Goa University

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

Syllabus of M.Sc. (Microbiology) Programme

Board of Studies in Microbiology approved course structure and syllabus of M. Sc Microbiology 1st & 2nd semester on 8-9th April 2010, subsequently syllabus of M. Sc Microbiology Semester 3rd on 07 & 08th February 2011 & Semester 4th on 09th February 2012.

The department of Microbiology offers two years full time M. Sc programs in Microbiology since 1973.

A brief description of the course.

- **Purpose**: This is full time course to impart knowledge and training in different fields of Microbiology so as to equip them for higher studies in research and/or job orientation.
- **Prerequisites**: B. Sc (Microbiology)
- **Credits (theory, tutorials, practicals):** 80 credits,
  Theory: 60 credits
  Practicals: 20 credits
- **Number of semesters, how the courses are distributed**: 4
- **Distribution of courses**: each semester has courses equivalent to 20 credits
- **Dissertation**: optional 8 credits offered in Semester III & IV
  to impart research training
- **Field work/Case studies/Cruise/Field trip/Report writing/Training in other University/Institute**: to impart specialized practical training in specific areas of Microbiology.

M. Sc Microbiology-List of courses
In the following tables L refers to Lectures, T to Tutorials and P to Practicals.
Description of course appears on the page numbers listed in the tables.

Compulsory Courses

M. Sc Microbiology

Course Number and Name	L-T-P (hours/ week)	Credits	Page number
1st semester			
MI-101-Microbial Biochemistry	3-0-3	4	3
MI-102-Microbial Genetics	3-0-3	4	5
MI-103-Microbial Taxonomy and Systematics	3-0-3	4	7
MI-104-Techniques and Instrumentation in Microbiology	3-0-3	4	8
MI-105-Biostatistics	3-0-3	4	10
2nd semester			
MI-201-Industrial Microbiology	3-0-3	4	12
MI-202-Archaea - Ecology, Physiology, biochemistry and Genetics	3-0-3	4	14
MI-203-Molecular Biology	3-0-3	4	16
MI-204-Marine Microbiology I	3-0-3	4	18
MI-205-Mycology	3-0-3	4	20

Optional Courses (a student must choose at least 40 credits)

Course Number and Name	L-T-P	Credits	Page Number
3rd semester			
MI-301-Medical Virology	3-0-0	3	22
MI-302-Environmental Microbiology	3-0-3	4	23
MI-303-Genetic Engineering	3-0-3	4	24
MI-304-Immunology	3-0-0	3	26
MI-305-Extremophilic Microorganisms	3-0-3	4	28
MI-306-Case Study/ Report writing / Training in other institutes/universities	0-0-3	1	-
MI-307-Research Methodology	1-0-0	1	29
MI-308-Field trip	0-0-3	1	-
4th semester			
MI-401-Microbial Technology	3-0-3	4	31
MI-402-Food Microbiology	3-0-3	4	32
MI-403-Agricultural Microbiology	3-0-3	4	34
MI-404-Microbiology in environmental pollution and its control	3-0-3	4	36
MI-405-Medical Microbiology and epidemiology	3-0-3	4	37
MI-406-Marine microbiology II	3-0-3	4	39
MID-Dissertation	0-3-9	8	

Syllabus of the M.Sc. Microbiology Programme

Compulsory courses

MI 101 – Microbial Biochemistry
Course credit: 4 – Three credit theory and one credit practical

(CH)

1 Proteins and Enzymology (15)

1.1 Proteins: structure, principles of separation and purification, molecular weight determination; sequencing and synthesis

1.2 Enzymes: Activity, Inhibition, Mechanism of action; Regulatory – Allosteric and Covalently Modulated Enzymes and their significance in metabolism.

1.3 Amino acid biosynthethic pathways and their regulation

2 Carbohydrates and Lipids (15)

2.1a **Carbohydrate Metabolism**

Carbohydrates: Central pathways of metabolism – regulatory mechanisms, bioenergetics and significance - EMP and alternate pathways: Entner-Doudoroff, HMP and oxidative pentose phosphate; TCA cycle (glucose aerobic and anaerobic, malate metabolism), Glyoxylate cycle

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

2.1b **Carbohydrate Metabolism**

Gluconeogenesis from TCA intermediates / amino acids / acetyl-CoA; biosynthesis of polysaccharides and interconversion of sugars

2.2 **Lipid Metabolism**

1. Lipids: fatty acids - structure, properties; classification of lipids, structure, properties, lipid composition of microorganisms
2. Catabolism: Bioenergetics of β-oxidation of fatty acids, long chain fatty acids
3. Anabolism: (a) Biosynthesis of fatty acids: saturated, unsaturated
   (b) Biosynthesis of triglycerides, phospholipids, sterols

3 Other Metabolic Pathways and Bioenergetics of Metabolism (15)

3.1 **Nucleotide biosynthesis**

Biosynthesis and its regulation of purine and pyrimidine nucleotides, deoxyribo nucleotides

Biosynthesis of nucleotide coenzymes

3.2 **Bioenergetics and ATP generation**

Exergonic and endergonic reactions;

Redox enzymes, aerobic electron transport and oxidative phosphorylation;

Intermediary metabolism - flexibility economy.

3.3 **Photosynthetic Metabolism**

Organisms and photosynthetic pigments, fundamental processes in photosynthesis

Photosynthetic electron transcript and photophosphorylation

3.4 **Chemolithotrophy**
Organisms, substrates, bioenergetics of metabolism

3.5 **Antimicrobials**
Bacteriocins and antibiotics - mode of action and resistance

4 Practical (45)

1 Study of standard protein sample.
1.1 Precipitation of protein from solution by salting out; dialysis
1.2 Gel filtration / molecular exclusion chromatography
1.3 Specific activity, fold purification, percentage yield of enzyme
2 Extraction of microbial whole cell protein
2.1 Growth and harvesting of the culture
2.2 Cell lysis: homogenisation/ sonication
2.3 Protein estimation of lysate - quantification per unit biomass
3 Protein Profile / Molecular weight determination by SDS-PAGE

Reference Books:

1. Lehninger Principles of Biochemistry edited by Albert Lehninger , Michael Cox , David L. Nelson. (2004). Fourth Edition. W. H. Freeman & Company
2. Microbial Physiology edited by Albert G. Moat and John W. Foster. 4th Edition.
3. Companion to Microbiology edited by Bull, Alan T. and Meadow, Pauline (1978).
4. An introduction to practical biochemistry edited by David T. Plummer (1987).
5. Biochemical Methods edited by S. Sadasivam, A. Manickam. (2007) Edition, 3. Publisher, New Age International (P) Limited
6. Laboratory Manual in Biochemistry edited by J. Jayaraman. (1981). Publisher, John Wiley & Sons Australia, Limited.

BACK

MI-102 MICROBIAL GENETICS
Course credit: 4 – Three credit theory and one credit practical

1			**CH**
	1.1	Classical Mendelian Genetics and Deviation from Mendelian Principles, Genomes in Mitochondria and Plastids, mitochondria and chloroplast have diverse genomes, Mitochondrial genes have been inherited by Non-Mendelian mechanism, why mitochondria and plastids (chloroplast) have their own genetic system?	(3)
	1.2	Special types of chromosomes-Polytene and Lampbrush chromosomes and their genetic significance Structural chromosomal Aberrations and their significance: Deletion, Duplication, Inversion, Translocation Bacterial genomes – organization, replication, segregation and regulation Structure of Prokaryotic and Eukaryotic Genes (interrupted Genes), Prokaryotic genes are colinear with their proteins, Prokaryotic & Eukaryotic genome Size, Gene numbers, types and families of genes, pseudogenes and their significance.	(7)
	1.3	Viral Genetics : Genomic organization and Replication of viruses-T4,Lambda , M13, SV40, Hepatitis B, Poliomyeletis, HIV, H-1 N-1 (Swine Flu). Lambda Phage and its strategies-Lytic and Lysogenic cycles. Retroviruses and Retroposons-introduction and genetic significance.	(5)
2			
	2.1	Genomic (DNA) Rearrangements: Mechanism of General and programmed DNA rearrangements, Role of transposons in DNA rearrangements. Transposons: IS elements – Composite transposons (Tn3, Tn 5, Tn 7, Tn 10), Copia and P type , Mechanism of transposition, transposons as research tools.	(5)
	2.2	Mutagenesis, mutation and mutants: spontaneous and induced mutations, different types of mutants, molecular basis of mutagenesis, site specific and random mutagenesis. Tn mutagenesis; transition & transversion, tautomeric shift Point mutations and consequences: silent mutation, missense mutation, nonsense mutation, Read through mutation Mutagenic chemicals and radiations and their mechanism of action: EMS, MMS, acridines, Acriflavins, NTG, Hydroxylamine; mutagenic radiations- UV and gamma rays Importance of mutations	(10)

3

3.2 Fungal Genetics: Yeast (*Saccharomyces cerevisiae, S.pombe*) and *Neurospora* genomes as model genetic systems; (15)
Chromosome replication, yeast artificial chromosomes, Crosses, tetrad analysis, genetic compatibility and non-compatibility genes, heterokaryosis, Parasexuality, Parthenogenesis, Gene conversion, mutagenesis (Petite mutants of yeast);

Bacterial plasmids: Types of plasmids, F plasmids and their use in genetic analysis, colicin and col plasmids, R plasmids and plasmids with genes encoding metal resistance and degradation of organic recalcitrants (PAH, PCB's, etc)., Replication mechanism of plasmids, regulation of copy number and compatibility; Bacterial plasmids as research tools.

4 Practicals (45)

1 Isolation of plasmid DNA from recombinant *E.coli* cells by Boil Prep method (Holmes and Quigley,1989).
2 Isolation of Genomic DNA of Bacterial cells using Rapid genomic DNA extraction method.
3 Isolation of plasmid DNA from bacterial cells by Alkaline Lysis method (Birnboim and Doly,1979).
4 Agarose gel electrophoresis, visualization and documentation of plasmid DNA using Gel Doc system.
5 Agarose gel electrophoresis of genomic DNA, visualization of genomic DNA and recording of gel using Gel doc system.
6 Spectrophotometric quantitation and purity of genomic DNA of bacterial cells.
7 Recovery of genomic DNA embedded in agarose gels (Freeze Squeeze, column)
8 UV mutagenesis and screening of pigment deficient mutants of *Serratia* sp.
9 Determination of UV survival of *Serratia* sp.

References:

i. Microbial Genetics by David Freifelder (2009)
ii. Microbial Genetics by Maloy et al. 2009
iii.Modern Microbial Genetics by Streips and Yasbin (2009)
iv.Molecular Genetics of Bacteria by J. W. Dale , John Wiley publishers, (2009)
v .Genetics by M.W. Strickberger (2009)
vi.Principles of Genetics by Gardner, Simmons and Snustad (2009)
vii.Bacterial Plasmids by Hardy

BACK

MI103 - Microbial Taxonomy and Systematics
Course credit: 4 – Three credit theory and one credit practical

1			**(CH)**
	1.1	**Microbial taxonomy and systematics** Concepts of classification of microorganisms, three domain and six-kingdom systems.	(3)
	1.2	**Methods for identification** **Phenotypic characters** - Morphology, Biochemical tests (e.g. API, BIOLOG), Bacteriophage typing, Serotyping	(6)
	1.3	**Methods for identification** **Chemotaxonomic markers –** Cell wall components, lipid composition, isoprenoid, quinones, protein profiles, cytochrome composition.	(6)
2			
	2.1	**Methods for identification** **Nucleic acid based techniques -** DNA-DNA hybridization, G+C content, PCR based fingerprinting - RAPD, ribotyping; DNA sequencing for phylogenetic analysis, 16S rRNA sequencing	(6)
	2.2	**Tools for Systematics -** Numerical taxonomy, Polyphasic taxonomy, Phylogenetic analysis	(6)
	2.3	**Salient features** of division, class and orders with representative examples under following kingdoms – Archaea, Mycota and viruses	(3)
3			
	3.1	**Salient features** of division, class and orders with representative examples under following kingdoms - Eubacteria (bacteria, cyanobacteria, actinomycetes), Protista (algae, protozoan, diatoms, yeast)	(15)

4		**Practicals**	**(45)**
	1	Identification of bacteria using Bergey's Manual	6
	2	Chemotaxonomic analysis - cell wall, cell lipid, quinines, cytochromes	6
	3	Isolation, identification and characterization of actinomycetes (Streptomyces sp.)	6
	4	Isolation, identification and characterization of yeast (Saccharomyces cerevisiae, Schizosaccharomyces pombe)	6x2
	5	Anaerobic microorganisms	3
	6	Isolation and identification of Cyanobacteria	6x2

Reference Books

1. Chemotaxonomic analysis by Good fellow & Minnins
2. Bergey's manual of systematic bacteriology by Smith et. al.
3. Methods in Microbiology, Vol. 18 & 19; Peter Thomas .

BACK

MI104 – Techniques and Instrumentation in Microbiology
Course credit: 4 – Three credit theory and one credit practical

1			**(CH)**
	1.1	**Chromatographic techniques:** GC, HPLC/FPLC, Ion-exchange, Affinity, Molecular exclusion	(5)
	1.2	**Centrifugation:** Principles, methodology, application; Density gradient centrifugation; Ultracentrifugation	(3)
	1.3	**Spectrophotometry:** Atomic Absorption Spectrophotometry (AAS), UV-VIS, fluorimetry, Fourier transformation infra red spectroscopy (FTIR), MALDI-TOF, IR, NMR, MS	(7)
2			
	2.1	**Microscopy:** Epifluroscence filter technique (DEFT), SEM, TEM and AFM.	(5)
	2.2	**Radio-isotope and tracer techniques :** Isotope and types of isotopes, Radio-activity counters, Autoradiography, Radiorespirometry	(5)
	2.3	**Cell and tissue culture techniques:** Primary & secondary/established cell lines, Monolayer & suspension cultures, Fluorescence activated cell sorting (FACS)	(5)
3			
	3.1	**Electrophoretic technique:** PAGE, IEF, Agarose gel electrophoresis, PFGE, DGGE, TGGE, Capillary electrophoresis, Single stranded conformation polymorphism (SSCP)	(6)
	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	(6)
	3.3	**Others:** X-ray diffraction, Oxygen analyser, Biosensors	(3)
4			**(45)**
	1	**Isolation of mitochondria**	
	2	**Preparation of protoplast**	
	3	**Density gradient (sucrose) centrifugation**	
	4	**Native PAGE**	
	5	**Phase Contrast microscopy**	
	6	**Lyophilisation**	
	7	**Cell disruption by sonicator**	
	8	**UV-Vis**	
	9	**Fluorimetry**	
	10	**Demonstration:** HPLC, GC, Atomic absorption spectrophotometer, NMR, IR, MS	

Reference Books:

1. Molecular cellular **microbiology (Methods in microbiology**) edited by J. R. Norris, D.W. Ribbons.
2. **Methods in Enzymology** edited by Sidney P. Colowick and Nathan, Academic Press.
3. Molecular Biology and **Biotechnology** : **Microbial Methods** Manoj V. Parakhia, Rukam S. Tomar, Sunil Patel and B. A. Golakiya.
4. A classic reference work in **Molecular Biology by** E. F. Fritsch · Tom **Maniatis** · Joseph Sambrook

BACK

MI105 - Biostatistics
Course credit: 4 – Three credit theory and one credit practical

1 **(CH)**

1.1a **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); (3)

1.1b **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 (3)

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 (5)

Graphical representation: types of graphs, preparation and their applications

1.3 Introduction to Bioinformatics (4)
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 (5)

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 (5)

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, Spearson's Rank Correlation coefficient, scatter and dot diagram (graphical method) (5)

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	(5)
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	(5)
3.3	Chi-square test, F-test and ANOVA	(5)

4 Practicals (45)

1. Excel spreadsheet and data analysis
2. Linear equation analysis (regression analysis)
3. Exponential equation analysis (Survival curve)
4. Chi square test
5. Normal distribution
6. Hypothesis testing

Reference books:

1. Quantitative techniques by Kothari, Vikas Publishing House
2. Biostatistics by Arora and Malhan, Himalaya Publishing House
3. Computational mathematics by Danilina et al., Mir Publishers
4. Biostatistics by Surya, Himalaya Publishing House

BACK

MI 201 - Industrial Microbiology
Course credit: 4 – Three credits for theory and one for practical.

1			CH
	1.1	History of Industrial Microbiology, fermentation processes, descriptive layout and components of fermentation process for extracellular and intracellular microbial products	(5)
	1.2	Microbial growth kinetics: 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	(5)
	1.3	Microbial growth kinetics: Fed-batch kinetics – fixed volume, variable volume and cyclic fed-batch, applications and examples of fed-batch systems, Continuous cultivation system – relationship between □ and dilution rate, multistage systems, feedback systems (internal and external feedback), applications and examples of continuous cultivation system; comparison between various cultivation systems	(5)
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	(5)
	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	(5)
	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	(5)
3			
	3.1	Solid substrate fermentation (SSF): Principles and application; Surface fermentation Comparison between SSF, Surface fermentation and SmF. Problems in fermentation process and handling (foam, contamination, strain degeneration, etc), Immobilized enzymes and cell systems	(5)

	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.	(5)
	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)	(5)
4		**Practicals**	**(45)**
	1	Fermentation kinetics – growth of *E.coli/S.cerevisiae* and determination of μ_{max}, Ks, Yx/s, m	
	2	Rheology of substrate solutions, culture broth and harvested cell suspension	
	3	Designing of fermentor – stirred tank reactor	
	4	Aeration efficiency using dissolved oxygen analysis	
	5	Immobilization using alginate	
	6	Baker's yeast – ISI quality assurance	

Reference Books:

1. Manual of Industrial Microbiology and Biotechnology, Demain et al., Wiley
2. Fermentation and Biochemical Engineering Handbook - Principles, Process Design, and Equipment, Vogel and Tadaro, William Andrew Publishing
3. Biochemical Engineering and Biotechnology Handbook, Atkinson, Grove's Dictionaries
4. Encyclopedia of Bioprocess Technology, Fermentation, Biocatalysis and Bioseparation, Volumes 1 - 5, Flickinger and Drew, Wiley
5. Principles of Fermentation Technology, Stanbury et al., Butterworth-Heinemann

BACK

MI 202 - Archaea - Ecology, Physiology, Biochemistry and Genetics
Course credit: 4 – Three credits for theory and one for practical.

1			CH
	1.1	**Emergence of Archaeobacteria and the domain Archaea:** Three major lineages of life – Archaea, Eubacteria, Eukarya Similarities and dissimilarities - Archaea, eubacteria and eukaryotes Uniqueness of archaebacteria v/s other Extremophilic microorganisms	(1)
	1.2	**Significance of Archaea**: Biotechnology, Biogeochemical cycling, Evolutionary developments	(2)
	1.3	**Ecology, physiology and diversity of Archaea** Global econiches; Culture – Retrieval- methods, novel samplers, Non-culture-methods. Preservation Nutrition, Growth and growth kinetics and physiological versatility, Stress Response, Methanogens (*Methanobacterium thermoautotrophicum);* Halophiles (*Halobacterim halobium)*; Thermophiles (*Thermoplasma*) and Thermoacidophiles (*Sulfolobus).*	(3)
	1.4	**Cell structure and architecture of Archaea:** Cellular organization - cell morphotypes, cell envelopes, Purple membrane, cell organelles - ribosomes, appendages; molecular organization Novel bio-molecules: GDEMs and macrocyclic lipid, enzymes, Co-enzymes Methanopterin, formaldehyde activation factor, Component B, Coenzyme M, F420, F430, corrinoids. DNA Binding and Repair proteins	(9)
2		**Metabolism and energetics of Archaea**	(15)
	2.1	Modified anabolic pathways. (carbohydrates, lipids), Methanogenesis and acetoclastic reactions	
	2.2	Modified Central metabolic pathways including C1, C3 compounds. Incomplete TCA; Carbon dioxide reduction pathways	
	2.3	Bioenergetics: (i) respiration driven (ii) light driven (iii) chloride driven (iv) cation driven ATP synthesis. Anaerobiosis.	
	2.4	Bacterioruberin pathway	
	2.5	Lipid synthesis	
3		**Genome of Archaea**	(15)
	3.1	Size of genome, G + C content, associated proteins	
	3.2	FI-DNA, FII-DNA, Plasmids, IS elements, AT-rich-islands. Modifications in tRNA and rRNA structure. Novel 7S rRNA. Signature sequences. DNA Replication, Recombination and DNA Repair in archaea	
	3.3	Gene organization in Archaea: (i) *fdh* operon (ii) *his* operon (iii) *bob* operon (iv) *mcr* operon.	
	3.4	Archaeal virus like particles and phages.	

4 Practicals (45)

1 Isolation and Culturing of Archaea
2 Identification of isolate:
2.1 Analysis of morphological features by SEM.
2.2 Cellular lipids - Extraction and chromatographic resolution of lipids
3 Bioprospecting for hydrolytic enzymes / for Archaeocin

Reference books:

1. The **Bacteria** : A Treatise on Structure and Function. **Archaebacteria**, **vol**. **8**, pp. 525–544, Woese C. R. and Wolfe R. S. (eds), Academic Press,
2. Archaea: New Models for Prokaryotic Biology edited by Paul Blum, *Beadle* Caister (Academic Press).
3. Archaea: Evolution, Physiology, and Molecular Biology edited by Garrett and Klenk Amazon.com
4. **Archaea:** Molecular and Cellular Biology**,** model **archaea,** archaeal genomes, other **haloarchaea,** archaeal flagella Amazon.com

BACK

MI 203 – MOLECULAR BIOLOGY
Course credit: 4 – Three credits for theory and one for practical.

1			CH
	1.1	Nucleic Acids- structure of DNA and RNA, Bondings and different types of DNA (B-DNA & Z-DNA); DNA packaging in bacteria, viruses and eukaryotes, Hybrid genome of Eucaryotes: Regulatory sequences, yeast as a minimal model eukaryote, *Arabidopsis* as a model of higher eukaryote; Diversity of genomes and the tree of life.	(10)
	1.2	**DNA, chromosomes and Genomes**: structure and function of DNA, chromosomal DNA and its packaging in the chromatin fibre, chromatin structure, structural features (Telomere, Centromere and Repetitive sequences) of chromosomes and their functions. Packaging of Viral genomes; bacterial genome - nucleoid, Evolution of Genomes; Gene duplication and mutations.	(5)
2		**DNA Damage and repair, recombination**	(15)
	2.1	DNA damage elements/factors, Types of DNA damage(spontaneous and induced DNA damage), mechanisms/pathways to remove damaged DNA: Excision repair, mismatch repair, recombination repair in *E.coli,* SOS Repair, role of Rec A in DNA damage repair, Photoreactivation repair in *E.coli* involving photolyase.	
	2.2	Mechanisms of Genetic Recombination: General and site specific recombination, Heteroduplex DNA formation (Homologous recombination), Synaptonemal Complex, Bacterial Rec BCD system and its stimulation of chi sequences; role of Rec A protein, homologous recombination, Holliday junctions.	
3			(15)
	3.1	**How cells read the Genome: 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 & Control of Gene expression in Prokaryotes and eukaryotes:** An overview of Gene control, DNA binding motifs in Gene regulatory proteins, Genetic switches and their role in control of gene expressions; molecular Genetic mechanisms that create specialized cell types, Post-transcriptional controls-transcription attenuation, Riboswitches, Alternate splicing, RNA editing, RNA Interference, Translation of mRNA in Prokaryotes and Eukaryotes and role of Regulatory Switches, leader sequences and protein localization.	

Practicals(15x3) **(45)**

1 Demonstration of working principle of Gel Documentation system.
2 Demonstration of working principle of Thermal Cycler.
3 PCR amplification of a specific gene (target DNA sequence) from genomic DNA. Agarose Gel analysis of PCR product to check it's size and purity.
4 Curing of plasmid DNA by acridine orange/SDS and determination of plasmid loss by loss of resistance to antibiotic and agarose gel electrophoresis.
5 Fluctuation test
6 NTG –Mutagenesis and Screening of NTG - induced heavy metal resistant Mutants

Reference books

i. Molecular Biology of Cell by Alberts et al. 2009
ii. Molecular cell Biology by Darnell , Lodish and Baltimore
iii. Molecular Biology of Gene by Watson et al. 2009
iv. Essentials of Molecular Biology by David Freifelder, 2009
v. Genes IX/X by Benjamin Lewin 2009/2010
vi. Principles of Genetics by Gardner, Simmons and Snustad-2009
vii. Principles of genetics by Tamarin- 2009
viii. Basic Methods in Molecular Biology by Davis et al. 2007(Elsevier)
ix. Advanced Molecular Biology by R. M. Twyman , 2008

BACK

MI-204: Marine Microbiology I
Credit: 4 (Three theory and one Practical)

1. Microbes in the marine environment **6**

What is marine microbiology, Biological organization and the evolution of life, The world's oceans and seas, Chemical and physical factors in the marine environment, Properties of seawater, Marine microbial habitats - water column, Sediments, coastal ecosystems, mangroves salt marshes. Biofilms and Microbial mats, Microbial life at surfaces of living and non-living systems. Quorum sensing in marine microbes and significance. Microbial interactions.

Physiology of marine prokaryotes

Metabolic diversity and the importance of microbial communities. Energy-yielding processes: Phototrophy and primary productivity, Fermentation, respiration, Methanogenesis. Carbon dioxide fixation in autotrophs, nitrification and denitrification. Specific nutrients needed for growth: Macronutrients, micronutrients and trace elements.

2. Methods in marine microbiology **12**

Sampling and experimental approaches, specific staining procedures for Microscopy, study of cellular and sub-cellular organisation using Confocal laser scanning microscopy (CLSM), particulate and cellular composition using Flow cytometry (FCM). Laboratory culture: The importance of cultural conditions, viable but non-culturable (VBNC) organisms, Enrichment culture, Isolation, Biochemical methods for identification and taxonomt. Molecular tools in study of marine microbial diversity, Phylogenetic analysis, Metagenomics; Community fingerprinting, Limitations of analysis of nucleic acids directly from marine environment, Genomic fingerprinting and molecular markers; RAPD; Fluorescence *in situ* hybridization (FISH)

3. The role of microbes in ocean processes **9**

Carbon cycling in the oceans, Photosynthesis and primary productivity, Microbes in nitrogen cycling, importance of iron, microbial loop in ocean food webs, Microbial processes in eutrophication of coastal waters, Microbial processes and climate change. Beneficial and Harmful effects.
Biofouling and bio deterioration, indicator organisms and polution control.

4. Practical (15x3): **45**

1. Isolation and identification of microbes from mangroves, coastal waters and sediments with special emphasis on sample collection methodology, collection trips in boats/trawlers.
2. Assessment of salt requirement of marine isolates from different ecosystem
3. Analysis of physic-chemical parameters including metal analysis using AAS
4. Study of biofilm microorganisms
5. Hydrolytic Enzyme profiling of the marine isolates
6. Nitrification and denitrification by the marine isolates
7. Enrichment techniques for (VBNC)

Reference books:

1. Marine Microbial Diversity: David Karl & Merry Buckley
2. Microbial Ecology of the Oceans: Ralph Metchell
3. Ocean & health: Pathogens of the Marine Environment Rita Colwell & Shinishon Belkin
4. Biological Oceanography-Charles Meller

BACK

MI-205: Mycology
(Course Credits: 4 – Three credits for theory and one for practical)

THEORY **(45)**

I Fungal diversity and distribution
(15)

1. **Origin and phylogeny**; **classification**
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
3. **Extremophilic Fungi**
   (a) Oligotrophs, (b) Alkaliphiles, (c) Acidophiles, (d) Barophiles, (e) Psychrophiles, (f) Thermophiles, (g) Halophiles, (h) Osmophiles, (i) Xerophiles.

II Physiology and Genetics **(15)**

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, mycotoxins, pigments

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

3 Identification of fungi
(a) Colonial and morphological characteristics
(b) Molecular finger printing

III Pathogenesis - Antifungal Therapy
(05)

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

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

IV Applications **(10)**

1. Industrially important enzymes
2. Secondary metabolites: pigments, antimicrobials
3. Biodegradation
4. Bioremediation
5. Biocontrol

References:

1. Alexopoulus
2. Mehrotra
3. Ecophysiology of Fungi - Cooke and Whipps Deacon
4. Kendricks
5. Davis, Dulbecco
6. Introduction to Genetics- M.W. Strickberger

PRACTICAL S (15x3) (45)

I Study and Identification of fungi

1. Study of standard cultures: (a) Colony and (b) Morphological characteristics
2. Identification: (a) Observation of colonial and morphological characteristics (b) Reference to identification keys

II Fungal Genetics

1. Isolation of fungal DNA

III Application of fungi for bioremediation

1. Metal biosorption and removal from solution

References

1. Compendium of soil fungi- Domasch
2. Soil fungi - Gilman ,Onions, Allsop
3. www.drfungus
4. Research journals

BACK

Optional courses

MI-301 MEDICAL VIROLOGY
Course credit: 3

(45)

I. Virus: Structure, Cultivation and Assay (10)

1. Viruses
   (a) Introduction
   (b) Visualization by electron microscopy
   (c) Structure: envelope, capsid, nucleic acid
   (d) Defective viruses
   (e) Classification
2. Viral genome
   Genomic diversity - RNA or DNA, segmented or non-segmented
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
   - infectivity and cultivation methods
   Detection by plaque, pock, polykaryocytes, haemadsorption, immunofluorescence, cytopathicity, tumor.

II Viral Diseases (20)

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

III Oncogenic and Emerging Viruses and Antiviral Combat (15)

1. Oncogenic – Papova and Adeno viruses, Herpes EBV and HCV, Retrovirus.
   Emerging viral agents of disease
2. Virus-Host interactions
   Host specific and nonspecific defense mechanisms; neutralizing antibodies; role of interferon.
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. Microbiology by Davis, Dulbecco.
2. Microbiology and Immunology - On-line, Department of Pathology, Microbiology and Immunology, University of South Carolina School of Medicine

BACK

MI - 302 Environmental Microbiology

Course Credits: 4 – Three credits for theory and one credit for practical

1. **Microbial Ecology**: (24)

Microbial community structure, evolution of communities
Ecosystem: components and functioning of ecosystem concept of homeostasis.
Biotic and abiotic components in the environment and their interaction.
Characteristics and functions of typical ecosystem. Types of ecosystems. Energy flow and material cycling. Food webs. Biogeochemical cycling of carbon, nitrogen, phosphorous and sulphur. 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. **Concepts of sustainable and holistic development** (9)

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

3. **Microbes on surface** – (6)

nature and significance, activity in surface films
Biofilm kinetics and its application to waste water treatment

4. **Geomicrobiological processes** – (3)

Role of microbes in biogeochemical cycles: physiological and biochemical aspects,

5. **Introduction to nanotechnology and its applications in environment cleanup and monitoring -** (3)

Origin and definition of nanotechnology. Distinguishing attributes of nanosystems. Introduction to nanomaterial preparation using microorganisms. Methods of environmental monitoring and pollution control using nanotechnology. Risks associated with the use of nanomaterials

6. **Practical (15x3)**
   1. Study of an ecosystem
   2. Studies on biofilm on solid surface
   3. Analysis of water samples - Physico-chemical and Microbiological
   4. AAS for Fe/Mn from environmental/microbial samples
   5. Biodegradation of aromatic compounds/recalcitrants

Reference books:

1. Environmental Biotechnology- Alann Scraqg
2. Environmental Microbiology- P D Sharma
3. Molecular Microbial Ecology-Mark Osborn
4. Environmental Molecular Microbiology – Janet Janson

BACK

MI-303: Genetic Engineering
(Course Credits: 4 – Three credits for theory and one for practical)

Module I **(15)**

(i) **Introduction to genetic engineering (Recombinant DNA technology)**

Enzymes used in Recombinant DNA technology: restriction endonucleases, exonucleases, DNA ligases (T_4 & *E.coli* ligases), Terminal DNA transferase, DNA Polymerases (Taq, Amplitaq, vent,Exo-vent, Pfu, T4 etc), Reverse transcriptase, T_4 polynucleotide kinases, Alkaline-phosphatase, S-1 Nuclease, Mung bean nuclease, RNases.

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

(iii) Cloning vectors: plasmid(pUC19, pBR 322 and their derivatives), λ phage, cosmid, Phasmid(Lambda Zap); shuttle /transfer vectors,

(iv) Sequencing Vectors: pUC 19 and M-13 Phage vector,

(v) High capacity Cloning vectors: BAC and YACs.

(vi) Expression vectors: Prokaryotic (pET, pGEX-2T and others) and their characteristics; regulatable strong bacterial and viral promoters(*lac,trp,tac, Lambda PL ,SV40, T7* etc) for induction of gene expression.

(vii) Preparation of rDNA molecule and its transfer to appropriate host (bacteria/yeast/plant cell/animal cell) using a suitable technique: transformation, electroporation , transfection, gene gun, Particle bombardment etc.

Module II **(10)**

(i) 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.

(ii) 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 and its applications, DNA micro arrays and their use in Genomics; DNA sequencing using Sanger's Dideoxy chain termination method and automated sequencer; chromosome walking, Hybrid release and hybrid arrest translation to screen the clones, site directed mutagenesis.

Module III **(10)**

(a) **Application of Genetic Engineering in Biology , forensics and medicine**

I. Screening of Genetic diseases using DNA probes (DNA diagnostics); Production of recombinant proteins and drugs(insulin, tissue plasminogen activator, erythropoietin, human growth hormones, Antibodies(including Bispecific antibodies for cancer treatment),vaccines, interferons, DNA

vaccines: merits and demerits; Edible vaccines- merits and demerits; DNA typing and finger printing

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

(b) **Application of Genetic Engineering in Agriculture**

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

II. Strategies to develop transgenic crops and horticulture plants using various tools of recombinant DNA technology: Development of Bt Brinjal, Golden Rice and flavre savre tomato

III. 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.

Module IV **(10)**

Application of Genetic Engineering in Industry

Genetic manipulation of microbes to over produce industrially valuable enzymes, recombinant pharmaceuticals, nutraceuticals and other biomolecules , production of fermentation products using recombinant organisms, SCP production.

Application of Genetic engineering in Biomonitoring and Bioremediation of environmental pollutants

Microbial degradation of xenobiotics such as PAH by recombinant microbes, bioremediation of toxic heavy metals, biohydrometallurgy using recombinant microbes for recovery of precious metals. Genetic manipulation of microbes to develop biosensors for monitoring toxic organic and inorganic pollutants.

Practical (15 x 3)

1. Restriction mapping of bacterial plasmid
2. Transformation of bacteria with plasmid
3. Cloning of DNA fragment in pUC 19.
4. Demonstration of insertional inactivation marker

Reference Books

1. Principles of Gene manipulation – R.W. Old and S.B. primrose
2. Molecular Biotechnology: Principles and Applications of recombinant DNA- B.R. Glick and J. J. Pasternak
3. Genetic Engineering –Williamson
4. Gene Cloning -Glover
5. Molecular Cloning: A Laboratory Manual -Sambrook et al. 1989
6. Basic Methods in Molecular Biology- L. G. Davis, M. D. Dibner and J.F. Battey
7. Methods for General and Molecular Bacteriology- Gerhardt, Murray, Wood and Krieg
8. Methods in Microbiology-Vol. 21 (Plasmid Technology)- Edited by J. Grinsted and P. M. Bennett
9. Genetic Engineering – Kreutzer and Massey

BACK

MI-304: Immunology
Course credits: 3

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	(5)
	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	(5)
	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)	(5)
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	(5)
	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	(5)
	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	(5)
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	(5)

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	(5)
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	(5)

References:

Goldsby, RA, Kindt TJ and Osborne, BA. Kuby Immunology. W.H. Freeman
Bona, CA and Bonilla, FA. TEXTBOOK OF IMMUNOLOGY. Fine Arts Press
Janeway, CA, Travers, P, Walport, M and Shlomchik, MJ. Immunobiology. Garland Science
Delves, P, Martin, S, Burton, D and Roitt, I. Roitt's Essential Immunology. Wiley-Blackwell

BACK

MI-305: Extremophilic Microorganisms
Course credits: 4 (Three credits for theory and one credit for practical)

1. Concept of Extremophiles v/s conventional Microbial forms & Archaeabacteria. (1)
2. Habitats in universe. Econiches. Communities and community associations. (2)
3. Significance in biogeochemical cycling, Industry and others. (2).
4. Key Molecular components, Unique : Physiological features, Adaptation strategies and growth kinetics of various extremophilic types:
    a) Anearobes, Barophiles/ Peizophiles, Cryophiles & Thermophiles (10)
    b) Oligotrophs , Psychrophiles, Osmophiles, Halophiles & Xerophiles (10)
    c) Radiophiles Metallophiles & Xenobiotic utilizers (10)
    d) Alkaliphiles/ basophiles, Acidophiles & Neutrophiles (10)

Practicals (15x3)

i. Culturing of Anearobes, Oligotrophs UV resistant microbes
ii. Tolerance levels of Thermophiles, Metallophiles.
iii. Buffering capacity of Alkaliphiles.
iv. Detection of Osmolytes in halophiles.

Refrences:

Brock, T. D.: *Thermophilic Microorganisms and Life at High Temperatures*, Springer, New York, 1978, 465 pages

Extreme microorganisms and the methods to handle them by Fred A Rainey and Aharon Oren

Horikoshi, K. and W. D. Grant: *Extremophiles-Microbial Life in Extreme Environments*, Wiley, New York, 1998, 322 pages.

Ventosa, A., J. J. Nieto, and Oren A.: "Biology of moderately halophilic aerobic bacteria," *Microbiology and Molecular Biology Reviews*, 1998, vol. 62, pages 504-544.

BACK

MI-307: Research Methodology
Course credit: 1

1. Defining the problem.
   (i) Selecting a emerging/ vital / thrust area for research.
   (ii) Gathering information about the problem.
   (iii) Reasoning out strategies to engage into the research topic.

2. Literature survey
   (i) Gathering information on existing research findings on the topic and on state-of-the-art techniques to achieve some advancement in the field of research.
   (ii) Lacunae in the area of research
   (iii) Writing a description of the literature survey with due citations and proper record of bibliography

3. Defining the aim and objectives
   (i) Aim: The intent of the work.
   (ii) Objectives: The main 3-5 points to achieve the aim.

4. Work Plan – Time-bound Frame
   (i) Long term plan of work: Month-wise.
   (ii) Short term/Immediate plan of work: Week/Day-wise.

5. Methodology
   (i) Maintaining a laboratory note book
   (ii) Field trip: Sample collection; viewing and assessment of habitats/location.
   (iii) Experimental: Description of strategies to meet the objectives using state-of-the-art techniques and proper citation of established/recorded procedures.
   (iv) Instrumentation: Involves proper handling and correct usage:
      - Maintaining proper record on log books.
      - Reporting duly any mishap/ misfunctioning
      - Maintaining cleanliness and care of the instrument during and after use.

6. Experimental protocol
   (i) Flow-sheet
   (ii) Importance of date, time of individual steps
   (iii) Materials: chemicals and glassware – size and numbers required
   (iv) Significance of triplicate readings.

7. Recording of observations and results
   (i) Importance of recording in the laboratory note book, every observation during the experimental process – intended/unintended; value of serendipity.
   (ii) Tabular presentations of results
   (iii) Graphical presentations
   (iv) Statistical and computational analysis where required

8. Analysis and Conclusions
   (i) Analyzing the data
   (ii) Drawing an inference/conclusion from the analysis
   (iii) Planning the next experiment based on the conclusion of the previous.

9. Report Writing
   (i) Literature survey (with proper flow of thought, due citations and proper indexing of bibliography)
   (ii) Abstract
   (iii) Methodology
   (iv) Results
   (v) Discussion (substantiated with reported data, corroborating earlier records or defending new findings)
   (vi) Conclusion
   (vii) Bibliography

BACK

MI-401- Microbial Technology
Credit: 4 (Three credit for theory and one for practical)
Theory : 45 contact hrs

1. Biotechnology and prospecting with microbes. (CH 6)

` i. advantages of using microbial technology over chemical and physical technology.
ii Increasing relevance of Microbiology in all Biotechnologies.
iii. Ethics in the use of GEMs.
iv Commercialization of Microbial Biotechnology

2. Microbial technology in agriculture (CH9)

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

3. Microbial technology in mining. (CH15)

i Bioleaching, ii.Biomining,.iii Recovery of oil.MEOR
Microbial technology in waste and pollution management in mining:
i.Bioconversions, ii.Bioremediation iii.Biosedimentation, iv. Bio-beneficiation, v. Aquifer cleaning.

4. Microbial technology for energy production (CH7)

i. Microbial fuel cell, ii Biogas, iii. Microbial cell mass.

5. Microbial technology in Human health & aquaculture (CH8)

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

Practicals

i. Determination of stability of microbial fertilizer
ii. Effect of microbes on sedimentation and clarification of water.
iii. Preparation of Pigments, probiotics and bioactives

BACK

MI-402- FOOD MICROBIOLOGY

Theory (3C) **(45)**

I Microbial Food Spoilage and Food Preservation (15)

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

II Microbiology in Food Processes (15)

1. Fermented and processed foods
   (a) Indian fermented foods
   (b) Oriental mould modified foods
   (c) Fermented meats and fish: - sausage, fish sauce.
   (d) Fermentations: wine, vinegar
2. Genetically engineered microorganisms in the Food Industry
   (a) Concept, advancements, principles.
   (b) Role of genetically engineered microbes in the food industry.

III Food Safety and Quality Assurance (15)

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.
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

Practical (1C) **(45)**

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

Reference books:

i. Adams M. R., Mass, M. O. (1996). Food Microbiology. New Age International (P) Limited Publishers, New Delhi

ii. Frazier, W. C., Westhoff, D. C. (1988). Food Microbiology, M. C. Graw-Hill Companies, Inc., New York.

iii. Jay, M. J., Loessner, M. J., Golden, D.A. (2005). Modern Food Microbiology, Springer Science + Business Media Inc., New York.

iv. E-books -Hayes, P. R. Food Microbiology and Hygiene (1995). Published by Chapman & Hall, 2-6 Boundary Row, London SE 1 BHN.
v. E-books-Montrille T. J., Matthews, K. R. (2005). Food Microbiology, ASM Press, 175 2 S2 NW Washington, USA.
vi. Journals

BACK

MI-403-Agricultural Microbiology
Total Credits: 4(Theory-3 and Practical-1)
Contact hrs for Theory:45

Module I Soil Microbiology (15)

(i) Terrestrial Ecosystem, Pyramids and Econiches
(ii) Types of Soil, soil Profile, Physico-Chemical Characteristics
(iii) Suitability of soil for agriculture
(iv) Soil Enzymes and significance
(v) Inter-relationship of soil and microorganisms
(vi) Influence of microbial metabolism on soil chemistry & humus formation
(vii) Importance of humic & fulvic acids in soil mineralization.
(viii) Effect of soil on microorganisms; fate of microbes introduced into soil
(ix) Factors influencing bacterial survival in soils: Biotic & Abiotic
(x) Establishment of microbial inoculant.
(xi) Rhizosphere and Rhizoplane Microflora,

Module II 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 N_2 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- *Nostoc, 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 (Nuclear polyhedrosis virus)

Module III- **(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) RNAi in controlling plant pathogens
(iv) Mycoviruses acting against fungal plant pathogens

Practicals (15x3)

1. Characterization of different soils for detection of various microbial enzymes viz. amylase, lipase, protease, catalase, urease.
2. Isolation of nitrogen-fixing microorganisms and estimation of nitrogenase activity.
3. Morphological characterization of cyanobacteria, extraction and estimation of cyanobacterial pigments (chlorophyll a, carotenoids, phycocyanin, allophycocyanin, phycoerythrin).
4. Isolation and characterization of microbial plant pathogen(s)

Reference books

(i) Soil Microbiology - Alexander
(ii) Agricultural Microbiology Biotechnological approaches in soil microorganisms for sustainable crop production by Dadarwal 1997
(iii) Agricultural Microbiology by N.S. SubbaRao
(iv) Biology of Nitrogen fixing Cyanobacteria by N.G. Carr and B. A.Whitton
(v) Fundamentals of Agricultural Microbiology by K. C. Mahanta
(vi) Applied Soil Biology and Ecology by G.K. Veeresh and D. Rajagopal
(vii) Biofertilizers edited by Somani et al. 1990.
(viii) Biofertilizers in Agriculture and Forestry by N.S. SubbaRao
(ix) Plant Microbe Interactions - by K.S. Bilgrami ,2000
(x) Biology of Microorganisms by M.T. Madigan and J.M. Martinko XI th edition
(xi) Modern Concepts of Microbiology H.D. Kumar & Swati Kumar, 2009

BACK

MI-404: Microbiology in Environmental Pollution and its Control

(credits: 3+1) Theory : 45 Contact hrs

1. Pollution and its hazards : sources, effects on microorganisms in various ecosystem**s:** (6) Environment protection regulations, impact assessment and standards.
2. Monitoring of pollution using microorganisms (6CH)
   Indicator microorganisms and their quantification , Bacteriophages.
   Biosensors for pollution monitoring : Microbial consortia, including GMs, enzymes etc
3. Microbiological bioremediation – (3 CH)
   Concept of bioremediation technologies, reactors, microbial consortium.
   Combined biological treatment processes.
4. Biodeterioration and biodegradation of Natural organic molecules in soil and water. (9CH)
   Agricultural polymers such as cellulose, lignin, chitin, pectin and fossil fuels.
   Degradation/ metabolic pathways, enzymes and reactions involved. (6)
5. Biodegradation and biotransformation of aromatic, aliphatic hydrocarbons both aerobic and anaerobic systems . Xenobiotics and recalcitrant compounds
6. Recent advances in waste water treatment , suspended/ attached systems. (9CH)
   Substrate utilization in suspended and attached growth systems –
   i) Microbial nitrification and denitrification ii) Microbial Phosphorous removal, iii) Microbial detoxification of toxic and recalcitrant organics and heavy metals. Iv) Effect of environmental factors and biosurfactants
7. Solid waste Management – (6 CH)
   Processes of Composting : vermicomposting and termigradation -mechanism, operation, monitoring and control.

Practicals (15x3)

1. Characteristics of Surfactant and effect on viscosity
2. Studies on the enzymes degrading pant polymers cellulose/starch from compost samples and efficacy of one of the enzymes
3. Bioindicators for sewage pollution E.coli and Bacteriophages from sewage treatment effluent
4. Use of enriched organisms for bioremediation

Reference books:

Environmental Microbiology
-Ralph Mitchell & Ji Dong Cu
Wiley-Blackwell publication
Environmental Microbiology
-K.Vijaya Ramesh,
MJP Publishers India
Environmental Microbiology
-Raena Maier
-Ian Pepper
-Charles Gerba,
Academic Press

BACK

MI-405- Medical Microbiology and epidemiology
Total Course credit: 4 (3 for theory and 1 for Practical)

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,	(5)
	1.2	Pili, flagella, biofilm, quorum-sensing, iron scavenging, aggressins/impedins against host defence	(3)
	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	(7)
2			
	2.1	Exotoxins – Type III secretion system, AB – type toxins, examples (Tetanospasmin, diphtheria toxin, pertusis toxin), bifunctional toxins, cytotoxins and cytolysins; Endotoxin – structure, biosynthesis, assay, pathophysiological effects, excessive inflammatory response, endotoxin neutralizing compound, antagonists of LPS	(8)
	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	(3)
	2.3	Cystic fibrosis, Spongiform encephalopathy	(4)
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	(9)
	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	(6)
4		**Practicals(15x3)**	
	1	Demonstration of malaria parasite in blood film	3
	2	Isolation of bacteria from sputum/ mouth swab on chocolate agar and partial characterization	3x3
	3	Determination of sensitivity of bacteria to antibiotics (Disc method)	6

4	Serological method for detecting presence of pathogen antigen in the patient	3
5	Demonstration of blood haemolysis (chick embryo / plate)	6
6	Enrichment, isolation and identification of Enteric pathogen	3x3
7	Analysis of disease incidence using CDC/epidemiological data	6
8	ELISA	3

Reference books:

1. Microbiology by Davis et al.
2. Principal and Practice of Clinical Bacteriology by Gillespie and Hawkey
3. Manual of Practical Microbiology and Parasitology by Chakraborty and Pal
4. Clinical Bacteriology by Struthers and Westran

BACK

MI-406- Marine Microbiology-II

3 credits for theory and 1 credit for practical

Theory (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)

Bacterial and viral diseases of fresh water, sea water, aqua culture: fish, bivalve mollusks, crustaceans, corals. Diagnostic methods. Control of disease.
Protistan infections. HAB.

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

Biodegradation and bioremediation of marine pollutants: oil, persistent organics and plastics, Other pollutants.
Environmental monitoring: Indicator microorganisms; Microbial enzymes and polymers.
Biomedical and health products.
Biofouling and biodeterioration,

Practicals (15x3)

1. Assessment of the microbiological quality standards for marine water in aquaculture – monitoring for physicochemical parameters and potential pathogens of fish

2. Determining *E.coli* in shell fish –MPN/ EC-MUG medium

3. Isolation of hydrocarbon degrading / biosurfactant producing bacteria from marine environment

4. Study of enzymes involved in deterioration of wood/litter in marine environments

BACK

MI-407 BIOINFORMATICS (Credits:Theory-2, Practical-1)
(Theory: Total 30 contact hrs)

Unit I Database search: Introduction to Bioinformatics, Importance of biological databases. Primary and secondary databases- sequence and structure databases. Genomic databases. Scoring matrices- PAM, BLOSSUM. Heuristic database search methods- BLAST and FASTA.

9 hrs

Unit II Sequence alignment: Pair wise sequence alignment- Dynamic Programming for Sequence Similarity- Smith Waterman Algorithm and Needleman Wuntch Algorithm. Pairwise alignment tools.
6 hrs

Unit III Multiple Alignments and Phylogenetic analysis: Progressive and iterative alignment and tools based on these algorithms- Clustal W and MultAlign. Introduction and basic tools for phylogenetic analysis.
6 hrs

Unit IV Gene and protein prediction tools: ORF search, Exon region prediction, Promoter prediction in eukaryotic and prokaryotic sequences. Protein Profile and Pattern searching. Primary and secondary structure prediction tools. Structure visualization.
9 hrs

BIOINFORMATICS- PRACTICALS (Credits-1) 15 Contact hrs

1. Sequence databases - Data mining using NCBI, SWISSPROT, EBI
2. Structure databases - Data mining using PDB
3. Genome databases- MBGD- Microbial Genome Database**,** GOLD- Genome On Line Database, Ensemble project- Human.
4. Database search- Working on various BLAST programs
5. Pairwise sequence alignment- LALIGN, EMBOSS.
6. Multiple sequence alignment- Clustal W, MultAlign
7. Phylogenetic analysis- Clustal W, Phylodraw
8. Gene prediction and protein prediction programs- ORF prediction tool, Translation tool, Domain and motif search tools, Primary and secondary structure analysis tools.

BACK