Department of Microbiology

Mohanlal Sukhadia University

Syllabus for M. Sc. Microbiology CBCS Scheme

Type of course	Course code	Title of the Course	L-T-P/Week	No. of credits	University exam	Internal assessment	Total
Semester I							
Core course 1	M1MB01CT01	Instrumentation and Analytical Techniques	3-1-0	4	80	20	100
Core course 2	M1MB02CT02	Cell Biology and Molecular Genetics	3-1-0	4	80	20	100
Core course 3	M1MB03CT03	Fundamentals of Microbiology	3-1-0	4	80	20	100
Core course 4	M1MB04CT04	Biomolecules and Metabolism	3-1-0	4	80	20	100
Core course practical 1	M1MB05CP01	Instrumentation and Analytical Techniques + Cell Biology and Molecular Genetics	0-0-8	4	80	20	100
Core course practical 2	M1MB06CP02	Fundamentals of Microbiology + Biomolecules and Metabolism	0-0-8	4	80	20	100
				24	**480**	**120**	**600**
Semester II							
Core course 5	M2MB01CT05	Molecular Biology	3-1-0	4	80	20	100
Core course 6	M2MB02CT06	Immunology and Enzymology	3-1-0	4	80	20	100
Core course 7	M2MB03CT07	Bioinformatics and Biostatistics	3-1-0	4	80	20	100
Core course 8	M2MB04CT08	Genetic Engineering	3-1-0	4	80	20	100
Core course practical 3	M2MB05CP03	Molecular Biology + Immunology and Enzymology	0-0-8	4	80	20	100
Core course practical 4	M2MB06CP04	Bioinformatics and Biostatistics + Genetic Engineering	0-0-8	4	80	20	100
Skill course 1	M2MB07SEC01	Any one from the given list	1-0-2	2	80	20	100
				26	**560**	**140**	**700**
Semester III							
Core course 9	M3MB01CT09	Microbial Genetics	3-1-0	4	80	20	100
Core course 10	M3MB02CT10	Virology	3-1-0	4	80	20	100
Core course 11	M3MB03CT11	Microbial Ecology	3-1-0	4	80	20	100

Core course 12	M3MB04CT12	Microbial Physiology and Metabolism	3-1-0	4	80	20	100
Core course practical 5	M3MB05CP05	Microbial Genetics + Virology	0-0-8	4	80	20	100
Core course practical 6	M3MB06CP06	Microbial Ecology + Microbial Physiology and Metabolism	0-0-8	4	80	20	100
Skill course 2	M3MB07SEC02	Any one from the given list	1-0-2	2	80	20	100
				26	**560**	**140**	**700**
Semester IV Choice of A or B							
A.	**Industrial Training**	Major Research Project (at research laboratory or institute of repute (5 months)	**0-0-8**	**24**	**480***	**120**	**600**
B.	**DSE**						
Discipline Specific Elective 1	M4MB01ET01	Minor Research Project	3-1-0	4	80	20	100
Discipline Specific Elective 2	M4MB02ET02 (a/b)	Choose any one from the given list	3-1-0	4	80	20	100
Discipline Specific Elective 3	M4MB03ET03 (a/b)	Choose any one from the given list	3-1-0	4	80	20	100
Discipline Specific Elective 4	M4MB04ET04 (a/b)	Choose any one from the given list	3-1-0	4	80	20	100
Discipline Specific Elective practical	M4MB05EP01	Practical 1 DSE	0-0-8	4	80	20	100
Discipline Specific Elective practical	M4MB06EP02	Practical 2 DSE	0-0-8	4	80	20	100
				24	**480**	**120**	**600**
GRAND TOTAL				**100**	**2080**	**520**	**2600**

***480 :** (Project dissertati1on 200 + Presentation 150 + Viva Voce 100, Scientific Paper 30)

Core Course

S.No.	Type of course	Semester	Course code	Title of the Course
1.	Core course 1	I	M1MB01CT01	Instrumentation and Analytical Techniques
2.	Core course 2	I	M1MB02CT02	Cell Biology and Genetics
3.	Core course 3	I	M1MB03CT03	Fundamentals of Microbiology
4.	Core course 4	I	M1MB04CT04	Biomolecules and Metabolism
5.	Core course 5	II	M2MB01CT05	Molecular Biology
6.	Core course 6	II	M2MB02CT06	Immunology and Enzymology
7.	Core course 7	II	M2MB03CT07	Bioinformatics and Biostatistics
8.	Core course 8	II	M2MB04CT08	Genetic Engineering
9.	Core course 9	III	M3MB01CT09	Microbial Genetics
10.	Core course 10	III	M3MB02CT10	Virology
11.	Core course 11	III	M3MB01CT11	Microbial Ecology
12.	Core course 12	III	M3MB01CT12	Microbial Physiology and Metabolism

Core Course Practical

S.No.	Type of course	Semester	Course code	Title of the Course
1.	Core course practical 1	I	M1MB05CP01	Instrumentation and Analytical Techniques + Cell Biology and Genetics
2.	Core course practical 2	I	M1MB06CP02	Fundamentals of Microbiology + Biomolecules and Metabolism
3.	Core course practical 3	II	M2MB05CP03	Molecular Biology + Immunology and Enzymology
4.	Core course practical 4	II	M2MB06CP04	Bioinformatics and Biostatistics + Genetic Engineering
5.	Core course practical 5	III	M3MB05CP05	Microbial Genetics + Virology
6.	Core course practical 6	III	M3MB06CP06	Microbial Ecology + Microbial Physiology and Metabolism

Skill Enhancement Course Elective

S.No.	Type of course	Semester	Course code	Title of the Course
1.	Skill course 1	II	M2MB07SEC01	Skill course elective 1 (Techniques of Microbiology)
2.	Skill course 2	III	M3MB08SEC02	Skill course elective 2 (Probiotics Air and Water microbiology)

Discipline Specific Elective

S.No.	Type of course	Semester	Course code	Title of the Course
1.	**A. Industrial Training**	IV		Major Research Project (at research laboratory or institute of repute (5 months)
2.	**B.**			
3.	Discipline Specific Elective 1	IV	M4MB01ET01	Minor Research Project (Compulsory)
4.	Discipline Specific Elective 2(a)	IV	M4MB02ET02	Environmental Microbiology
5.	Discipline Specific Elective 2(b)	IV	M4MB03ET02	Industrial Microbiology
6.	Discipline Specific Elective 3(a)	IV	M4MB04ET03	Food and Dairy Microbiology
7.	Discipline Specific Elective 3(b)	IV	M4MB05ET03	Advances in Microbiology
8.	Discipline Specific Elective 4(a)	IV	M4MB04ET04	Medical Microbiology
9.	Discipline Specific Elective 4(b)	IV	M4MB04ET04	Host- Parasite Interactions

Discipline Specific Elective Practical

S.No.	Type of course	Semester	Course code	Title of the Course
1.	Discipline Specific Elective practical 1,	IV	M4MB06EP01	Based on Choice of DSE
2.	Discipline Specific Elective practical 2	IV	M4MB07EP02	Based on Choice of DSE

NOTE:

1. In 4th semester the students have an option of either doing Major research project (MRP) for 5 months in a government institution other than parent university or take any four DSE electives.
2. Students opting for MRP in 4th semester will have to complete SEC 2 in 3rd semester.
3. The students opting for MRP will have to take prior permission from the HOD at least 3 months in advance and submit their acceptance letter from the institute where he/she is going to do the training one month in advance. Failing this the student will not be permitted to go for training.
4. The student who opts for MRP will have submit a duly signed and sealed certificate from the mentor and competent authority in the prescribed format (Annexure 1)
5. Student will be required to submit a hard copy of the continuous assessment report prepared by the mentor as per the prescribed format filled in a sealed envelope. The mentor will also have to send a soft copy of the same to the HOD. (Annexure 2)
6. Such students will also have to submit a dissertation report as per the prescribed format for the training. (Annexure 3)
7. Such students will also have to submit a research paper based on the research work done which may or may not have been published in any journal.
8. The total credits for the MRP will be 24 and the student will maintain a log book showing the presence for 32 hrs./week in the institution and submit the same along with the dissertation. Evaluation of the MRP will be done as per the prescribed scheme. (Annexure 4)
9. In the 4th semester students who opt to take four DSEs also have an alternative option of taking one in-house minor research project within the department or in sister departments of this University in lieu of one DSE.
10. The total credits and marks for minor research project will be the same as for any other DSE and Evaluation of the minor research project will be done as per the prescribed scheme. (Annexure 5)
11. The total contact hrs. for minor research project will be 8 hrs./week. The student who opts for industrial training will have submit a duly signed and sealed certificate from the mentor and competent authority in the prescribed format (Annexure 6)

12. Students can choose skill courses from the list provided in the syllabi of B. Sc. CBCS Biotechnology, M.Sc. Biotechnology, M. Sc. Botany, M. Sc. Microbiology or any other subject from the faculty of Science. The student also has the choice of choosing any general skill courses offered by College of Science
13. Students can also earn extra credits by taking addition skill courses during entire program period.

ANNEXURE 1

INSTITUTE NAME AND LOGO

Ref no.-…….. Date……

CERTIFICATE

This is to certify that the dissertation/project report entitled "**……**" submitted towards the partial fulfillment for the award of the degree of Master of Science in Microbiology, from Mohanlal Sukhadia University, Udaipur (Rajasthan) India is the result of bonafide work compiled by **Mr./Ms. …….** carried outunder the guidance of **Dr. …….** at **……..** under my supervision in the academic year of ……... It has no part the dissertation has been submitted for the award of any degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any scientific or popular journals or magazines.

Date

Name & Signature of the supervisor

Seal of the supervisor

ANNEXURE 2

M. Sc. Microbiology Semester IV

CONTINUOUS ASSESSMENT SHEET

Major Research Project

Name of Student:

A) Technical Competence	**Maximum Marks**	**Marks Obtained**
1. Experimental Design	7	
2. Handling of Equipments	7	
3. Experimental Skills	7	
4. Data Interpretation/ Result Analysis	7	
5. Technical Writing Skills	7	
TOTAL	**35**	
B) Professional Qualities		
1. Sincerity and Reliability	5	
2. Drive and Initiative	5	
3. Motivation to exceed minimum expectation	5	
4. Attendance	30	
TOTAL	**45**	
C) Ability to		
1. Work Independently	4	
2. Understand technical (Research Publication)	4	
3. Adjust in new working environment	4	
4. Plan and work Methodically	4	
5. Work in team	4	
TOTAL	**20**	
D) Communication Skills		
1. Written	10	
2. Oral	10	
TOTAL	**20**	
Grand Total	**120**	

Remark on professional competence (or deficiency) of the trainee and overall performance.

Name of the Mentor :

Designation : E-mail…….

Ph. No.

Organization:

Date: Signature with seal

ANNEXURE 3

General Guidelines for Preparation of Project Report

(For specific details the students are advised to consult their respective supervisors)

1. Strictly follow the format given to write the manuscript of the project.
2. On the front page include title of the project (font size 21, centered). The title should not contain abbreviation and scientific names of organisms should be in *italics.* This page should not be numbered.
3. Starting from second page, the pages must be numbered consecutively, including figures and table.
4. Text should be 1.5 point spaced type written using Times New Roman Font, Font Size 12, on one side of A 4 Size paper, with 1.5 inch margins throughout. Scientific names of the organisms should be in *italics.* Main headings (Summary, Introduction, Chapter details, Conclusions and References) should be bold type, justified and separated from the text.
5. The full text of project should not exceed 20-25 one side typed pages.
6. Literature citation in the text should be cited in alphabetic order. The form and style of references should be as indicated below.

(a) Journal article

Carvalho, L.C., Goulao, L., Oliveira, C., Goncalves, C.J. and Amancio, S. 2004. Rapid assessment for identification of clonal identity and genetic stability of *in vitro* propagated chestnut hybrids. Plant Cell Tiss. Org. Cult. 77:23-27.

Chae, W.B., Choi, G.W. and Chung, I.S. 2004. Plant regeneration depending on explant type in *Chrysanthemum coronarium* L. J. Plant Biotech. 6:253-258.

(b) Book reference

Salisbury, F. B., Ross, C. W. 1992. Plant Physiology. 4th edn. Wadsworth Publishing Company. Belmount.

(c) Edited books

Constantine, D.R. 1986. Micropropagation in the commercial environment. In : "Plant Tissue Culture and its Agricultural Applications". L.A. Withers and P.G. Alderson (Eds.) pp. 175-186. Butterworths, London, UK.

(d) Paper presented at a conference

Chaturvedi, H.C. 1992. Hardening of *in vitro* raised plants for transplant success. A state of art report. Paper presented in DBT Project Monitoring Committee Meeting held on 6^{th}-7^{th} July, 1992 in DBT, New Delhi, India.

(e) Proceeding of a symposium

Rajsekharan, P. E., Ganeshan, S. 2005. Designing *exsitu* conservation strategies for threatened medicinal plant species of South India. In: " Proc. Natl. Symp. and 27^{th} Annual Meeting of PTCA(I)." A.K. Kukreja *et al* (Eds). Pp.159-164. CIMAP, Lucknow, India.

(f) Thesis/ Dissertation

Dave, N. 2004. Factors influencing micropropagation of two varieties of *Achras sapota* and their rootstock *Mimusops hexandra*. Ph.D. Thesis, Mohanlal Sukhadia University, Udaipur, India.

(g) Patent

Trepaginer, J.H. 2000. New surface finishings and coatings. US Pat 1276323 (to DuPont Inc, USA). 27 June, 2000. Chem Abstr, 49 (2000) 27689.

(h) Reports

Anonymous, 1976. The Wealth of India. Raw Meterials. Vo. X. pp. 44-48. CSIR, New Delhi, India.

TITLE MUST BE IN CAPITAL LETTERS, SIZE 21 AND CENTERED, WITH *Scientific names* IN ITALICS

A Project Report submitted
for the partial fulfillment of the Degree of Master of Science

By

(**Name of student**)
[M.Sc. (Microbiology/Biotechnology), IV Semester]

DEPARTMENT OF MICROBIOLOGY
Vigyan Bhawan- Block 'B': New Campus
MOHANLAL SUKHADIA UNIVERSITY
UDAIPUR
2015-16

INSTITUTE NAME AND LOGO

Ref no.-…….. Date……

CERTIFICATE

This is to certify that the dissertation/project report entitled "**……**" submitted towards the partial fulfillment for the award of the degree of Master of Science in Microbiology, from Mohanlal Sukhadia University, Udaipur (Rajasthan) India is the result of bonafide work compiled by **Mr./Ms. …….** carried outunder the guidance of **Dr. …….** at **……..** under my supervision in the academic year of ……... It has no part the dissertation has been submitted for the award of any degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any scientific or popular journals or magazines.

Date

Name & Signature of the supervisor

Seal of the supervisor

Declaration

I, **……..** Roll No. _____student of M. Sc. IV Semester Microbiology (Session 2010-11) hereby declare that the project entitled "……..." is my own compilation. I have strictly adhered to the guidelines provided by the department for the preparation of the project report.

Dated: Signature of the Student

TABLE OF CONTENTS

S. No.	Chapter	Page No.
1.	Introduction	
2.	Review of Literature	
3.	Materials and Methods	
4.	Results	
5.	Discussion	
6.	Conclusion	
7.	References	

ANNEXURE 4

MARKING SCHEME FOR MAJOR RESEARCH PROJECT

M. Sc. Microbiology semester IV

S. No.		Maximum Marks	Marks Obtained
1	**Dissertation Report** a. Review of Literature b. Methodology c. Outcome d. Discussion	 100 50 30 20	
2	Presentation	150	
3	Viva – voce	100	
4	Research Paper	30	
5	Continuous Assessment	120	
	TOTAL MARKS	**600**	

ANNEXURE 5

MARKING SCHEME FOR MINOR RESEARCH PROJECT

M. Sc. Microbiology semester IV

S. No.		Maximum Marks	Marks Obtained
1	**Dissertation Report** a. Review of Literature b. Methodology c. Outcome	 15 10 15	
2	Seminar	25	
3	Viva – voce	15	
4	Continuous Assessment	20	
	TOTAL MARKS	**100**	

ANNEXURE 6

CONTINUOUS ASSESSMENT SHEET

M. Sc. Microbiology: Minor Research Project

Name of Student's :

Technical Competence	Maximum Marks	Minimum Marks
• Review of Literature	5	
• Experimental Design & Skills	5	
• Data Interpretation/ Result Analysis	5	
• Attendance	5	
GRAND TOTAL	**20**	

Remark on professional competence (or deficiency) of the trainee and overall performance.

Name :

Designation : E-mail…….

Ph. No.

Organization:

Date: Signature with seal

SYLLABUS
for
M. Sc. Microbiology

Structure of M. Sc. Microbiology under CBCS Scheme

Core Course

Semester I

CC1(M1MB01CT01): Instrumentation and Analytical Techniques
CC2(M1MB02CT02): Cell Biology and Molecular Genetics
CC3(M1MB03CT03): Fundamentals of Microbiology
CC4 (M1MB04CT04): Biomolecules and Metabolism
(Practical) CC1,2 (M1MB05CP01): Instrumentation and Analytical Techniques + Cell Biology and Molecular Genetics
(Practical) CC3,4 (M1MB06CP01): Fundamentals of Microbiology + Biomolecules and Metabolism2

Semester II

CC5(M2MB01CT05): Molecular Biology
CC6(M2MB02CT06): Immunology and Enzymology
CC7(M2MB03CT07): Bioinformatics and Biostatistics
CC8(M2MB04CT08): Genetic Engineering
(Practical) CC5, 6 (M2MB05CP03): Molecular Biology + Immunology and Enzymology
(Practical) CC7, 8(M2MB06CP04): Bioinformatics and Biostatistics + Genetic Engineering
SEC1(M2MB07SEC01): Techniques of Microbiology

Semester III

CC9 (M3MB01CT09): Microbial Genetics
CC10(M3MB02CT10): Virology
CC11(M3MB03CT11): Microbial Ecology
CC12(M3MB04CT12):Microbial Physiology and Metabolism
(Practical) CC9,10 (M3MB05CP05): Microbial Genetics + Virology
(Practical) CC11, 12(M3MB06CP06): Microbial Ecology + Microbial Physiology and Metabolism
SEC2 (M3MB07SEC02): Probiotics, Air and Water Microbiology

Semester IV : Choice of A or B

A : Industrial Training : Major Research Based Project including Practical work at research laboratory or institute of repute other than parent university (5 Months)

B : Discipline Specific Electives

DSE1(M4MB01ET01): Minor Research Project (Compulsory for all students)

(Any 3 out of the given list)

DSE2(M4MB02ET02) (a/b): a. Environmental Microbiology
b. Industrial Microbiology
DSE3(M4MB03ET03) (a/b): a. Food and Dairy Microbiology

	b. Advances in Microbiology
DSE4(M4MB04ET04)(a/b):	a. Medical Microbiology
	b. Host- Parasite Interactions

(Practical) DSE1 : Based on choice of DSE
(Practical) DSE 2 : Based on choice of DSE

SEMESTER –I

M. Sc. MICROBIOLOGY (CBCS STRUCTURE)

CC1(M1MB01CT01): INSTRUMENTATION AND ANALYTICAL TECHNIQUES (THEORY)

TOTAL HOURS: 60 **CREDITS: 4**

Unit I: **Credit hours: 10**

Laboratory instrumentation: principle, components, assembly, working and applications of: Laminar clean air flow bench, autoclave, incubators, weighing balances, pH meter, water bath, hot air oven, colony counter and microtome. Laboratory safety measures.

Unit II: **Credit hours: 10**

Aseptic techniques: Principles of sterilization, Brief idea of various methods of sterilization, Physical, chemical, disinfectants, membrane filtration, pasteurization, tyndallization. Definition and classification of compounds used for sterilization, antibiotics and antimicrobials. Evaluation of effectiveness of antimicrobial/antiseptic compounds.

Unit III: **Credit hours: 15**

Microscopy: Types, principle, components, working, specimen, preparation and applications of Light, Bright field, Dark field, Phase contrast, Electron (SEM, TEM). Scanning tunneling. Fluorescence, Nomarsky differential interference contrast, Confocal, Atomic force microscopes.

Unit IV: **Credit hours: 15**

Chromatography: General Principles, process and applications of Paper and Thin Layer Chromatography. GLC, HPLC, Absorption, Ion Exchange, Gel filtration, Affinity chromatography, Radioactive tracer technique, autoradiography, Gamma and Scintillation counters, Brief idea of NMR, IR, GC-MS.

UNIT V: **Credit hours: 10**

Centrifugation and spectrophotometry: Types of centrifuges. Principles, working and applications of preparative, Analytical, Microcentrifuge. Refrigerated ultracentrifuge. Colorimeter and types of spectrophotometer: principle, working and application.

Suggested Readings

1. Pattabhai, V. and Gautham (2002), N. Biophysics. 2nd edition Narosa pub.
2. Narayan, P. Essentials of Biophysics. New Age International.
3. Roy, R.N. A Text Book of Biophysics. New Central Book Agency.
4. Daniel, M. Basic Biophysics. Agrobios.
5. Rodney Cottegril (2003), Biophysics: an introduction 2nd edition, John wiley & sons publication.

CC2(M1MB02CT02): CELL BIOLOGY AND MOLECULAR GENETICS

TOTAL HOURS: 60 **CREDITS: 4**

Unit I **Credit hours: 10**

Structure and organization of cell. Intra-cellular compartmentalization. Structure, function and significance of cell wall, plasma membrane, Membrane proteins and transport across biomembrane. Structure, function and significance of Cell organelles, flagella, cilia, cytoskeleton. Genetic organization of Mitochondria and chloroplast.

Unit II **Credit hours: 15**

Nucleus: nuclear membrane, nucleolous and nuclear pore complex. Chromatin; structure, types organization and chemistry of the chromosome. C-value paradox, Nuclear dyes and their application in staining of chromosomes. Karyotyping, Polytene, lambrush and B-chromosomes. Chromosome banding and its staining.

Cell cycle events, regulation of cell division: cyclins, cyclin-dependent kinases, inhibitors, control of cell division in multicellular organisms.

Unit III **Credit hours: 15**

Brief idea of model organisms of genetic studies: *Drosophila, Neurospora, C. elegans*, *Acetabularia*. Gene interaction: modification of mendalian ratios. Linkage and crossing over, linkage map, linked gene inheritances. Genetic recombination at molecular level (Holliday model). Role of RecA protein in recombination. Numerical and structural changes in chromosomes.

Unit IV **Credit hours: 10**

Mutation – molecular basis of spontaneous and induced mutations. Adaptive mutations in bacteria. Detection of mutations: Ames test, Luria-delbruck fluctuation test. Molecular mechanism of radiation and chemical mutagenesis: use of base analogs, ionizing radiations and alkylating agents for mutagenesis.

Unit V **Credit hours: 10**

Transposons: Types, structure, properties and their significance. Mechanism of transposition, transposon mutagenesis. Integrons, Insertion sequences (IS), Composite transposons. Replicative and non replicative transpositions. Role of transposase and resolvase. Examples of Transposable elements, Retrotransposon.

Suggested Readings

1. Alberts, B., Bray, D. Lewis, J., Raff, M., Roberts, K. and Watson, J.D. 1999. Molecular Biology of Cell. Garland Publishing Co. New York, USA.
2. Snustad, D.P. and Simmons, M.J. 2000. Principles of genetics. John Wiley and Sons.
3. Russel, P.J. 1998. Genetics. The Benjamin/Cumming Publishing Co.
4. Gasque, E. Manual of Laboratory experiments in cell Biology. W.C. Wilson Public.
5. Robertis, E.D.P., Robertis, E.M.F. Cell and Molelcular Biology. Sauder College Publication.
6. Beeker, W.M. The world of the cell. Pearson Education.
7. Karp, G. Cell and Molecular Biology. John Willey and sons.
8. Lodish and Baltimore. Molecular Cell Biology. W.H. Freeman and Co.

CC3 (M1MB03CT03): FUNDAMENTALS OF MICROBIOLOGY

TOTAL HOURS: 60 **CREDITS: 4**

Unit-I **Credit hours: 10**

Historical events and contributions of important microbiologists. Kingdom and domain system of classification. Bacterial nomenclature and taxonomy. Numerical taxonomy, Chemotaxonomy, Bergey's manual of systematic bacteriology. Problems and paradoxes associated with bacterial taxonomy. Evolutionary relationships and phylogeny. Analysis of dendrograms and cladograms.

Unit-II **Credit hours: 15**

Archaea, Cyanobacteria, Actinobacteria: Discovery, General characters, classification, morphology, structural organization, reproduction, economic and ecological significance: differences and similarities with bacteria. L forms, Rickettsia, Chlamydia, Spirochaetes, viroids, prions, virusoids: Brief idea of general characteristics, structural organization and significance.

Unit-III **Credit hours: 10**

Bacteria: Morphological types. Structure, arrangement and function of flagella and pili. Cell membrane, Cell wall: types, structural organization, significance, Gram staining, Significance of LPS and role in pathogenicity. Nucleoid: organization and significance. Plasmids: properties and types. Important diseases caused by bacteria.

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Unit-IV **Credit hours: 10**

Virus: Structural organization, classification, multiplication, transmission and significance. Mycoplasma, Spiroplasma and Phytoplasma: General characters, reproduction, transmission and significance. Important diseases caused by viruses, mycoplasma, spiroplasma and phytoplasma.

Unit V **Credit hours: 15**

Techniques of microbial culture, Anaerobic culture. Culture media; types, composition, preparation. Selective culture methods, Enrichment culture. Isolation and development of pure culture. Maintaining and preservation of cultures, Enumeration of microbes. Principles of Staining, Nature of dyes and types of staining; Characterization and identification of microbes based on morphology, cultural physiological and biochemical characteristics, serology and molecular methods of identification.

Suggested Readings

1. Tortora GJ, Funke BR, and Case C.L. (2004). *Microbiology*: *An Introduction.* 4th edition. Pearson Education.
2. Atlas RM. (1997). *Principles of Microbiology*. 2nd edition. WM.T.Brown Publishers.
3. Cappucino J and Sherman N. (2010). *Microbiology: A Laboratory Manual*. 9th edition. Pearson Education limited.
4. Madigan MT, Martinko JM and Parker J. (2009). *Brock Biology of Microorganisms*. 12th edition. Pearson/Benjamin Cummings.
5. Pelczar MJ, Chan ECS and Krieg NR. (1993). *Microbiology*. 5th edition. McGraw Hill Book Company.
6. Dubey, R.C. and Maheshwari, D.K. A Text Book of Microbiology. S. Chand and Company.
7. Prescott, H. and Klein. 2000. Microbiology. McGraw Hill.

CC4(M1MB04CT04): BIOMOLECULES AND METABOLISM (THEORY)

TOTAL HOURS: 60 **CREDITS: 4**

Unit I **Credit hours: 10**

Bioenergetics: entropy, enthalpy, Gibbs free energy concept, Laws of thermodynamics. Acids and Bases, redox potential, pH and Buffers, Henderson and Hasselbach equation, pKa, pKb. Preparation of buffers. Electron transport mechanism (chemi-osmotic theroy), Energy rich molecules. Mechanism of ATP synthesis.

Unit II **Credit hours: 10**

Carbohydrates: classification, structure, properties and functions. Role of carbohydrates in signaling, glycosylation of other biomolecules. Carbohydrate derivatives: muriens, glycoproteins, glycolipids, peptidoglycan. Carbon fixation, Glycolysis, TCA and other pathways, Gluconeogenesis, Glycogenesis, Glycogenolysis.

Unit III **Credit hours: 10**

Lipids: classification, structure, properties and functions of fatty acids, triacylglycerols, phospholipids, sterols and terpenes, Conjugated lipids - lipoproteins. ketone bodies, Lipids with specific biological functions, micelles and liposomes. Biosynthesis of saturated and unsaturated fatty acids, β-oxidation.

Unit IV **Credit hours: 15**

Amino acids: general properties and biosynthesis, Transamination, Deamination, Decarboxylation; glutamine and glutamic acid pathway, urea cycle, uric acid biosynthesis. Protein structure (primary, secondary, tertiary and quaternary). Ramachandran plot. Protein sequencing, Vitamins and Co-enzyme (biological and biochemical functions).

Unit V **Credit hours: 15**

Electrophoresis: Types, Principles and applications: Gel electrophoresis, SDS PAGE, Affinity electrophoresis, Capillary electrophoresis, Dielectrophoresis, DNA electrophoresis, Electroblotting, Electrofocusing, Immunoelectrophoresis, Isotachophoresis, Pulsed field gel

electrophoresis. Methods of studying metabolism: Use of biochemical mutants, Isotopic labeling, Metabolome and its applications.

Suggested Readings

1. Voet and Voet. 2000. Biochemistry. John Wiley.
2. Lehninger. 2000. Principles of Biochemistry. CBS Publishers.
3. Stryer, L. 2002. Biochemistry. W.H. Freeman.
4. Harper. 2003. Biochemistry. McGraw-Hill.
5. Zubay. 1995. Biochemistry. Brown Publishers.
6. Trehan, K. Biochemistry. Wiley Eastern Publications.
7. Jain, J.L. Fundamentals of Biochemistry. S. Chand and Company.
8. Deb, A.C. Fundamental of Biochemistry.
9. Methew, C.K. Biochemistry. Pearson Education.
10. Horton and Moran. Principles & Biochemistry. Prentice Hall.

SEMESTER –II

CC5(M2MB01CT05): MOLECULAR BIOLOGY (THEORY)

TOTAL HOURS: 60 **CREDITS: 4**

Unit I **Credit hours: 10**

Eukaryotic and Prokaryotic genetic materials: Structure, chemical composition, organization, mechanism of replication. Discontinuous synthesis of DNA, RNA primer for DNA synthesis, Enzymes and proteins associated with DNA replication, repetitive DNA. DNA repair: photo-reactivation, excision repair, post replication repair, SOS repair.

Unit II **Credit hours: 15**

RNA: types, primary, secondary, tertiary and quaternary structure and synthesis.

Transcription: Prokaryotic transcription and RNA polymerase. Eukaryotic transcription and RNA polymerases. Transcription factors and their role. Modification in RNA: 5'-CAP formation, 3'-end processing, Polyadenylation, Splicing, Editing, Nuclear export of mRNA and mRNA stability. Processing of other RNAs, Ribosome formation. Reverse transcription. Inhibitors of RNA synthesis.

Unit III **Credit hours: 10**

Translation: Prokaryotic and Eukaryotic translation, mechanism of initiation, elongation & termination, Amino acid activation, Inhibitors, Regulation of translation, Co-& post translation modification of proteins. Protein sorting: synthesis of secretory and membrane proteins, import into nucleus, mitochondria, chloroplast and peroxisomes, Receptor mediated endocytosis.

Unit IV **Credit hours: 15**

Regulation of gene expression in prokaryotes and eukaryotes: Transcriptional control; enzyme induction and repression, constitutive synthesis of enzymes. The operon hypothesis: genes involved in regulation- regulatory gene, promoter gene, operator gene and structural gene, role of cAMP and cAMP receptor protein (CRP) in the expression of e.g. Lac operon, Tryptophan operon. Catabolite repression. *Cis* control elements, promoters, enhancers, Transacting factors, DNA binding motifs of transcription factors, post transcriptional control.

Unit- V **Credit hours: 10**

Principles and applications of blotting techniques: Southern, Northern, Western and Eastern blotting. Polymerase chain reaction: Types and applications. Radioactive and non radioactive probes. Autoradiography. DNA fingerprinting, DNA Foot printing and DNA sequencing , Antisense and siRNA technology. Chromosome walking.

Suggested Readings

1. Watson, J.D. Molecular Biology of Gene. Pearson Education.
2. Friefelder, D. Molecular Biology. Narosa Publishing House, New Delhi.
3. Weaver, R. Molecular Biology. McGraw Hill.
4. Lewin, B. Gene VIII. Pearson Education.
5. Lodish and Baltimore. Molecular Cell Biology. W.H. Freeman and Co.
6. Cooper, M. The Cell – A molecular approach. Sinauer.
7. Daniel. Molecular Cell Biology. Scientific American Books.
8. Smith. Molecular Biology. Faber and Faber Publications.
9. Dabre, P.D. Introduction to (Practical) Molecular Biology. John Wiley and Sons, Ltd.Meyers, R.A. (Ed). Molecular Biology and Biotechnology : A comprehensive desk reference. VCH Publishers, New York

CC6(M2MB02CT06): IMMUNOLOGY AND ENZYMOLOGY (THEORY)

TOTAL HOURS: 60 **CREDITS: 4**

Unit I **Credit hours: 10**

Innate and acquired immunity, clonal nature of the immune response. Immune system: primary lymphoid organs, secondary lymphoid organs. Cells of the immune system: B-lymphocytes, T-lymphocytes, Macrophages, Natural killer, Lymphokine activated killer cells. Haptens and adjuants. Nature of antigens, Antibody: types structure and function, Abzymes, Antigen-antibody reactions, serological techniques.

UNIT II **Credit hours: 10**

Major histocompatibility Complex, complement system. Regulation of the immune response, activation of B and T-lymphocytes, cytokines, T-cell regulation, MHC restriction, Immunological tolerance. Hybridoma technology and monoclonal and polyclonal antibodies. Autoimmunity.

UNIT III **Credit hours: 15**

Classification of Enzymes, Mechanism of Enzyme Action; Concept of active site and energetics of enzyme substrate complex formation; Specifically of enzyme action; Kinetics of single substrate reactions; turnover number; estimation of Michaelis-Menten parameters, multi - substrate reactions- mechanism and kinetics; Types of inhibition-kinetic models; Substrate and Product Inhibition; Allosteric regulation of enzyme; Deactivation kinetics.

UNIT IV **Credit hours: 15**

Extraction and purification of enzymes, Physical and Chemical methods used for cell disintegration. Enzyme fractionation by precipitation (using Temperature, Salt, solvent, pH, chemicals), Liquid-liquid extraction, ionic exchange, Gel Chromatography, Affinity chromatograhy and other special purification methods. Enzymes for analytical and diagnostic applications. Multi enzyme complex, isozymes,Coenzymes, Ribozymes.

UNIT V **Credit hours: 10**

Physical and Chemical techniques for enzyme immobilization-adsorption, matrix entrapment, encapsulation, cross linking, covalent binding. Advantages and disadvantages of different immobilization techniques, overview of application of immobilized enzyme systems. Enzyme crystallization techniques. Commercial applications of enzymes in food, pharmaceutical and other industries.

Suggested Readings

1. Harvey W. Blanch, Douglas S. Clark, “Biochemical Engineering”, marcel Dekker, Inc.
2. James M. Lee, “Biochemical Engineering”, PHI, USA.
3. James, E. Bailey & David F. Ollis, “Biochemical Engineering fundamentals”, McGraw-Hill.
4. Wiseman, “Enzyme Biotechnology”’ Ellis Horwood Pub.
5. Kuby, J. “Immunology”. W. H. Freeman and Company.
6. Roitt, Brostoff, Male and Mosby, Immunology.
7. Palmer, T. Understanding Enzymes.
8. Coleman, R.M. Fundamental Immunology. McGraw Hill.

CC7 (M2MB03CT07): BIOINFORMATICS AND BIOSTATISTICS (THEORY)

TOTAL HOURS: 60 **CREDITS: 4**

Unit I **Credit hours: 10**

Computer Architecture, Internal and External devices, computer software, operating system windows, Unix, Application software like word processor, spread sheet, Database, RDBMS. Computer Network- Advantages of network, types of network (LAN, WAN & MAN), Network protocols, Internet protocol (TCP, IP), and File transfer protocol (FTP), WWW, HTTP, HTML, VRL.

Unit II **Credit hours: 15**

Computer words coding (ASCII and EBCDIC), Numeric data. Introduction to programming languages, C^{++} Perl. Databases: Introduction to databases- Relational databases- Oracle, SQL, Database generation, Sequence databases- Resources-Human Genome project (HGP), Microbial genomes, Structural databases- protein data bank (PDB).

Unit III **Credit hours: 15**

Principles behind computational analysis, Sequence analysis, sequence alignment, scoring matrices for sequence alignment, Similarity searching (FASTA and BLAST), Pair wise comparison of sequences, multiple alignment of sequences.

Unit IV **Credit hours: 10**

Brief description of tabulation of data and their graphical representation, measures of central tendency and dispersion: Mean, median, mode, range, standard deviation, variance. Simple linear regression and correlation. Brief idea of statistical softwares and their applications.

Unit V **Credit hours: 10**

Elementary idea of probability, definition and properties of binomial, poison and normal distributions. Elementary idea of random sampling, selection of simple random samples from a finite population, definition of sampling distribution, Randomized block design, sampling variance and standard error. Analysis of Variance (ANOVA), Idea of two types of errors and level of significance, test of significance, chi-square test of independence and homogeneity test based on Z and T statistics.

Suggested Readings

1. Zar, J.H. Biostatical Analysis. Pearson Edu.
2. Gupta, S.C. and Kapoor, V.K. Fundamentals of applied statistics. S. Chand and Company.
3. Dutta, N.K. Funadamentals of Biostatistics. Kanika Pub. New Delhi.
4. Arora, P.N. and Malhan, P.K. Biostatistics. Himalya Publishers.
5. Daniel, M. 1999. Biostatistics (3rd Edition). Panima Publishing Corporation.
6. Campbell, R.C. Statistics for Biologist. Cambridge University Press.
7. Bliss, C.J.K. Statistics in Biology. McGraw Hill.
8. Swardlaw, A.C. (Practical) statistics for experimental Biology. John Wiley and Sons.

CC8(M2MB04CT08): GENETIC ENGINEERING (THEORY)

TOTAL HOURS: 60 **CREDITS: 4**

Unit I **Credit hours: 10**

Recombinant DNA Technology: History and Milestones In Genetic Engineering, Application of enzymes in recombinant DNA technology- exo and endonucleases, restriction enzymes, DNA ligases, polymerases, DNA modifying enzymes etc. General concept and principle of cloning: Cloning vectors, classification, plasmids: pBR 322, pBR327, pUC8. Phage vectors: M13 and λ. Phagemids and cosmids.

Unit II **Credit hours: 10**

Purification of DNA from living cells- Extraction of bacterial DNA, Plasmid DNA. Isolation of DNA, molecular probes, insertion of DNA into living cell- microinjection, electroporation, shot gun method, ultrasonication, microlaser, uptake of DNA by bacterial cell and introduction of phage DNA in to bacterial cell. Nucleic acid purification, yield analysis.

Unit III **Credit hours: 15**

Methods for Constructing rDNA and cloning: Inserts; vector insert ligation; Use of linkers, adaptors and homo-polymer tailing. Methods for screening and selection of recombinant clones. Nucleic Acid sequencing: Sanger's, Maxam Gillbert's method and pyrosequencing. Site-directed mutagenesis. Protein engineering and its applications.

Unit-IV **Credit hours: 15**

Shuttle and expression vectors: Design and characteristics of expression vectors for cloning in prokaryotes and factors that affects expression. Yeast cloning vectors: 2μm plasmid, Yep, Yip and YAC. Animal virus derived vectors: SV40 and retroviral vectors. Applications of cloning in gene analysis: Obtaining clone of specific gene, Study of gene location, expression and regulation of gene expression, Study of translated product of a cloned gene. DNA Libraries: types, construction and screening of Genomic and C- DNA libraries.

Unit V **Credit hours: 10**

Principle and applications of gel mobility shift assay, Ribozyme, Antisense and siRNA technology. Gene Therapy: Vector engineering, gene replacement/augmentation, gene correction, gene editing, gene regulation and silencing. Restriction Mapping of DNA Fragments and Map Construction.

Suggested Readings

1. Watson, J.D. Molecular Biology of Gene. Pearson Education.
2. Friefelder, D. Molecular Biology. Narosa Publishing House, New Delhi.
3. Weaver, R. Molecular Biology. McGraw Hill.
4. Lewin, B. Gene VIII. Pearson Education.
5. Lodish and Baltimore. Molecular Cell Biology. W.H. Freeman and Co.
6. Cooper, M. The Cell – A molecular approach. Sinauer.
7. Daniel. Molecular Cell Biology. Scientific American Books.
8. Smith. Molecular Biology. Faber and Faber Publications.
9. Dabre, P.D. Introduction to (Practical) Molecular Biology. John Wiley and Sons, Ltd

SEMESTER III

CC9(M3MB01CT09) : MICROBIAL GENETICS (THEORY)

TOTAL HOURS: 60 **CREDITS: 4**

Unit-I **Credit hours:10**

Prokaryotic Genomes - Structure of the bacterial nucleoid, DNA supercoiling and associated proteins: writhning number, twisting number. Replication and partitioning of the bacterial genome and Genome of Archaea.

Unit-II **Credit hours:15**

Bacterial conjugation: discovery, effective contact and pilli in conjugation, F-factor, the conjugal transfer process; high frequency recombination and Hfr strains, cointegrate formation; the order of chromosome transfer; formation of F prime (F'), Time–of–Entry, Mapping of bacterial genes. Plasmid: F Plasmid , Conjugate plasmid', Non-conjugative plasmid, R plasmid, Col plasmid (copy number and incompatibility) and sex pili. Episomes.: mechanism and significance.Site specific recombination, replicative recombination.

Unit –III **Credit hours:15**

Bacterial Transformation: discovery, mechanism and significance, detection of transformation, development of competence, mechanism of transformation, transfection, Transduction: discovery, mechanism (Generalized and specialized transduction), significance. Sex duction Mutant phenotype. Metagenomics and its applications. Expression of foreign gene in bacteria.

Unit-IV **Credit hours:10**

Conventional, molecular and recent approaches to polyphasic bacterial taxonomy, evolutionary chronometers, rRNA oligonucleotide sequencing, signature sequences, and protein sequences. Microbial genomics: identification of unculturable prokaryotes, safer food production, improved biosensing, genomic islands, pathogenecity islands. Genetically engineered microbes: development , commercial and pratical applications.

Unit-V **Credit hours:10**

Gene regulation – Post transcriptional processing of RNAs – methylation, polyadenylation and splicing of mRNA; cutting and modification of tRNA degradation system; CatalyticRNA, Group I and Group II intron splicing; Gene regulation – negative regulation – E. coli lac operon (structural, operator, promoter and repressor genes), Positive regulation – E. coli trp operon; Regulation by small molecules e.g. ppGpp and cAMP Post-translational processing (removal of fmet from polypeptide; ribosome editing: protein folding); Gene silencing (RNAi):An introduction and its application.

Suggested Readings:

1. Gardner, E. J,Simmons, M J& D P Snustard ,1991 , Principles of Genetics, 8 edition. John Wiley & Sons.NY.
2. Freifelder .S ,1987 Microbial Genetics, Jones & Bartlett, Boston.
3. Robert H .Tamarin. Principles of Genetics, 5th edition, Cm Brown Publishers.
4. Lewin.B, 1990. Genes, 6 th edition, Oxford University Press.
5. Klug .W.S. & Cummings,MR, 1996, Essentials of Genetics, Mentics Hail. NewJersey.
6. Microbiology – A (Practical) Approach - Bhavesh Patel and Nandini PhanSolutions to Practical
7. Microbiology - Bhavesh Patel and Nandini PhanseExperiments in Biotechnology - Nighojkar and Nighojkar

CC10 (M3MB02CT10): VIROLOGY (THEORY)

Unit I **Credit hours: 10**

Discovery, origin, nature, physical and chemical properties of viruses. Nomenclature and classification of viruses; LHT system, Baltimore classification, classification schemes of ICTV / ICNV. Ultrasrtructure: Capsid symmetry and types, enveloped and non-enveloped viruses. Viral genomes: Unusual bases (TMV,T4 phage), overlapping genes (□X174, Hepatitis B virus), alternate splicing (HIV), terminal redundancy (T4 phage), terminal cohesive ends (lambda phage), partial double stranded genomes (Hepatitis B), long terminal repeats (retrovirus),

segmented (Influenza virus), and non-segmented genomes (picornavirus), capping and tailing (TMV) . Satellite viruses. Emerging viruses. Oncogenic viruses: Concepts of oncogenes and proto-oncogenes

Unit II **Credit hours: 10**

Bacteriophage; discovery, structure, life cycle, identification, nomenclature. lytic and lysogenic phages: Brief details of M13, Mu, T3, T4, and Lambda, P1 phages. Stages in the Lytic Life Cycle of a typical phage, *E. coli* PhageT4, *E.coli* phage lambda. Lysogenic Cycle, Prophage integration and induction. Phage production; burst size. Bacteriophage based vectors for cDNA and genetic libraries. Phage phenotyping.. Properties of a phage infected bacterial culture,

Unit III **Credit hours: 15**

Viral replication: adsorption, Interaction of viruses with cellular receptors and entry, Concept of early and late proteins, eclipse phase; genome replication, mRNA production, DNA and RNA synthesis, transcription and post transcriptional processing, translation of viral proteins, assembly, maturation and release. Bacterial cell transformation, host cell restriction, transduction.;. One step multiplication curve, Replication strategies of viruses as per Baltimore classification (phi X 174, Retroviridae, Vaccinia, Picorna),

Unit IV **Credit hours: 15**

Plant Viruses: Classification and nomenclature. Characteristics of important plant viruses and symptoms, pathogenesis, control of diseases caused by them (TMV, Tomato spotted wilt virus, Cucumber mosaic virus, Potato virus Y, Cauliflower mosaic virus, Potato virus X, Citrus tristeza virus, Barley yellow dwarf virus), Prevention of crop loss due to virus infection and vector control. NPV and its role in pest management. Animal Viruses: Classification and nomenclature, Characteristics of important animal viruses, and symptoms, pathogenesis, control of diseases caused by them (AIDS, H5N1, SARS, Polio, chickenpox, Smallpox, Herpes, Rabies, influenza, hepatitis). Modes of plant and animal viral transmission: Persistent, non-persistent, vertical and horizontal.

Unit V **Credit hours: 10**

Isolation, Purification, Physical and Chemical methods of Assay, Cultivation (embryonated eggs, experimental animals and cell cultures: cell-lines, cell strains and transgenic systems) of plant and animal viruses, Infectivity assay (plaque method, end point method) , Cytopathic effects, Serological methods of viral identification, Genetic analysis of viruses by classical genetic methods. General principles of viral vaccination. Interferons and chemotherapeutic agents and their mode of action. Use of viral vectors in cloning and expression, Gene therapy.

Suggested Reading

1. Medical Virology 10Th Edition by Morag C and Tim bury M C 1994. Churchil Livingstone, London.
2. Introduction to Modern Virology 4th Edition by Dimmock N J, Primrose S. B. 1994. Blackwell Scientific Publications. Oxford.
3. Virology 3 rd Edition by Conrat H.F., Kimball P.C. and Levy J.A. 1994. Prentice Hall, Englewood Cliff, New Jersey.
4. Text Book on Principles of Bacteriology, Virology and Immunology Topley and Wilsons 1995.
5. Molecular Biology, Pathogenesis and Control by S.J. Flint and others. ASM Press, Washington, D.C.
6. Applied Virology. 1984. Edited by Edonard Kurstak. Academic Press Inc.
7. Introduction to Modern Virology by Dimmock.
8. Prion diseases by Gaschup, M.H.
9. Clinical virology Manual by Steven, S., Adinka, R.L., Young, S.A. 10. Principles of Virology. 2000 by Edward Arnold.

CC11 (M3MB03CT11): MICROBIAL ECOLOGY (THEORY)

Total Hrs. 60 **Credits : 4**

Unit – I **Credit hours: 10**

Soil microbiology: Soil as a habitat for organisms and their reactions, soil texture and properties, distribution of microorganisms in soil and its significance, microbial density in soil- zymogenous and autochthonous flora in Soil. Interaction between microbes and plants: rhizosphere and

zhizoplane microbes, R:S ratio, spermosphere, phyllosphere microorganisms, their importance in plant growth. Interaction among microorganisms: mutualisms, commensalism, competition, amensalism, parasitism and predation.

Unit - II **Credit hours: 10**

Air microbiology: microbial population and its significance. Aerosol, droplet nuclei, air pollution- sources (Microbiological) – air quality analysis- air sampling devices. Isolation, enumeration and methods of studying. Water microbiology: microbial population and its significance, Isolation and enumeration. Methods of studying water microbiology. Eutrophication, algal blooms and red tides. Definition, causes, effects. Water treatment- Primary, secondary and tertiary. Drinking water- Potability- MPN technique. Marine Microbiology: biodiversity resources, Microbial corrosion, Deep sea microbiology and Geothermal Events.

Unit – III **Credit hours: 15**

Microbes in extreme environments: Habitat, biodiversity, metabolic characteristics, physiological adaptations, evolutionary, ecological, commercial and biotechnological significance. Thermophiles; Classification and properties,. Hyperthermophiles and extreme thermophilic habitats. Alkaline environment and Alkalophiles: Classification and properties, Soda lakes and deserts , calcium alkalophily,. Acidophiles: Classification, life at low pH, acidotolerence, applications.

Unit – IV **Credit hours: 15**

Halophiles: Classification and properties, Evolutionary, ecological and commercial significance, Dead Sea, discovery basin, cell walls and membranes – Purple membrane, compatible solutes. Osmoadaptation / halotolerence. Applications of halophiles and their extremozymes. Barophiles: Classification and properties, Evolutionary, ecological and commercial significance, high-pressure habitats, life under pressure, death under pressure.

Unit V **Credit hours: 10**

Psycrophiles and psychrotrophs: Classification and properties, Evolutionary, ecological and commercial significance, Role of microorganisms in the biogeochemical cycling of carbon, nitrogen, phosphorus, sulphur, iron, manganese, silicon etc.). nitrogen fixing microorganisms-root nodule bacteria – non symbiotic Nitrogen fixers- Rhizobium and phosphate solubilisers. Methanogens, Methylotrophs. Microbial Biofilms: Nature, properties and significance, Mechanism of microbial adherence.

Suggested Readings

1. Atlas RM and Bartha R. (2000). *Microbial Ecology: Fundamentals & Applications*. 4th edition. Benjamin/Cummings Science Publishing, USA.
2. Atlas RM. (1989). *Microbiology: Fundamentals and Applications*. 2nd Edition, MacMillan Publishing Company, New York.
3. Madigan MT, Martinko JM and Parker J. (2009). *Brock Biology of Microorganisms*. 12th edition Pearson/ Benjamin Cummings.
4. Campbell RE. (1983). *Microbial Ecology*. Blackwell Scientific Publication, Oxford, England.
5. Coyne MS. (2001). *Soil Microbiology: An Exploratory Approach*. Delmar Thomson Learning.
6. Lynch JM & Hobbie JE. (1988). *Microorganisms in Action: Concepts & Application in Microbial Ecology*. Blackwell Scientific Publication, U.K.
7. Maier RM, Pepper IL and Gerba CP. (2009). *Environmental Microbiology*. 2nd edition, Academic Press.
8. Martin A. (1977). *An Introduction to Soil Microbiology*. 2nd edition. John Wiley & Sons Inc. New York & London.
9. Stolp H. (1988). *Microbial Ecology: Organisms Habitats Activities*. Cambridge University Press, Cambridge, England.
10. Subba Rao NS. (1999). *Soil Microbiology*. 4th edition. Oxford & IBH PublishingCo. New Delhi.

CC12(M3MB04CT12): MICROBIAL PHYSIOLOGY AND METABOLISM (THEORY)

Total Hrs. 60 **Credits : 4**

Unit-I **Credit hours: 10**

Chemical composition and structure of bacterial and archaebacterial and cyanobacterial membranes. Lipid bilayer, membrane proteins, Spectrins, Glycophorin, Multipass membrane proteins Bacteriorhodopsin. Membrane Transport : Principles of membrane transport, ion channels and electrical properties of membranes. Uptake of nutrients. Cellular movement; types of locomotion, structures involved in locomotion, structure and arrangement of flagella, Movement in response to external stimuli, mechanism of chemotaxis. Cell signalling, two component system.

Unit-II **Credit hours: 10**

Bacterial nutrition; types and modes of nutrition in bacteria, Nutrient requirements of microbes. Nutritional classification. Bacterial growth; events in cellular growth, growth rate and generation time. Phases of , Growth curve, Growth kinetics, factors effecting growth; temperature, pH, osmotic pressure, salinity, oxygen tension, water, nutrient availability etc. Measurement of growth. Measurement of cell mass and number. Pattern of death. Methods used to study, microbial metabolism – nutrient balance, metabolically blocked microbes; radiolabelled compounds.

Unit-III **Credit hours: 15**

Autotrophic metabolism: Photoautotrophy; Photosynthetic microorganisms, photosynthetic pigments, and generation of reducing power Absorption spectrum, pigments involved in absorption of light energy, site of absorption in bacteria and cyanobacteria, oxygenic and anoxygenic photosynthesis. Purple sulphur bacteria and the green sulphur bacteria. Chemoautotrophy; sources of energy, Energy yielding processes: oxidation of inorganic

compounds. Sulphur bacteria, iron bacteria, nitrifying bacteria, hydrogen bacteria. Photoheterotrophs: purple nonsulphur bacteria.

Unit-IV **Credit hours: 10**

Heterotrophic metabolism: Metabolism of two carbon compounds: EMP pathway, citric acid cycle, EDP, PPP and other alternate pathways. Fermentation and anaerobic respiration. Anaerobic fermentation – alcoholic fermentation, propionic acid fermentation, formic acid fermentation. Metabolism of one carbon compounds: methylotrophs; Oxidation of methane, methanol, methylamines and carbon assimilation in methylotrophic bacteria and yeasts, Metahnogens: Methanogenesis form H_2,CO_2, CH_3OH, HCOOH, methylamines, energy coupling and biosynthesis in methanogenic bacteria. Significance of methanogenesis, Acetogens: autotrophic pathway of acetate synthesis and CO_2 fixation.

Unit-V **Credit hours: 15**

Nitrogen fixation by rhizobia; formation and structure of root nodule, Physiology of nitrogen fixation, Importance of leghemoglobin and nitrogenase enzyme. Nitrogen fixing genes. Non leguminous nitrogen fixers, Physiology of hetrocyst and actinorhizal nodules. Factors affecting nitrogen transformation, nitrogen assimilation, incorporation of ammonia into organic compounds (GOGAT pathway), transporting of fixed nitrogen in symbiotic systems. PGPR. Phosphate solubilizing bacteria, Mechanism of Phosphate solubilisation.

Suggested Readings

1. Ananthanarayan R and Paniker CKJ. (2005). *Textbook of Microbiology*. 7th edition (edited by Paniker CKJ). University Press Publication.
2. Brooks GF, Carroll KC, Butel JS and Morse SA. (2007). *Jawetz, Melnick and Adelberg's Medical Microbiology*. 24th edition. McGraw Hill Publication.
3. Goering R, Dockrell H, Zuckerman M and Wakelin D. (2007). *Mims' Medical Microbiology*. 4th edition. Elsevier. Crofts publication.
4. Willey JM, Sherwood LM, and Woolverton CJ. (2008). *Prescott, Harley and Klein's Microbiology*. 7th edition. McGraw Hill Higher Education.

SEMESTER IV

DSE1: MINOR RESEARCH PROJECT

TOTAL HOURS: 60 **CREDITS: 4**

DSE2: a. ENVIRONMENTAL MICROBIOLOGY

Total Hrs. 60 **Credits: 4**

Unit I **Credit hours: 15**

Applications of microbes in biodegradation and bioremediation: Microbial degradation of cellulose, Hemi cellulose, lignin, pectin, chitin, pesticides, xenobiotics and other recalcitrant chemicals, petroleum and hydrocarbons and its ecological significance. Bioprospecting and bioleaching, Bioaccumulation of heavy metals ions from industrial effluents. Biomining: Biooxidation-Direct and indirect mechanisms, Bacterial oxidation of sphalerite, chalcopyrite and Pyrite, Microbial leaching; Recovery of metals from solutions; Microbes in petroleum extraction.

Unit II **Credit hours: 10**

Biomagnification and degradative plasmids, biotransformation. Biodeterioration and its control. Biological control and biopesticides. definition, significance, types , sources, manufacture, use and mode of action. Entemopathogenic fungi, viral insecticides. significance of *Bacillus thuringiensis* in biocontrol.

Unit III **Credit hours: 15**

Microbes and pollution :waste water; Types, Sources, Microbiology. Methods of waste water treatment. Eutrophication: Definition, causes and effects. Algal blooms, Red tides. Solid waste: Source, types and characterization. Methods of treatment: Physical, chemical, biological, aerobic, anaerobic, primary, secondary and tertiary treatments. Use of genetically engineered organisms for control of pollution.

Unit IV **Credit hours: 10**

Bioconversion of Solid Waste: Composting, vermi composting and vermi culture. Microbial biofertilizers: types, sources, manufacture and significance. Green manuring, Mycorrhizae as fertilizers: Rhizhobia and other symbiotic and non symbiotic nitrogen fixing microbes as biofertilizer. Application of microbes as biofertilizers. Significance and application of PSB (Phosphate Solubilizing Bacteria) and PGPR (Plant Growth Promoting Rhizobacteria).

Unit V **Credit hours: 10**

Microbes as biological weapons, Role of microbes in production of Biofuels. Biogas production and factors affecting methane formation. Biosensors: Principle, working, Types of biosensors Applications of *biosensors* in environmental monitoring. Application of microbes as biosensors.

Suggested Readings

1. Mooray Moo-Young. (Eds). Comprehensive Biotechnology (Vol. I, II, III) Pergamon Press, England.
2. Metcalf and Eddy. Waste water engineering treatment and uses. McGraw Hill.
3. Jogdand, S.N. Environmental Biotechnology. Himalaya Publication House.
4. De, A.K. Environmental Chemistry. Wiley Eastern Ltd.
5. Abbasi and Abbasi. Renewable Energy Sources and their environmental impact. Prentice Hall of India, Pvt. Ltd.
6. Chatterji, A.K. Introduction to Environmental Biotechnology. Prentice Hall of India.
7. Thakur, I. S. Text Book of Environmental Biotechnology. I. K. International Publisher, New Delhi.
8. Mohapatra, P. K. Text Book of Environmental Biotechnology. I. K. International Publisher, New Delhi.

DSE 2: b. INDUSTRIAL MICROBIOLOGY (THEORY)

TOTAL HOURS: 60 **CREDITS: 4**

Unit I **Credit hours: 10**

Introduction to industrial microbiology and fermentation processes

Brief history and developments in industrial microbiology Types of fermentation processes - Solid-state and liquid-state (stationary and submerged) fermentations; batch, fed-batch (eg. baker's yeast) and continuous fermentations

Unit II **Credit hours: 10**

Types of bio-reactors and measurement of fermentation parameters

Components of a typical bio-reactor, Types of bioreactors-Laboratory, pilot- scale and production fermenters, constantly stirred tank and air-lift fermenters, Measurement and control of fermentation parameters - pH, temperature, dissolved oxygen, foaming and aeration

Unit III **Credit hours: 15**

Isolation of industrially important microbial strains and fermentation media

Sources of industrially important microbes and methods for their isolation, preservation and maintenance of industrial strains, strain improvement, Crude and synthetic media; molasses, cornsteep liquor, sulphite waste liquor, whey, yeast extract and protein hydrolysates

Unit IV Down-stream processing **Credit hours: 15**

Cell disruption, filtration, centrifugation, solvent extraction, precipitation, lyophilization and spray drying. Microbial production of industrial products (micro-organisms involved, media, fermentation conditions, downstream processing and uses) Citric acid, ethanol, penicillin, glutamic acid, Vitamin B12 Enzymes (amylase, protease, lipase)

Wine, beer

Unit V **Credit hours: 10**

Enzyme immobilization

Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes (glucose isomerase and penicillin acylase**)**

Suggested Readings

1. Patel A.H. (1996). Industrial Microbiology. 1st edition, Macmillan India Limited
2. Okafor N. (2007). Modern Industrial Microbiology and Biotechnology. 1st edition. Bios Scientific Publishers Limited. USA
3. Waites M.J., Morgan N.L., Rockey J.S. and Higton G. (2001). Industrial Microbiology: An Introduction. 1st edition. Wiley – Blackwell
4. Glaze A.N. and Nikaido H. (1995). Microbial Biotechnology: Fundamentals of Applied Microbiology. 1st edition. W.H. Freeman and Company
5. Casida LE. (1991). Industrial Microbiology. 1st edition. Wiley Eastern Limited.
6. Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd edition. Panima Publishing Co. New Delhi.
7. Stanbury PF, Whitaker A and Hall SJ. (2006). Principles of Fermentation Technology. 2nd edition, Elsevier Science Ltd.

DSE 3: a. FOOD AND DAIRY MICROBIOLOGY (THEORY)

Total Hrs. 60 **Credits: 4**

Unit I **Credit hours:. 10**

Intrinsic and extrinsic factors that affect growth and survival of microbes in foods, natural flora and source of contamination of foods in general. Microbial spoilage of various foods Principles, Spoilage of vegetables, fruits, meat, eggs, milk and butter, bread, canned Foods

Unit II **Credit hours:. 15**

Principles, physical methods of food preservation: temperature (low, high, canning, drying), irradiation, hydrostatic pressure, high voltage pulse, microwave processing and aseptic packaging, chemical methods of food preservation: salt, sugar, organic acids, SO2, nitrite and nitrates, ethylene oxide, antibiotics and bacteriocins

Unit III **Credit hours:. 10**

Dairy starter cultures, fermented dairy products: yogurt, acidophilus milk, kumiss, kefir, dahi and cheese, other fermented foods: dosa, sauerkraut, soy sauce and tampeh, Probiotics: Health benefits, types of microorganisms used, probiotic foods available in market.

Unit IV **Credit hours:. 15**

Food intoxications: *Staphylococcus aureus*, *Clostridium botulinum* and mycotoxins; Food infections: *Bacillus cereus*, *Vibrio parahaemolyticus*, *Escherichia coli*, Salmonellosis, Shigellosis, *Yersinia enterocolitica*, *Listeria monocytogenes* and *Campylobacter jejuni*

Unit V **Credit hours:. 10**

HACCP, Indices of food sanitary quality and sanitizers Cultural and rapid detection methods of food borne pathogens in foods and introduction to predictive microbiology.

Suggested Readings

1. Adams MR and Moss MO. (1995). Food Microbiology. 4th edition, New Age International (P) Limited Publishers, New Delhi, India.
2. Banwart JM. (1987). Basic Food Microbiology. 1st edition. CBS Publishers and Distributors, Delhi, India.
3. Davidson PM and Brannen AL. (1993). Antimicrobials in Foods. Marcel Dekker, New York.
4. Dillion VM and Board RG. (1996). Natural Antimicrobial Systems and Food Preservation. CAB International, Wallingford, Oxon.
5. Frazier WC and Westhoff DC. (1992). Food Microbiology. 3rd edition. Tata McGraw-Hill Publishing Company Ltd, New Delhi, India.

6. Gould GW. (1995). New Methods of Food Preservation. Blackie Academic and Professional, London.
7. Jay JM, Loessner MJ and Golden DA. (2005). Modern Food Microbiology. 7th edition, CBS Publishers and Distributors, Delhi, India.
8. Lund BM, Baird Parker AC, and Gould GW. (2000). The Microbiological Safety and Quality of Foods. Vol. 1-2, ASPEN Publication, Gaithersberg, MD.
9. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9th edition. Pearson Education.

DSE 3: b. ADVANCES IN MICROBIOLOGY (THEORY)

TOTAL HOURS: 60 **CREDITS: 4**

Unit I Evolution of Microbial Genomes **Credit hours: 15**

Salient features of sequenced microbial genomes, core genome pool, flexible genome pool and concept of pangenome, Horizontal gene transfer (HGT), Evolution of bacterial virulence Genomic islands, Pathogenicity islands (PAI) and their characteristics

Unit II Metagenomics **Credit hours: 15**

Brief history and development of metagenomics, Understanding bacterial diversity using metagenomics approach, Prospecting genes of biotechnological importance using metagenomics Basic knowledge of viral metagenome, metatranscriptomics, metaproteomics and metabolomics.

Unit III Molecular Basis of Host-Microbe Interactions **Credit hours: 15**

Epiphytic fitness and its mechanism in plant pathogens, Hypersensitive response (HR) to plant pathogens and its mechanism, Type three secretion systems (TTSS) of plant and animal pathogens,

Unit IV Biofilms **Credit hours: 5**

Biofilms: types of microorganisms, molecular aspects and significance in environment, health care, virulence and antimicrobial resistance

Unit V Systems and Synthetic Biology **Credit hours: 10**

Networking in biological systems, Quorum sensing in bacteria, Co-ordinated regulation of bacterial virulence factors, Basics of synthesis of poliovirus in laboratory, Future implications of synthetic biology with respect to bacteria and viruses

Suggested Reading

1. Fraser CM, Read TD and Nelson KE. Microbial Genomes, 2004, Humana Press
2. Miller RV and Day MJ. Microbial Evolution- Gene establishment, survival and exchange, 2004, ASM Press
3. Bull AT. Microbial Diversity and Bioprospecting, 2004, ASM Press
4. Sangdun C. Introduction to Systems Biology, 2007, Humana Press
5. Klipp E, Liebermeister W. Systems Biology – A Textbook, 2009, Wiley –VCH Verlag
6. Caetano-Anolles G. Evolutionary Genomics and Systems Biology, 2010, John Wiley and Sons
7. Madigan MT, Martink JM, Dunlap PV and Clark DP (2014) Brook's Biology of Microorganisms, 14th edition, Pearson-Bejamin Cummings
8. Wilson BA, Salyers AA Whitt DD and Winkler ME (2011)Bacterial Pathogenesis- A molecular Approach, 3rd edition, ASM Press,
9. Bouarab K, Brisson and Daayf F (2009) Molecular Plant-Microbe interaction CAB International
10. Voit EO (2012) A First Course in Systems Biology, Ist edition,Garland Science

DSE 4: a. MEDICAL MICROBIOLOGY

TOTAL HOURS: 60 **CREDITS: 4**

Unit-I: **Credit hours: 12**

Brief idea of virulence of microorganism, invasiveness, bacterial enzymes as invasive factors, immune reactions, toxins (bacterial, fungal, algal), Epidemiology- definition, diseases out break, sources, reservoirs of pathogens, epidemics. Disease transmission- portals of entry, air borne transmission, food and water borne transmission, blood borne infections, post surgical infections.Normal microflora of human body.

Unit II **Credit hours: 12**

Nosocomial infections, Diagnosis of infectious disease- blood count, hypersensitivity reactions, isolation and identification of pathogens by culture methods (Respiratory tract, CSF, urine, blood, vaginal smear and skin lesion culture). Disease prevention: prevention procedures, removal from food , water and soil. Vector control,quarantine etc. Immunization, Antibiotic susceptibility testing.

Unit-III **Credit hours: 12**

Epidemiology, causal organism, life cycle, mode of action ,transmission, detection, control, therapeutic measures of following fungal diseases: Mycoses, Mycotoxicoses, Epidemiology, Phycomycosis, Candidiasis, Actinomycosis, Dermatophytosis, Aspergillosis, Otomycosis and Pencillinosis. zoonosis and vector transmission of human diseases: Rocky mountain spotted fever, typhus fever, Lyme disease.

Unit-IV **Credit hours: 12**

Pathogenic viruses, Classification, Epidemiology, causal organism, life cycle, mode of action ,transmission, detection, control, therapeutic measures of following viral diseases: Influenza, Measles, Mumps, Rubella and Small pox, Yellow fever, Dengue, Polio, Viral hepatitis, Rabies, Cold sores, AIDS, genital herpes, warts.

Unit-V **Credit hours: 12**

Epidemiology, causal organism, life cycle, mode of action ,transmission, detection, control, therapeutic measures of following bacterial and protozoan diseases: Tuberculosis, Diptheria, Meningitis, Pertussis, Streptococcal Pneumonia, Cholera, Botulism, Typhoid, Tetanus, Gonorrhoea, Syphilis, Leprosy, Malaria, Leishmaniasis, Toxoplasmosis, Meningitis, Balantidiosis, Vaginitis, Giardiasis, Trypanosomiasis, Amoebiasis.

SUGGESTED READINGS

1. Devlin RM. (1975). *Plant Physiology*. 3rd edition, Willard Grant Press.
2. Gottschalk G. (1986). *Bacterial Metabolism*. 2nd edition. Springer Verlag
3. Madigan MT, Martinko JM and Parker J. (2003). *Brock Biology of Microorganisms*. 10th edition. Pearson/ Benjamin Cummings.
4. Moat AG and Foster JW. (2002). *Microbial Physiology*. 4th edition. John Wiley & Sons.
5. Reddy SR and Reddy SM. (2005). *Microbial Physiology*. Scientific Publishers India.
6. Stanier RY, Ingrahm JI, Wheelis ML and Painter PR. (1987). *General Microbiology*. 5th edition, McMillan Press.
7. Willey JM, Sherwood LM, and Woolverton CJ. (2008). *Prescott, Harley and Klein's Microbiology*. 7th edition. McGraw Hill Higher Education.

DSE 4: b. HOST-PARASITE INTERACTIONS

TOTAL HOURS: 60 **CREDITS: 4**

Unit I **Credit hours: 12**

Microbial parasites: Historical account; Bacteria, Fungi, Viruses, Protozoas, Helminthes and Arthropods, Prions; Host-parasite relationship; Infection-mode of transmission in infection, factors predisposing to microbial pathogenecity, types of infectious diseases

Unit II **Credit hours: 12**

Invasion of Microbes: Adsorption to the potential sites, membrane trafficking in eukaryotic cells, routes of invasion and selection of intracellular niche, bacterial manipulation of host cell cytoskeleton, nosocomial infection; Normal microflora of human body; Bacterial toxins and virulence genes; Strategies of host defense.

Unit III **Credit hours: 12**

Methods of Disease Diagnosis: Sampling site-normally sterile and with normal microflora; Sample collection-method of collection, transport and processing of samples, interpretation of

results; Diagnostic methods- cultured: microscopy, microbial antigen; non-cultured: PCR based microbial typing: Eubacterial identification based on 16s rRNA sequences.

Unit IV **Credit hours: 12**

Diagnosis of Infections : Bacteria- *Streptococcus*, Coliforms, *Salmonella*, *Shigella, Vibrio* and *Mycobacterium*; Fungi-Major fungal diseases, Dermatophytoses, Candidiosis and Aspergillosis DNA and RNA Viruses- POX virus, Rhabdo Virus, Hepatitis Virus and Retro Virus.

UNIT V **Credit hours: 12**

Diagnosis of Infections Viruses-AIDS Virus; Protozoan diseases-Amoebiosis, Malaria, Trypnosomiosis, Leishmaniasis; Helminthis diseases- *Fasciola hepatica* and *Ascaris lumbricoides*; Filariasis and Schistomiosis.

Suggested Readings

1. Bailey and Scott□s Diagnostic Microbiology (2002). Betty A. Forbes, Daniel F. Sahm, Alice S. Weissefeld, Ernest A Trevino. Published by C.V. Mosby
2. Medical Microbiology (1997). Edited by Greenwood. D, Slack. R and Peutherer. J, ELST Publishers.
3. Fundamental of Molecular Diagnostics (2007). David E. Bruns, Edward R. Ashwood, Carl A. Burtis. Sauders group.
4. Henry.S. Clinical Diagnosis and Management by Laboratory Methods (2007). Mepherson. Molecular Diagnostics for the Clinical Laboratorian 2nd ed. (2006). W.B.Coleman. Humana Press.

DEPARTMENT OF MICROBIOLOGY

MB SEC1(M2MB07SEC01):TECHNIQUES OF MICROBIOLOGY

TOTAL HOURS: 30 **CREDITS: 2**

Duration- 6 months

Overview- The program is offered to students undergoing program in Microbiology, Biochemistry, Biotechnology etc. In addition to the practical training the program also gives an excellent opportunity to students to use and work with latest equipments and concepts. Students perform interesting experiments in small groups as well as individually. At the end of the program, interactive session is held to assess the training and also give appropriate counseling which acts as an eye-opener for the budding microbiologist.

Eligibility: Higher secondary /U.G. /P.G. in Science

Goal

Short term skill based Training programs goal to train all the interested individuals to function as independent researchers/experts in a multidisciplinary environment of Biotechnology, Forensic Science, and clinical Research.

Fee – 15,000/- per student
Student intake - 20

Course details-

UNIT I **Credit hours: 6**

Sterilization techniques

UNIT II **Credit hours: 6**

Preparation of media, Isolation of microorganisms from clinical samples and pure culture techniques

UNIT III **Credit hours: 6**

Staining techniques (Grams staining, Negative staining etc.), Determination of total viable count & preparation of growth curves

UNIT IV **Credit hours: 6**

Bacterial identification – biochemical tests, Confirmatory tests on selective media.

UNIT V **Credit hours: 6**

Enumeration of coliforms in water for human consumption, Antibiotic susceptibility testing, Mutational studies by Replica Plating Technique.

MB SEC 2 (M3MB07SEC02)

PROBIOTICS AIR AND WATER MICROBIOLOGY

TOTAL HOURS: 30 **CREDITS: 2**

Duration- 6 months

Overview- The program is offered to students undergoing program in Probiotics and Microbiology. In addition to the practical training the program also gives an excellent opportunity to students to use and work with latest equipments and concepts. Students perform interesting experiments in small groups as well as individually. At the end of the program, interactive session is held to assess the training and also give appropriate counseling which acts as an eye-opener for the budding microbiologist.

Eligibility: Higher secondary /U.G. /P.G. in Science

Goal

Short term skill based Training programs goal to train all the interested individuals to function as independent researchers/experts in a multidisciplinary environment of Microbiology, environmental Sciences, probiotic industries, Forensic Science and clinical Research.

Fee – 15,000/- per student
Student intake - 20

Course details-

Unit I **Credit hours: 6**

Aeromicrobiology

Bioaerosols, Air borne microorganisms (bacteria, Viruses, fungi) and their impact on human health and environment, significance in food and pharma industries and operation theatres, allergens.

Unit II **Credit hours: 6**

Air sample collection and analysis

Bioaerosol sampling, air samplers, methods of analysis, CFU, culture media for bacteria and fungi, Enumeration of bacteria, Isolation: Pour plate technique (streaking four way, Zig Zaq, and linear. Spreading, Slant, Stab culture) and characterization.

Unit III **Credit hours: 6**

Control measures

Fate of bioaerosols, inactivation mechanisms – UV light, HEPA filters, desiccation, Incineration. Sterilization techniques: Physical, chemical methods of sterilization, filter sterilization, Dry and wet heat sterilization. Screening of antibiotic susceptibility.

Unit IV **Credit hours: 6**

Water Microbiology

Sample Collection, Treatment and safety of drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive test/MPN test, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests Precipitation, chemical disinfection, filteration, high temperature, UV light

Unit V **Credit hours: 6**

Probiotic technology

Screening of probiotic properties bacteria and their properties: Antibiotic resistance, Bile tolerance, BSH activity, Antibacterial activity, preparation of skim milk and viability testing. Biochemical characterization: Catalase test, Growth in litmus milk, Growth on BCP-MRS agar, nitrate reduction, arginine hydrolysis, Esculin hydrolysis. Voges Proskauer's test.