sea water/ aqua culture:

Bacterial – vibriosis, pasteurellosis, furunculosis, marine, bacterial kidney disease, mycobacteriosis, streptococcosis, black band disease, white plague, white pox, Juvenile Oyster Disease (JOD), bacterial shell disease.

Viral – Infectious salmon anemia (ISA) virus, viral hemorrhagic septicemia virus (VHSV), lymphocystis virus, birnaviruses, viral nervous necrosis.

Protistan – *Paramoeba perurans, Kudoa sp., Loma salmonae, Hematodinium*

Diagnostic methods.

Control of disease.

3. Marine microbes - Beneficial and harmful **(15)**

Beneficial aspects:

Biodegradation and bioremediation of marine pollutants such as oil, persistent organics and plastics.

Environmental monitoring using indicator microorganisms.

Microbial enzymes and polymers; biomedical and health products.

Harmful aspects:

Harmful Algal Blooms (HABs).

Biodeterioration, biofouling, bio-invasion – ballast waters.

MIO 111-P MARINE MICROBIAL INTERACTIONS [P]

Practical Course Credit : 1

Contact Hours : 30

1. Assessment of the microbiological quality of marine water in aquaculture:
   – physicochemical parameters.
   – potential pathogens.
2. Determining *E. coli* in shellfish –MPN/ EC-MUG medium.
3. Isolation of luminescent bacteria from fish/shellfish.
4. Screening of enzymes involved in deterioration of wood/litter in marine environments.

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.

MIO 201 STUDY TOUR / FIELD TRIP
Practical Course Credit : 1
Contact Hours : 30

1. **Visit to National Research Institutes:** National Centre for Antarctic and Ocean Research [NCAOR], National Institute of Oceanography [NIO] and ICAR – Central Coastal Agricultural Research Institute (ICAR - CCARI)

2. **Visits to Industries:**

2.1. Pharmaceutical industry
2.2. Agricultural farming
2.3. Food and beverage

3. **Report writing**

4. **Presentation and group discussion**

MIO 202 TRAINING IN AN INSTITUTE/ INDUSTRY/ UNIVERSITY
Course Credit : 1

The student shall be required to:

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.

Students may opt to undertake a Summer Training Course in an Institute/ Industry/ University of their choice. A student shall be required to make the necessary enquiries to seek the possibility of doing such a training; faculty will be assigned to assist them in their preparations. An official letter from the Department will then be issued.

MID 301 DISSERTATION
Course Credit : 8

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.