

**Kavayitri Bahinabai Chaudhari
North Maharashtra University, Jalgaon**

॥अंतरी पेटवू ज्ञानज्योत॥



'A' Grade
NAAC Re-Accredited
(3rd Cycle)

SYLLABUS

for

**Master of Science
(M. Sc.) II**

Microbiology

**Choice Based Credit System
(Outcome Based Curriculum)**

For

**Affiliated Colleges of
Kavayitri Bahinabai Chaudhari North Maharashtra University
Jalgaon 425 001 (MS)**

Second Year 2022-2023

Program at a Glance

Name of the program (Degree)	:	<i>M. Sc.</i>
Subject	:	<i>Microbiology</i>
Faculty	:	<i>Science and Technology</i>
Duration of the Program	:	<i>Two years (four semesters)</i>
Medium of Instruction and Examination	:	<i>English</i>
Credits of the program	:	<i>Total 88 credits (64 core credits including 4 credits of project/dissertation, skill enhancement- 08, subject elective credits 08 and audit 08 credits)</i>
Examination Pattern	:	<i>The 60 : 40 (60 marks University assessment (exam) and 40 marks continuous internal college assessment (exam))</i>
Evaluation mode	:	<i>CGPA</i>
Passing standards	:	<i>The 40% in each exam separately (separate head of passing)</i>
Result	:	<i>As per the University's rules of CGPA system</i>

Prologue

The requirement for trained and skilled human resource is the need of time in the higher education and industry to match with rapid pace of technology development. Students need to acquire thorough knowledge of theoretical concepts and hands-on laboratory methods in the subject. Thus, it is imperative to revise and update the curriculum to accommodate the fundamental aspects as well as advanced developments in various disciplines of Microbiology and to complement the needs of its applied sectors. The program is designed to provide skilled manpower in this subject, facilitate to improve linkages with industries, and intended to offer practical skills needed to pursue the jobs in a chosen profession. Beside this, the students will be enlightened with knowledge in the newer areas of Bioinformatics, Bioinstrumentations, Biomolecules, Genetics, Immunology, etc.. Students are taught how to plan experiments, perform them carefully, analyse the data

accurately, and present the results both, qualitatively and quantitatively through their dissertations or the project work. The students are encouraged to deliver seminars on the topics of research to develop presentation skills and enable to build confidence which will lead them to read about different themes and enhances their assimilation abilities. A project component in the final semester will enable students to select a research problem, plan to execute experiments related to it, collect data and analyse it, and present the results in the form of an oral presentation as well as a thesis. This not only equips the student for a career in research as well as industry, but also fosters self-confidence and self-reliance in the student as he/she learns to work and think independently. At the end of the programme the student will be well-versed in this subject as well as be familiar with the most recent advances in the field of Life Sciences and will have gained hands-on experience in this subject of study. The student will be able to take up a suitable position in academia or industry and will be equipped to pursue a career in research or be an entrepreneur, if so desired.

Process of Curriculum Design

The Choice-Based Credit System (CBCS) provides a framework within which there is flexibility in the design of courses and their content, simultaneously also providing the student a choice of the courses he/she wishes to study. The courses are assigned credits based on teaching hours, which in turn is linked to course content and structure. When revising the syllabi for the courses, the courses to be implemented as well as the content of each course was extensively discussed and debated on, over meetings between the faculty members and the students. Several alumni contributed to useful inputs. Furthermore, the opinions of prospective employers of the corporate sector were also sought and obtained. The opinions of experts were taken into consideration as well. The syllabi presented here are the culmination of the combined efforts of the faculty members, feedback obtained from students, alumni, external experts and members of industry.

The student will acquire knowledge about Microbiology such as Genetic Engineering, plant-microbes interaction, and Microbial Diversity, Molecular Biology, Pharmaceutical Microbiology, Fermentation Technology Applied and Environmental Microbiology, Industrial Microbiology Immunology, Agricultural and Food Microbiology. The student can design and execute experiments related to Basic Microbiology, Molecular Biology,

Recombinant DNA Technology, and Microbial Genetics and can execute a short research project incorporating techniques of Basic and Applied Microbiology under supervision.

Program Objectives for M.Sc. Program:

- 1. To impart the profound theoretical and practical knowledge of the specific science discipline along with the fundamental core concepts*
- 2. To train the students to employ modern techniques, tools, methodologies, equipment, hardware/software etc. to perform objective oriented scientific and planned experiments.*
- 3. To groom the students for all-round development and mold them in a trained workforce to provide teaching-learning, research, business, professional supports in the various science disciplines.*
- 4. To make the student to develop the ability to think analytically, independently and draw logical conclusions to solve real-life problems.*
- 5. To utilize the skills and knowledge gained through the subject to deal with real life situations and problems related to society, environment, research and development etc.*

Structure of M.Sc. program in Microbiology

M.Sc. Microbiology program is of two years duration and is conducted into four semesters. Since inception, the program was mostly student centric. Now in lieu of accreditation standards of NAAC, the university adopted outcome-based education approach. The various courses of the program are designed to include classroom teaching, laboratory work, project, seminars, assignments, etc. Three categories of courses are being offered in this program: (A) Prerequisites and Core courses (12 theory and 8 practical's of 4 credit each as mandatory courses), (B) Skill Based/ Subject Elective courses (04 courses of 4 credits each) and (C) Audit courses (4 Courses of 2 credits each). The core courses of 4 credits include theory as well as practical. The core courses embody a research-based course that leads to a project dissertation. The student is required to accumulate 22 credits each semester, a total of 88 credits, to fulfil the requirements for a

M.Sc. degree. Forty percent of the total marks for each course will be awarded through internal assessment. Final examinations for four credit courses will be of three hours duration while examinations for each laboratory- based courses will be held over two days of three hours (incubation based practicals) each or one day of 5-6 hours each. However, there could be certain changes in the number of classes of theory and practicals, ways of teaching either through online or offline mode and even the examination pattern owing to the prevailing situation like pandemic and as per the need by following the rules and regulations.

Duration

The duration of M.Sc. degree program shall consist of two academic years divided in to four semesters. Each Semester consist of 90 working days. Each theory and practical course should be completed in about 50 lectures.

Medium of instruction

The medium of instruction and examination for each course shall be English.

Credit to contact hour

One credit is equivalent to 15 periods of 60 minutes each for theory course lecture. While credit weightage for self-learning based on e-content shall be 50% or less than that for lectures.

Attendance

The student enrolled for this M.Sc. course must have 75% attendance in each course in order to appear for term end examinations, otherwise the candidate may not be allowed to appear for term end examination as per ordinance.

Examination

Each theory and practical course will be of 100 marks comprising of 40 marks internal (20 marks of 2 internal examinations) and 60 marks external examination. Separate head of passing in Internal and External examination is mandatory. In case of failure in internal examination of particular course, student will have to appear for the same in next semester as per the schedule of the examination. In case a student fails in particular course in a semester and the same course(s) are revised/removed from curriculum in due course, the student will have to appear as per new curriculum and or pattern in subsequent semester at his own responsibility observing the course equivalence..

Term end examination (60 marks) will be of three hours duration for each theory course. There shall be 5 questions each carrying equal marks (12 marks each).

Internal examination (40 marks each semester)

Internal assessment of the student by respective teacher will be comprehensive and continuous, based on written test. The written test shall comprise of both objective and subjective type questions. Two internal tests (20 marks each) will be conducted during semester as a part of continuous assessment.

Practical Examination

Practical examination shall be conducted at the end of the semester. Practical examination will be of minimum 6 hours duration and shall be conducted as per schedule (10 am to 5 pm on schedule date or can be scheduled 10 am - 1pm / 2 – 5 pm for 2 consecutive days) in case of practicals where incubation condition, allied aspects are essential. There shall be 5 marks for laboratory record book and well written certified journal, 10 marks for viva-voce and minimum three experiments (major and minor). Certified journal is compulsory to appear for practical examination. There shall be one expert and two examiners (external and internal) per batch for the practical examination.

**Summary of Distribution of Credits under CBCS Scheme
for M.Sc. at Affiliated Colleges [w.e.f. 2021-22]**

Sr. No	Type of course	Sem I	Sem II	Sem III	Sem IV
01	Core	16	16	16	12
02	Skill based	04	04	-	-
03	Elective	-	-	04	04
04	Project	-	-	-	04
05	Audit	02	02	02	02
06	Total Credits	22	22	22	22

Subject Type	Core	Skill based	Elective	Project	Audit	Total
Credits	60	08	08	04	08	88

Total Credits = 88

**Affiliated Colleges of
Kavayitri Bahinabai Chaudhari North Maharashtra University, Jalgaon
Choice Based Credit System (Outcome Based Curriculum) with effect from 2021 -2022
Course credit scheme**

Semester	(A) Core Courses			(B) Skill Based / Elective Course			(C) Audit Course			Total Credits (A+B+C)
	No. of Courses	Credits	Total Credits	No. of Courses	Credits	Total Credits	No. of Courses	Credits (Pract.)	Total Credits	
I	4	8 + 8	1	1	4 + 0	4	1	2	2	2
I	4	12 + 4	1	1	0 + 4	4	1	2	2	2
I	4	8 + 8	1	1	4 + 0	4	1	2	2	2
I	3	8 + 4	1	2	8 + 0	8	1	2	2	2
Total	6			1			8			8

(T, Theory; P, Practical)

Structure of Curriculum

		First				Second				Total Credit Value
		Semester I		Semester II		Semester III		Semester IV		
		Credit	Course	Credit	Course	Credit	Course	Credit	Course	
(A)	Prerequisite and									
	Theory	4	2	4	3	4	2	4	2	36
	Practical	4	2	4	1	4	2	4	1	24
(B)	Skill Based / Subject Elective Courses									
1	Theory /Practical	4	1	4	1	4	1	8	2	20
(C)	Audit Course (No weightage in CGPA calculations)									
1	Practicing	2	1							2
2	Personality & Cultural Development			2	1					2
3	Technology Related + Value					2	1			
4	Professional and Social + Value							2	1	2
	Total Credit Value	14	6	14	6	14	6	14	6	88

List of Audit Courses (Select any ONE course of Choice from Semester II)			
Semester I (Compulsory)		Semester II (Choose One)	
		Personality and Cultural Development	
Course Code	Course Title	Course Code	Course Title
AC-101	Practicing Cleanliness	AC-201A	Soft Skills
		AC-201B	Sport Activities
		AC-201C	Yoga
		AC-201D	Music

Semester-wise Course Structure of M.Sc. Microbiology**Semester I**

Course	Course Type	Course Title	Teaching Hours/ Week			Marks (Total 100)				Credits
			T	P	Total	Internal		External		
						T	P	T	P	
MB-101	Core	Microbial Taxonomy and Diversity	4	--	4	40	--	60	--	4
MB-102	Core	Microbial Physiology and Biochemistry	4	--	4	40	--	60	--	4
MB-103	Core	Methods in Microbiology	--	4+4	8	--	40	--	60	4
MB-104	Core	Methods in Microbial Chemistry	--	4+4	8	--	40	--	60	4
MB-105	Skill Based	Bioinstrumentation	4	--	4	40	--	60	--	4
AC-101	Audit Course	Practicing Cleanliness		2	2	--	100	--	--	2
Total Credit for Semester I: 22 (T = Theory: 8; P = Practical:8; Skill Based:4; Audit Course:2)										

Semester II

Course	Course Type	Course Title	Teaching Hours/ Week			Marks (Total 100)				Credits
			T	P	Total	Internal		External		
						T	P	T	P	
MB-201	Core	Molecular Biology and Bioinformatics	4	--	4	40	--	60	--	4
MB-202	Core	Microbial Enzymology	4	--	4	40	--	60	--	4
MB-203	Core	Immunology	4	--	4	40	--	60	--	4
MB-204	Core	Methods in Molecular Biology and Immunology	--	4+4	8	--	40	--	60	4
MB-205	Skill Based	Methods in Enzymology	--	4+4	8	--	40	--	60	4
AC-201 A/B/C/D	Audit Course	Choose one out of Four (AC-201A/ AC-201B/AC-201C/AC-201D) from Personality and Cultural Development	--	2	2	--	100	--	--	2
Total Credit for Semester II: 22 (T = Theory: 12; P = Practical:4; Skill Based:4; Audit course:2)										

Program Outcomes (PO) for M.Sc. Program:

Upon successful completion of the M.Sc. program, student will be able to:

PO No.	PO	Cognitive level
PO1	Understand the basic concepts, fundamental principles, and the scientific theories related to various scientific phenomena and their relevancies in the day-to-day life.	2
PO2	Administer the skills in handling scientific instruments, planning and performing in laboratory experiments	3
PO3	Analyse the given scientific experimental data critically and systematically and the ability to draw the objective conclusions.	4
PO4	Develop various skills such as communication, managerial, leadership, entrepreneurship, teamwork, social, research etc., which will help in expressing ideas and views clearly and effectively	3
PO5	Model and formulate the real problems and find solution based-on knowledge acquired	6
PO6	To evaluate how developments in any science subject helps in the development of other science subjects and vice-versa and how interdisciplinary approach helps in providing better solutions and new ideas for the sustainable developments.	5

Program Specific Objectives for M.Sc. Microbiology program:

After completion, the students are expected to understand the;

- Basic concepts, principles and methods of Microbial Diversity, microbial Systematics and Bioinstruments used in isolation and identification of microbes and structural determination of biomolecules.
- Basic and applied aspects of Genetic makeup of bacteria, algae, fungi and viruses.
- Causes, mechanisms and consequences of defect in gene/genome of microorganisms.
- Basic concepts of microbial enzymes, enzyme kinetics, regulation of enzyme activity, industrial applications of enzymes.
- Biotechnological significance of enzymes of extremophiles in agriculture, environment, medicine and industry.
- Concepts and significance of enzymes in non-aqueous environment.

Program Specific Outcomes (PSOs) for M.Sc. Microbiology program:

Students who graduate with a Master of Science in Microbiology will:

PSO No.	PSO	Cognitive level
PSO1	Demonstrate an understanding of structure and metabolism of macromolecules, understand the regulation of metabolic pathways and understand the role of microbes in industry, health and environment.	2
PSO2	Gain proficiency in laboratory techniques in both microbiology and molecular biology and be able to apply the scientific methods to the processes of experimentation and hypothesis testing.	3
PSO3	Acquire significant knowledge on various aspects related to microbiology including biochemical techniques, immunology, physiology, agriculture, environment, pharmaceutical, molecular biology, applied recombinant DNA technology and technical skills related to microbial metabolites.	4
PSO4	Learn to work as a team as well as independently to retrieve information, carry out Research investigations and result interpretations.	6
PSO5	Develop the ability to understand and practice the ethics surrounding scientific research.	5
PSO6	Realize the impact of science in society and plan to pursue research.	5

Distribution of Course papers for M. Sc. Part I Microbiology

Subject Code	Title of the Paper		Duration (Hrs./Wk)	Max. Mark	Exam. Time (Hrs.)
M.Sc. Part I Microbiology					
Semester I : Theory Courses					
MB-101	Microbial Taxonomy and Diversity	Core course	04	100	03
MB-102	Microbial Physiology and Biochemistry	Core course	04	100	03
MB-105	Bioinstrumentation	Skill based	04	100	03
Semester I : Practical Courses					
MB-103	Methods in Microbiology	Core course	04+04	100	06
MB-104	Methods in Microbial Chemistry	Core course	04+04	100	06
AC-101	Practicing Cleanliness	Audit Course	02	100	
Semester II : Theory Courses					
MB-201	Molecular Biology and Bioinformatics	Core course	04	100	03
MB-202	Microbial Enzymology	Core course	04	100	03
MB-203	Immunology	Core course	04	100	03
Semester II : Practical Courses					
MB-204	Methods in Molecular Biology and Immunology	Core course	04+04	100	06
MB-205	Methods in Enzymology	Skill based	04+04	100	06
AC-201A/B/C/D	Choose one out of Four (AC-201A/ AC-201B/ AC-201C/ AC-201D) from Personality and Cultural Development (Audit Course)	Audit Course	02	100	

Semester III

MB – 301: Pharmaceutical Microbiology	
	<p>Course Objectives:</p> <ol style="list-style-type: none"> 1. To introduce knowledge about antibiotics, biopharmaceuticals and GMP, ICH process 2. To familiarize the students with spoilage and regulatory aspects as well as quality control issues in pharmaceuticals.
Unit I	<p>Antibiotics and Synthetic antimicrobial agents 10 L</p> <p>Mechanism of action, microbial resistance, therapeutic, prophylactic usage and adverse reactions</p> <ul style="list-style-type: none"> • Antibiotic and Synthetic antimicrobial agents: β-lactam, aminoglycosides, tetracyclines, ansamycins, macrolides • Antifungal antibiotics: Griseofulvin • Antiviral drugs: Amantidines, Nucleoside analogues, Interferons • Peptide antibiotics • Synthetic antibiotics: Sulphonamides, Chloramphenicol, Quinolone
Unit II	<p>Microbial aspects of pharmaceutical products 10 L</p> <ul style="list-style-type: none"> • Microbial contamination • Microbial spoilage (Types and factors) and preservation • Sterilization of pharmaceuticals (survivor curve, D, Z, F value) <ul style="list-style-type: none"> ○ Methods: Heat, Gaseous, Radiation, Filtration and method of validation ○ Disinfectants
Unit III	<p>Regulatory aspects and quality assurance in pharmaceuticals 10 L</p> <ul style="list-style-type: none"> • GMP in pharmaceuticals • FDA regulation and pharmacopeia • Design of sterile product manufacturing unit • Quality control in pharmaceuticals: In-process and final product control and ICH process • Sterilization control and sterility validation
Unit IV	<p>Production of Biopharmaceuticals 10 L</p> <ul style="list-style-type: none"> • Asparaginase, and Clinical dextran • Vaccines (DNA/ multivalent subunit/ bacterial) • Viral vaccines: Live attenuated, Inactivated, Live recombinant Virion subunit vaccines, production of viruses for vaccines, Virus-like particles, Synthetic peptide vaccines, • Immunoserum and toxoid
Unit V	<p>Drug design 10 L</p> <ul style="list-style-type: none"> • Rational drug design <ul style="list-style-type: none"> ○ Concepts and steps in drug design ○ Lead drug and Pro-drug ○ Structure based and combinatorial approach ○ Computer aided drug design and softwares ○ Peptidomimetic and strategies for drug discovery • Drug delivery: Concept and approaches
Suggested Readings:	
<ul style="list-style-type: none"> • Hugo, WB and Russell, AD (2003/1998) Pharmaceutical Microbiology, 6th edn, Blackwell Science, Oxford, UK (ISBN: 0-632-04196-X) Reprinted • Krogsgaard-Larsen, P., Lilijefors, T. and Madsen, U. (2004) Textbook of Drug Design and Discovery, 3rd edn., Taylor and Francis, London (ISBN: 0-415-28288 PB) 	

- Haider, SI (2006) Validation Standard Operating Procedures, 2nd edn., CRC Press Taylor and Francis Group, NY (ISBN: 0-8493-9529-1)
- Dutton CJ, Haxell MA, McArthur HAI and Wax RG (2002) Peptide Antibiotics, Marcel Dekker Inc., NY, USA (ISBN: 0-8247-0245-X)
- Seth SD (2004) Textbook of Pharmacology, 2nd edn., Elsevier, New Delhi (ISBN: 81-8147-553-4)
- Bhatia R and Ichhpujani RL (1995) Quality Assurance in Microbiology, CBS Publishers, New Delhi (ISBN: 81-239-0387-1)
- Chakraborty C and Bhattacharya A (2004) Pharmacogenomics: An approach to New Drug Development. Biotech Books, New Delhi (ISBN: 81-7622-105-8)

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C301.1	Get in-depth knowledge on different categories of antibiotics and biopharmaceuticals.	4
C301.2	Understand drug design, quality control and regulatory elements of pharmaceuticals.	2
C301.3	Discriminate conventional and combinatorial tools used in drug discovery.	4

MB – 302: Applied Molecular Biology

	<p>Course Objectives:</p> <ol style="list-style-type: none"> 1. To learn about the various enzymes involved in rDNA Technology 2. To know the principles of cDNA construction and amplification methods. 3. Making aware of synthesis of recombinant products 	
Unit I	<p>Tools of molecular biology (or rDNA technology)</p> <ul style="list-style-type: none"> • Enzymes: Restriction endonucleases and its types, DNA methylases, DNA polymerase, DNA ligases, Kinases, Phosphatases, topoisomerase • Cloning vectors: Choice and its properties, Bacterial vectors: plasmid, Bacteriophage, Cosmids, Phagmids, BACs. Eukaryotic vectors: YACs, Ti, SV40 • Cloning hosts: Prokaryotic and eukaryotic hosts: properties 	10
Unit II	<p>Methods in rDNA technology</p> <ul style="list-style-type: none"> • Vector mediated and chromosomal integration • Genomic and cDNA library construction • Gene transfer techniques: Transfection, Electroporation, Microinjection, Biolistic • Screening, analysis and confirmation of rDNA <ul style="list-style-type: none"> ○ Genetic methods ○ Hybridization techniques – Dot Blot, Colony, Dip stick, Plaque ○ Immunochemical methods ○ Plus, and minus screening, HRT and HART ○ Analysis – Restriction mapping, Blotting techniques ○ Confirmation by genetic marker and reporter genes • Applications of genetic engineering 	10
Unit III	<p>Microbial Genomics</p> <ul style="list-style-type: none"> • Concept of - Genome density, GC content, CPG Islands, Isochores, codon usage bias, cDNAs and ESTs, Contigs, epigenomics • Structural, Functional, Application and Comparative Genomics: <ul style="list-style-type: none"> ○ Methods for whole genome sequencing, gene annotation ○ Gene and SNP identification 	10

	<ul style="list-style-type: none"> ○ Genome mapping (Conjugation, Recombination and complementation) and map integration ● Genome editing using CRISPR-<i>cas</i> system 	
Unit IV	Protein Engineering and Proteomics	10
	<ul style="list-style-type: none"> ● Protein identification and Expression Mapping: 2D-gel electrophoresis, Mass Spectrophotometry and isotope labelling ● Protein-ligand docking ● Experimental approach to Protein-Protein interaction mapping: <ul style="list-style-type: none"> ○ Yeast and Bacterial 2-hybrid systems ○ Protein-ligand interactions ○ Protein fragment complement assays ● Protein arrays and chips: Antibody and peptide arrays 	
Unit V	Techniques in Molecular biology	10
	<ul style="list-style-type: none"> ● DNA Sequencing: Sanger, Maxam Gilbert and high throughput [Polony, 454 pyrosequencing, Illumina (Solexa), Massively parallel signature sequencing (MPSS), SOLiD, Ion Torrent semiconductor, single molecule, Single molecule real time (SMRT)] ● PCR: Basics, Reverse transcriptase PCR, Real time PCR, Applications ● Analysis of polymorphism: RFLP, RAPD, AFLP, SSCP, DGGE ● Analysis of gene expression: SAGE, Microarray 	

Suggested Readings:

- Nicholl, D.S.T. (2002) An Introduction to Genetic Engineering, 2nd edn., Cambridge University Press, Cambridge, UK (ISBN: 81-7596-101-5 paperback)
- Malacinski, G.M. (2003) Essential of Molecular Biology, 4th edn, Jones & Barlett Publishers, Boston (ISBN: 0-7637-2133-6)
- Alcamo, IE (2001) DNA Technology, Academic Press, London, UK (ISBN: 0-12-048920-1)
- Brown, TA (1995) Essential Molecular Biology, Vol. I (A Practical Approach), IRL Press, Oxford
- Terence A. Brown (2015) Gene Cloning and DNA Analysis: An Introduction, 7th Edn. John Wiley and Sons Ltd, UK. ISBN: 9781405181730
- Primrose, SB and Wardlow, AC (1982) Source Book for Experiments for the Teaching of Microbiology, Academic Press, London (ISBN: 0-12-565680-7)
- Sambrook and Russell Molecular Cloning Vol. I, II and III, CSHL Press, USA
- Weaver, RF (1999) Molecular Biology, WCB McGraw Hill Co., Inc., NY (ISBN: 0-321-0038-2)
- Timothy, Palzkill (2002) Proteomics. Springer US, ISBN 978-0-7923-7565-4
- Channarayappa (2006) Molecular Biotechnology: Principles and Practice, Universities Press (India) Pvt. Ltd, Hyderabad (ISBN: 81-7371-501:7)

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C302.1	Learn basic ideas on cloning vehicle.	2
C302.2	Know more about cDNA and amplification products.	4
C302.3	Understand the construction of recombinant DNA and molecular biology tools.	2

MB-304: Methods in Bioinformatics

	Course Objectives: 1. To impart training about elementary aspects of statistics used in microbiology 2. To introduce student to the variety of computational methods currently available for predicting functional behaviour of biological system 3. To analyse the output data to predict a biologically relevant function
1	Calculate mean, median, mode, range, variance, standard deviation, standard error, confidence interval using MS-Excel/suitable software
2	Plot straight Line (Linear Least squares) using LINEST Function of MS-excel/ suitable software
3	Plot - line, scatter graphs, bar graphs, error bars using MS-Excel/suitable software
4	Determine: linear regression, Correlation and their coefficients using MS-Excel/suitable software
5	Compute paired and unpaired, F-test, t-test, using MS-Excel/suitable software
6	Compute ANOVA, χ^2 -test using MS-Excel/suitable software
7	Biological databases – NCBI, Protein Data Bank and ExPaSy
8	Primary and tertiary structure analysis of protein/ DNA using BLAST
9	Multiple sequence alignments using Clustal W
10	Phylogenetic tree analysis using MEGA 5.
11	Primer designing using biological software
12	Demonstration of Microplate Reader
13	Demonstration of HPLC for analysis of microbial metabolite

Suggested Readings:

- Bailey, N.T.J (1959) *Statistical Methods in Biology*, ELBS and The English Universities Press Ltd., UK
- Irfan Ali Khan and Atiya Khanum (2004) *Fundamentals of biostatistics*, Ukaaz Publication, Hyderabad.
- Gupta, S. C. *Fundamentals of Statistics*, Himalaya Publishing House, New Delhi.
- Bliss, C. I. K. (1967) *Statistics in Biology*, Vol. 1, McGraw-Hill, New York.
- Baxevanis, A. D. and Ouellette, B. F. F. (2001) *Bioinformatics: A practical guide to the analysis of genes and proteins*. Second Edition. John Wiley & Sons, New York.
- Ewens Warren J. and Gregory R. Grant. (2004) *Statistical Methods in Bioinformatics, An Introduction*, Springer, New York.
- Lacroix, Z. and Critchlow, T. (Eds.) (2003) *Bioinformatics. Managing Scientific Data*. Morgan Kaufmann Publishers.
- Misener, S. and Krawetz, S. A. (Eds.). (2000) *Methods in Molecular Biology*, Volume 132. *Bioinformatics: Methods and Protocols*. Humana Press, New Jersey.
- Mount, D. W. (2001) *Bioinformatics: Sequence and Genome analysis*. Cold Spring Harbor Laboratory Press, New York.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C304.1	Access information from databases and interpret phylogenetic tree to gain insight into evolutionary path.	3
C304.2	Understand various algorithm.	4
C304.3	Practice biostatistics for interpretation of experimental data.	5

MB-305: Methods in Applied Microbiology

	Course Objectives: 1. To impart training to students about various quality control analysis carried out for pharmaceuticals
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	2. To familiarize the students with quality activities required in pharmaceutical industry
1	Survivor curve for Ultraviolet light/Heat /ethylene oxide
2	Validation of autoclave using chemical and biological indicator
3	Phenol coefficient (Rideal Walker Test/ Chick Martin Test),
4	Sterility testing of in-process materials and finished products
5	Evaluation of carcinogenicity using Ames test
6	Microbial Limit Test (analysis of water, raw material, finished product, packaging material, Excipients)
7	Evaluation of quality of media/reagents for Growth promotion tests.
8	Endotoxin/pyrogen using LAL (water, in-process, final product)
9	Validation of efficiency of laminar air flow
10	Biodegradation of pesticide and evaluation of CO ₂ as well as metabolites by suitable method
11	Pretreatment of lignocellulosic feedstock for saccharification using physico-chemical method, assessment of saccharification using suitable method and preparation for SSF/SHF
12	Production of biogas from feedstock and detection using water displacement method
13	Demonstrations: Lyophilization
14	Demonstration of LCMS for analysis of microbial product

Suggested Readings:

- White, D (2000) The Physiology and Biochemistry of Prokaryotes, Oxford University Press, Oxford
- Mudili, J (2007) Introductory Practical Microbiology, Narosa Publ. House Pvt. Ltd., New Delhi (ISBN: 978-81-7319-744-4)
- Primrose, SB and Wardlow, AC (1982) Source Book for Experiments for the Teaching of Microbiology, Academic Press, London (ISBN: 0-12-565680-7)
- Sawhney, SK and Singh, R. (2001) Introductory Practical Biochemistry, Narosa Publ. House, Chennai

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C305.1	Undertake quality control tests of pharmaceutical products.	5
C305.2	Carry out sterility testing and maintain sterility in the production area of pharma products.	4
C305.3	Understand various types of regulatory approvals required for pharmaceutical products.	2

M.Sc. Part II Semester III (Microbiology): Elective Course (Select only one)

MB - 303: Applied and Environmental Microbiology	
	<p><i>Course Objectives:</i></p> <ol style="list-style-type: none"> 1. To understand offline/ online strategies adopted for microbial analysis of food 2. To learn about role of microbes in wastewater treatment, as well as liquid and solid waste management 3. To impart knowledge about removal of recalcitrant from contaminated environment
Unit I	Food Microbiology 10

	<ul style="list-style-type: none"> • Methods of sampling and investigation • Preparation of dilutions • Offline and online approach of microbial analysis • Detection and enumeration of indicator bacteria, pathogenic and toxigenic microbes • Mycotoxins • Microbiological examination of specific foods <ul style="list-style-type: none"> ➤ Meat and meat products ➤ Milk and milk products • Food intoxications: Causes, pathogenesis and prevention and control 	
Unit-II	Microbiological treatment of waste water <ul style="list-style-type: none"> • Principles and need for biological waste water treatment • Conventional treatment process <ul style="list-style-type: none"> Primary- Sedimentation or settling Biological treatment process: Aerobic suspended-growth, Aerobic attached-growth (TF, RBC, PBR), Anaerobic suspended growth and Anaerobic attached growth • Advanced Tertiary Process: <ul style="list-style-type: none"> Solids removal, Biological nitrogen removal, Biological phosphorus removal and Disinfection • Waste water treatment for distillery and antibiotic industries • Solid waste management <ul style="list-style-type: none"> ➤ Composting: Principle, chemistry and biology of composting, technology of composting, criteria of compost maturity, applications of compost ➤ Biomethanation: Feedstocks, BMP, Microbiology of biomethanation, biochemistry of methane synthesis. 	10
Unit- III	Biological conversion of Lignocellulosic waste <ul style="list-style-type: none"> • Composition, structure of lignocelluloses and issues • Pre-treatment of lignocellulosic material: Physical, Chemical and Biological • Fermentation: Submerged, SSF, SHF, SScF • Applications in lignocellulosic ethanol production 	10
Unit- IV	Bioremediation and biodegradation of xenobiotics <ul style="list-style-type: none"> • Concept of biodegradability and bioconversion • Principles for measuring biodegradability • Mechanism of biodegradation / bioremediation • Methods for bioremediation: Intrinsic, Biostimulation, and Bioaugmentation • Impediments to microbial degradation of compounds • Biodegradation of xenobiotics <ul style="list-style-type: none"> ➤ Biochemical/ physiological approach ➤ Molecular techniques ➤ Toxicological risk assessments 	10
Unit- V	Biomarkers and Bioreporters <ul style="list-style-type: none"> • Concept and approaches to metagenomics analysis, ecological inference • Biomarker gene (antibiotic and heavy metal resistance genes, ice-nucleation, bioluminescence genes, green fluorescent genes) • Bioreporter genes and Biosensor 	10

Suggested Readings:

- Singh, A. and Ward, O. P. (2004) Biodegradation and Bioremediation, Springer-Verlag, Berlin (ISBN: 3-540-21101-2)
- Hurst, C.J. (2002) Manual of Environmental Microbiology, ASM Press, Washington D.C. (ISBN: 1-55581-199-x)

- Demain, A. L. and Davies, J. E. (1999) Manual of Industrial Microbiology and Biotechnology, ASM Press, Washington D.C. (ISBN: 1-55581-128-0)
- Martin, A. M. (1998) Bioconversion of waste materials to Industrial Products, Blackie Academic and Professional, London (ISBN: 0-7514-0423-3)
- Harrigan, W. F. and McCance, M.E. (1994) Laboratory Methods in Food and Dairy Microbiology. Academic Press, London
- Mossel, D.A.A., Correy, J.E.L., Struijk, C.B. and Baird, R. M. (1995) Essentials of the Microbiology of Foods, John-Wiley and Sons Inc., New York.
- Hobbs, B & Roberts, D. (1993) Food Poisoning & Food Hygiene, Edward Arnold, London
- Baker, K.H. and Herson, D. S. (1994) Bioremediation, Mc-Graw Hill Inc., New York.
- Rehm, R. G. and Reed, G. (1984) Biotechnology, Vol.1-8, Verlag-Chemie, Weinheim.
- Forster, C. F. (1985) Biotechnology and Wastewater Treatment, Cambridge University Press, Cambridge.
- Maier, R. Pepper, I. L. and Gerba, C. P. (2009) Environmental Microbiology, 2nd edn., Academic Press, London

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C303.1	Understand significance of microbes in food, wastewater treatment and clean-up	2
C303.2	Describe use of microbes in solid and liquid waste treatment as well as bioremediation of toxicants, thereby acquire knowledge about microbial potentials	4
C303.3	Understand the relevance of microbial standards for food quality assurance.	3

M.Sc. Part II Semester III Microbiology: Audit Courses

AC-301(A): Computer Skills		
(Technology + Value added Audit course; Practical; 2 Credits)		
(Optional: Campus + Program level)		
<i>Course Objectives (COs):</i>		
<ul style="list-style-type: none"> • To inculcate different daily useful computer skills among students. 		
Unit 1	Elements of Information Technology 1.1 Information Types: Text, Audio, Video, and Image, storage formats 1.2 Components: Operating System, Hardware and Software, firmware 1.3 Devices: Computer, Mobile Phones, Tablet, Touch Screen, Scanner, Printer, Projector, smart boards 1.4 Processor & Memory: Processor functions, speed, Memory types: RAM /ROM /HDD /DVD-ROM/Flash drives, memory measurement metrics	2 hrs
Unit 2	Office Automation-Text Processing 2.1 Views: Normal View, Web Layout View, Print Layout View, Outline View, ReadingLayout View 2.2 Working with Files: Create New Documents, Open Existing Documents, SaveDocuments to different formats, Rename Documents, Close Documents	5 hrs

	<p>2.3 Working with Text: Type and Insert Text, Highlight Text, Formatting Text, Delete Text, Spelling and Grammar, paragraphs, indentation, margins</p> <p>2.4 Lists: Bulleted and Numbered Lists,</p> <p>2.5 Tables: Insert Tables, Draw Tables, Nested Tables, Insert Rows and Columns, Move and Resize Tables, Moving the order of the column and/or rows inside a table, Table Properties</p> <p>2.6 Page Margins, Gutter Margins, Indentations, Columns, Graphics, Print Documents,</p> <p>2.7 Paragraph Formatting, Paragraph Attributes, Non-printing characters</p> <p>2.8 Types of document files: RTF, PDF, DOCX etc.</p>	
Unit 3	<p>Office Automation-Worksheet Data Processing</p> <p>3.1 Spreadsheet Basics: Adding and Renaming Worksheets, Modifying Worksheets,</p> <p>3.2 Moving Through Cells, Adding Rows, Columns, and Cells, Resizing Rows and Columns, Selecting Cells, Moving and Copying Cells</p> <p>3.3 Formulas and Functions: Formulas, Linking Worksheets, Basic Functions, AutoSum, Sorting and Filtering: Basic Sorts, Complex Sorts, Auto-fill, Deleting Rows, Columns, and Cells</p> <p>3.4 Charting: Chart Types, drawing charts, Ranges, formatting charts</p>	5 hrs
Unit 4	<p>Office Automation- Presentation Techniques and slide shows</p> <p>4.1 Create a new presentation, AutoContent Wizard, Design Template, Blank Presentation, Open an Existing Presentation, PowerPoint screen, Screen Layout</p> <p>4.2 Working with slides: Insert a new slide, Notes, Slide layout, Apply a design template, Reorder Slides, Hide Slides, Hide Slide text, Add content, resize a placeholder or textbox, Move a placeholder or text box, Delete a placeholder or text box, Placeholder or Text box properties, Bulleted and numbered lists, Adding notes</p> <p>4.3 Work with text: Add text and edit options, Format text, Copy text formatting, Replace fonts, Line spacing, Change case, Spelling check, Spelling options</p> <p>4.4 Working with tables: Adding a table, Entering text, Deleting a table, Changing row width, Adding a row/column, Deleting a row/column, Combining cells, Splitting a cell, Adding color to cells, To align text vertically in cells, To change table borders, Graphics, Add clip art, Add an image from a file, Save & Print, slide shows, slide animation/transitions.</p>	6 hrs
Unit 5	<p>Internet & Applications:</p> <p>5.1 Computer Network Types: LAN, PAN, MAN, CAN, WAN, Defining and describing the Internet, Brief history, Browsing the Web, Hypertext and hyperlinks, browsers, Uniform resource locator</p> <p>5.2 Internet Resources: Email, Parts of email,</p> <p>5.3 Protecting the computer: Password protection, Viruses, Virus protection software, Updating the software, Scanning files, Net banking precautions.</p> <p>5.4 Social Networking: Features, Social impact, emerging trends, issues, Social Networking sites: Facebook, Twitter, LinkedIn, Orkut, online booking services</p> <p>5.5 Online Resources: Wikipedia, Blog, Job portals, C.V. writing</p> <p>5.6 e-learning: e-Books, e-Magazines, e-News papers, OCW (open course wares): Sakshat (NPTEL) portal, MIT courseware</p>	4 hrs
Unit 6	<p>Cloud Computing Basics</p> <p>6.1 Introduction to cloud computing</p> <p>6.2 Cloud computing models: SAS, AAS, PAS</p> <p>6.3 Examples of SAS, AAS, PAS (DropBox, Google Drive, Google Docs, Office 365 Prezi, etc.)</p>	3 hrs

Suggested readings:

1. TCI, "Introduction to Computers and Application Software", Publisher: Jones & Bartlett Learning, 2010, ISBN: 1449609821, 9781449609825

2. Laura Story, Dawna Walls, "Microsoft Office 2010 Fundamentals", Publisher: Cengage Learning, 2010, ISBN: 0538472464, 9780538472463
3. June Jamrich Parsons, Dan Oja, "Computer Concepts Illustrated series", Edition 5, Publisher Course Technology, 2005, ISBN 0619273550, 9780619273552
4. Cloud computing online resources

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC301A.1	Identify their lacunas about some computer skills and try to overcome the same.	2
AC301A.2	Practice the learned computer skills in real life and do their jobs more effectively.	3

AC-301(B): Cyber Security

(Technology + Value added Audit course; Practical; 2 Credits)

(Optional: Campus + Program level)

Course Objectives (COs):

- To make students aware of different daily useful cyber security skills/rules.

Unit 1	Networking Concepts Overview Basics of Communication Systems, Transmission Media, ISO/OSI and TCP/IP models, Network types: Local Area Networks, Wide Area Networks, Internetworking, Packet Formats, Wireless Networks: Wireless concepts, Advantages of Wireless, Wireless network architecture, Reasons to use wireless, Internet	3 hrs
Unit 2	Security Concepts Information Security Overview, Information Security Services, Types of Attacks, Goals for Security, E-commerce Security, Computer Forensics, Steganography. Importance of Physical Security, Biometric security & its types, Risk associated with improper physical access, Physical Security equipments. Passwords: Define passwords, Types of passwords, Passwords Storage – Windows & Linux.	7 hrs
Unit 3	Security Threats and vulnerabilities Overview of Security threats, Hacking Techniques, Password Cracking, Types of password attacks, Insecure Network connections, Wi-Fi attacks & countermeasures, Information Warfare and Surveillance. Cyber crime: e-mail related cyber crimes, Social network related cyber crimes, Desktop related cyber crimes, Social Engineering related cyber crimes, Network related cyber crimes, Cyber terrorism, Banking crimes	7 hrs
Unit 4	Cryptography Understanding cryptography, Goals of cryptography, Types of cryptography, Applications of Cryptography, Use of Hash function in cryptography, Digital signature in cryptography, Public Key infrastructure	5 hrs
Unit 5	System & Network Security System Security: Desktop Security, email security: PGP and SMIME, Web Security: web authentication, Security certificates, SSL and SET, Network Security: Overview of IDS, Intrusion Detection Systems and Intrusion Prevention Systems, Overview of Firewalls, Types of Firewalls, VPN Security, Security in Multimedia Networks, Fax	3 hrs

	Security.	
Unit 6	OS Security OS Security Vulnerabilities updates and patches, OS integrity checks, Anti-virus software, Design of secure OS and OS hardening, configuring the OS for security, Trusted OS.	2 hrs
Unit 7	Security Laws and Standards Security laws genesis, International Scenario, Security Audit, IT Act 2000 and its amendments.	3 hrs

Suggested readings:

1. Skills Factory, Certificate in Cyber Security, Text Book Special edition, Specially published for KBC NMU, Jalgaon
2. BPB Publication, "Fundamentals of Cyber Security", Mayank Bhushan, Rajkumar Singh Rathore , Aatif Jamshed
3. CreateSpace Independent Publishing Platform, "Cyber Security Basics", Don Franke, ISBN-13: 978-1522952190 ISBN-10: 1522952195
4. Online references

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC301B.1	Practice learned cyber security skills/rules in real life.	3
AC301B.2	Provide guidance about cyber security skills/rules to their friends, parents and relatives.	2

AC-301(C): Seminar + Review Writing

(Technology + Value added Audit course; Optional: Program-level; Practical; 2 Credits)

Course Objectives (COs):

- To motivate students to develop skills to search, retrieve, interpret, organize, and present relevant biological information.

Writing a Scientific Literature Review:

- Choosing a topic, Deciding the scope of topic, Significance and impact of scientific problem being addressed, Relevance to subject, current issues and social relevance, Strengths and limitations of the study, Enticing broad audience.
- Literature Survey and Information to consider in the review:
 - Literature search using authentic library resources (print and non-print, digital and virtual) for Almanacs, Encyclopaedia, Dissertations, Theses, Research papers, Review articles, Reference/ Textbooks, and Popular articles (INFLIBNET, Google Scholar, PubMed, Highwire, Google patents, Indian patent database, etc.)
 - Analyzing the literature quality (indexing, peer review, citations, journal impact factor, etc.)
- Deciding a writing approach (theoretical, experimental, interpretive, clinical, etc.), prepare the highlights and drawing important conclusion from literature
- Sections to include and tips for writing them: Abstract, Introduction, Body, Discussion, Conclusion, References
- Reference styles (MLA, APA, etc.), Use of bibliography/ reference/ citation managers and generators (Reference Manager, EndNote, RefWorks, Mendeley, Zotero, Qiqqa, etc.)
- Ethics of publication: Approval and consent, Data ethics (accuracy, falsification, fabrication, and confidentiality), Plagiarism and self-plagiarism, collaborative authorship, conflict of interest, legal

consequences

- Content similarity detection, Use of anti-plagiarism services (Urkund, iThenticate, Turnitin, Copyscape, Grammarly, etc.)

Seminar Activity:

- Students are encouraged to deliver seminars on the topics of research, preferably published research paper in a reputed and indexed journal to develop presentation skills and enable to build confidence which will lead them to read different themes and enhance their scientific approach and knowledge assimilation abilities.
- Presentations must be created and presented by students using digital platform using a suitable software in the presence of student audience and faculty for evaluation

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC301C.1	Retrieve, analyse, comprehend the scientific information on a given topic and derive logical inferences.	4
AC301C.2	Compile the scientific information on a topic, verify for similarity index or plagiarism.	2
AC301C.3	Deliver the interactive presentation of scientific data before audience and participate in open discussion with confidence.	2

AC-301(D): Biostatistics

(Technology + Value added Audit course; Optional: Program-level; Practical; 2 Credits)

Course Objectives (COs):

- To learn basic statistical concepts/methods and their applications in biological processes and experiments.

Unit 1	Descriptive Statistics and Presentation of Data <ul style="list-style-type: none"> • Types of Data: qualitative and quantitative data; nominal and ordinal data; discrete and continuous data; frequency and non-frequency data, Different types of scale - nominal, ordinal, ratio and interval. • Analysis of univariate Quantitative Data: Concepts of central tendency or location, dispersion, skewness and kurtosis, measures of dispersion: range, quartile deviation, variance, standard deviation. • Analysis of bivariate Data: measures of association, correlation. • Presentation of Data: construction of tables with one or more factors of classification, diagrammatic and graphical representation of non-frequency data, frequency distributions, histogram. • Graphical presentation of data through bar graph, line graph, pie chart, histogram, dot plot, box-plot, multiple line/bar graphs etc. 	8 hrs
Unit 2	Correlation and regression <ul style="list-style-type: none"> • Bivariate data: scatter diagram, coefficient of determination, rank correlation: Spearman's rank correlation coefficient. • Meaning and concept of regression, fitting of simple linear regression and quadratic regression in single predictor variable. • Multivariate data: multiple regression, coefficient of determination, R-square and its interpretation, testing significance of predictor variables. 	8 hrs

Unit 3	Testing of hypothesis and basic statistical designs <ul style="list-style-type: none"> • Introduction of methods of sampling. • Statistical hypothesis, problem of testing of hypothesis, simple and composite hypothesis, types of errors, p-value, conclusions in hypothesis testing. • Statistical tests: one sample t-test, paired t-test, test for proportions, chi-square test for testing independence/association of attributes. • Design of experiments: introduction to basic terms of design of experiments, standard designs: Completely Randomized Design (CRD), Randomized Block Design(RBD), concept of ANOVA, F-test in ANOVA, interpretation of results from ANOVA. 	8 hrs
Unit 4	PRACTICALS (Emphasis on examples from Biological Sciences) <ul style="list-style-type: none"> • Based on graphical Representation • Based on measures of Central Tendency & Dispersion • Based on Distributions Binomial Poisson Normal • Based on t, f, z and Chi-square • Based on basic statistical designs 	6 hrs

Suggested readings:

1. Le CT (2003) Introductory Biostatistics. 1st edition, John Wiley
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. Edmondson A and Druce D (1996) Advanced Biology Statistics, Oxford University Press.
4. Danial W (2004) Biostatistics: A foundation for Analysis in Health Sciences, John Wiley and Sons Inc.
5. Design and Analysis of Experiments by Montgomery D.C. (2001), John Wiley.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC301D.1	Describe and identify data generated from biological processes and experiments.	1
AC301D.2	Use summary statistics: measures of central tendency, measures of dispersion with their interpretations for explain the data more effectively through graphical tools.	3
AC301D.3	Apply knowledge of correlation, regression analysis and testing of hypothesis to real life data and understand their interpretation.	3

M.Sc. Part II Semester IV (Microbiology): Core Courses

MB – 401: Fermentation Technology	
	<p>Course Objectives:</p> <ol style="list-style-type: none"> 1. To introduce microbial fermentation, product recovery and bioreactor design 2. To familiarize the student with separation techniques used for fermentation products 3. To introduce the microbial process adopted for production of various metabolites
Unit I	<p>Upstream processing 10</p> <ul style="list-style-type: none"> • Microbial growth kinetics and measurement of cell growth • Metabolic pathways and control mechanisms • Fermentation- kinetics of batch and continuous culture • Designing of medium and strain improvement • Stoichiometry of microbial growth and product formation
Unit II	<p>Bioreactors (Design and Application) bioreactor operation 10</p> <ul style="list-style-type: none"> • Design and construction materials of bioreactor • Parameters involved in fermentation process monitoring • Aeration and agitation for mass transfer • Strategy for medium sterilization, maintenance of aseptic/axenic condition • Control of process parameters and overview of process automation • Scale up and production economics
Unit III	<p>Downstream processing and IPR 10</p> <ul style="list-style-type: none"> • Biomass harvesting: centrifugation, filtration • Cell disruption: ultrasonication, thawing, enzymatic. • Product extraction: Liquid –liquid, supercritical fluid extraction, ultrafiltration, Three phase partitioning • Product purification and characterization: Chromatography: adsorption, size exclusion, affinity, ion exchange, reverse phase, HPLC, • Quality practices: concept of SOP, GLP and Biosafety aspects of handling infectious organisms • Intellectual Property Right (IPR): Patents, copyrights, trademarks, geographical indications Patenting biological materials, transgenic materials Patent regulatory bodies at National and International level
Unit IV	<p>Microbial Products I 10</p> <ul style="list-style-type: none"> • Enzymes: Protease, asparaginase • Organic acids: citric acid, lactic acid • Amino acids: Lysine, aspartic acid • Polysaccharides: Alginate, Hyaluronic acid
Unit V	<p>Microbial Products II 10</p> <ul style="list-style-type: none"> • Antibiotics: Penicillin, streptomycin • Ethanol: 1st, 2nd and 3rd generation • Vaccines production: DPT, MMR • Nucleotides: IMP, GMP • Recombinant proteins: Insulin, Monoclonal antibodies • Fermented milk: Kefir and Yoghurt
<p>Suggested Readings:</p> <ul style="list-style-type: none"> • Mukhopadhyay, S.N. (2004) Process Biotechnology Fundamentals, 2nd edn., Viva Books, Mumbai, (ISBN: 81-7649-496-8) 	

- Shuler M. L. and Kargi F (2008) Bioprocess Engineering-Basic Concepts, 2nd Edn. Prentice-Hall, USA
- The Indian Environmental Protection Act (EPA), 1986
- Food Safety and Standards act (Government of India), 2006
- El-Mansi, EMT, Bryce, CFA, Demain, AL and Allman, AR (2007) Fermentation Microbiology and Biotechnology, 2nd edn., CRC Taylor & Francis Group, Boca Raton, Florida (ISBN: 0-8493-5334-3)
- Lodish, MR (2001) Bioseparation Engineering, Wiley Interscience, NY (ISBN: 0-471-24476-7)
- SreeKrishna, V. (2007) Bioethics and Biosafety in Biotechnology, New Age International (P) Ltd., Publ., Mumbai (ISBN: 81-224-2085-0)
- Moo-Young, MC (2011) Comprehensive Biotechnology, Vol. I, II and III, Elsevier, ISBN:978-0-08-088504-9
- Goodfrey, T. and Reichelt, JR (1997) Industrial Enzymology, 2nd edn., McMillan Publ. Co., London
- Rhem, HJ, Reed, G, Puhler, A. and Stadler, P. (1997) Biotechnology, 2nd edn., VCH Pub. Germany
- Singh, KC (2004) Intellectual Property Rights on Biotechnology, BCIL, New Delhi
- Stanbury, Peter F.; Whitaker, Allan; Hall, Stephen J. (1994) Principles of Fermentation Technology. II Edn, Butterworth-Heinemann Publishers
- Okafor Nduka (2007) Modern Industrial Microbiology and Biotechnology, Science Publishers, USA

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C401.1	Learn industrially relevant microbial products and their production process	2
C401.2	Get knowledge about bioreactor configuration, recovery of fermentation products	3
C401.3	Understand IPR and regulatory procedures required for final product.	4

MB - 402: Microbial Genetics		
	Course Objectives: 1. To extend the knowledge on molecular basis of mutation and repairs in microbes 2. To understand different modes of gene regulation and expression mechanisms in bacteria 3. To understand the principle role of plasmids, gene transfer methods and DNA replication	
Unit 1	Genome organization <ul style="list-style-type: none"> • General features of genome: viruses, prokaryotes, archea and eukaryotes, • Genome: Phage (T4), <i>E. coli</i>, <i>Saccharomyces</i> and <i>Neurospora</i> • Genome vocabulary: Operon, interrupted genes, gene families, structure of chromatin and chromosomes, unique and repetitive DNA, heterochromatin, euchromatin, allele, transposons. 	05 L
Unit 2	Virus genome replication <ul style="list-style-type: none"> • General aspects of viral genome replication: in Prokaryotic and eukaryotic cells, Polymerases • Replication: DNA replication (Initiation, elongation and termination), Double-stranded RNA replication, Single-stranded RNA replication • Reverse transcription 	10 L
Unit 3	DNA Damage and Repair <ul style="list-style-type: none"> • Mutation: Spontaneous and induced (Physical and Chemical mutagens), Molecular mechanisms of mutations: Point mutations, base substitution-transition and transversion (frameshift mutations, deletion, and addition), mutation rates, mutation probability, inversion. 	15L

	<ul style="list-style-type: none"> • Effects of mutation on the gene product: loss of the function of mutants (null, leaky mutations), gain of function of mutants, random or adaptive mutations, • Significance of mutants: Uses of bacterial and fungal mutants in Strain improvement, Bacteriophage mutants in viral genetics. • DNA protection and repair: Role of restriction-modification system in DNA protection and repair 	
Unit 4	Plasmids <ul style="list-style-type: none"> • Characteristics of bacterial plasmid: size, conformation, replication origin of replication, replication proteins, regulation of plasmid copy number, amplification and compatibility. Curing of plasmids, • Plasmid segregation: Random diffusion, par regions, post-segregational killing • Types of plasmid in: bacteria and Saccharomyces • Plasmid isolation: isolation and purification techniques for bacterial plasmids 	10 L
Unit 5	Gene regulations <ul style="list-style-type: none"> • Gene regulation in bacteria and Viruses: Lac operon, Quorum sensing, Riboswitch, gene regulation by repressor in Lysogenic cycle of bacteriophage • Gene regulation in eukaryotes: DNA Rearrangements, Chromatin Modification, Cis-acting site, RNA Silencing 	10 L

Suggested readings:

1. Streips, U.N. and Yasbin, R.E. (2002) Modern Microbial Genetics, 2nd Edn., Wiley-Liss, New York
2. Maloy, S. and Freifelder, D. (1994) Microbial Genetics, Jones & Barlett Publishers, London
3. Dale, J. W. (1994) Molecular Genetics, John Wiley & Sons, Hoboken, NJ, USA
4. Upadhyay, A., and Upadhyay, K. (2005) Molbio: Fundamentals of Molecular Biology, Himalya Publication House, Mumbai
5. Trun, N.J. and Trempy, J.E. (2006) Fundamental Bacterial Genetics, Blackwell Publishers, New York
6. Larry, Snyder and Wendy, Champness (2007) Molecular Genetics of Bacteria, 3rd Edn, ASM Press, Washington, USA.
7. Malacinski, G.M. (2005) Freifelder's Essentials of Molecular Biology, 4th Edn., Narosa Publishing House, New Delhi

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C402.1	Receive elaborate knowledge on mutation analysis, genome and its replication	2
C402.2	Understand about gene regulation and repair mechanisms in DNA damage	2
C402.3	Get in-depth knowledge on gene transfer mechanisms in microbes and able to explain how plasmid copy number is regulated.	4

MB - 404: Methods in Biotechnology

	Course Objectives: <ol style="list-style-type: none"> 1. To train the student in basic molecular biology tools 2. To learn gene transfer and gene expression 3. To introduce microbial interaction with plant
1	Isolation and estimation of RNA / mRNA from bacteria/ yeast/ fungi
2	Determination of T _m and % (G+C) of DNA
3	DNA fingerprinting through southern blotting
4	Gene transfer using electroporation
5	Demonstration of GFP marker cloning and expression

6	Fermentative production / biotransformation of antibiotic/ steroid
7	Estimation of penicillin/ streptomycin by microbiological and chemical assay
8	Analysis of biogas digested slurry for organic C, COD, lignin, Fatty acids and N
9	Nodulation of legume by Rhizobium using Leonard Jar/ Pot assay
10	Production and detection of siderophore produced by bacteria / fungi
11	Isolation of VAM spores from soil
12	Isolation of microbes from Rhizosphere / Phyllo-plane/ PGPR
13	Demonstration of Acetylene Reduction Assay for nitrogen fixation

Suggested Readings:

- Sawhney, SK and Singh, R. (2001) Introductory Practical Biochemistry, Narosa Publ. House, Chennai
- Aneja, KR (2005) Experiments in Microbiology, Plant Pathology and Biotechnology, International Publishers, New Delhi (ISBN: 81-224-1494-X)
- Tablot, N. (2005) Molecular and Cellular Biology of Filamentous Fungi, Practical Approach, Indian Edn., Oxford University Press, New Delhi (ISBN: 0-19-567943-1)
- Hewitt, W (1977) Microbiological Assay, Academic Press, New York
- McMei, B. and Harvey, L. (1986) Fermentations: Practical Approach, IRL Press, Oxford
- Kalaichelvan, PT (2006) Microbiology and Biotechnology: A Laboratory Manual, MJP Publ., Chennai (ISBN: 81-8094-008-X)
- IMTECH Laboratory Manual for Bacterial Genetics, Institute of Microbial Technology, Chandigarh
- Cappucino, J and Sherman, N.C. (2015) Microbiology-A Laboratory Manual, The Benjamin-Cummings Publ. Co., Inc.
- Sambrook and Russell Molecular Cloning Vol I, II and III, CSHL Press, USA
- Janarthanan, S. and Vincent, S. (2007) Practical Biotechnology, Universities Press (India) Pvt. Ltd., Hyderabad (ISBN: 13-978-81-7371-582-2)
- Schmauder, H.P, Schweizer, M and Schewizer, L.M (2003) Methods in Biotechnology, Taylor and Francis Ltd., London (ISBN: 0-7484-0430-9)
- Davis, L.G., Dibner, MD and Battey, JF (1986) Basic Methods in Molecular Biology, Appleton and Lange, Norwalk (ISBN: 0-8385-0582-1)

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C404.1	Perform gene transfer, GFP gene cloning and carry out southern blotting	6
C404.2	Understand plant microbe relations	4

M.Sc. Part II Semester IV (Microbiology): Skill Based Courses**MB – 405: Laboratory course (Project Dissertation)****Course Objectives:**

1. To give exposure to the students to research culture and technology
2. To introduce students how to select a research topic, plan, perform experiments, collect data and analyse the data
3. To foster self-confidence and self-reliance in the students as he/she learns to work and think independently

The project is allotted during the Forth semester. The students will get an opportunity to become a part of ongoing research activities in the respective supervisor's laboratory and can explore experience in different areas of microbiology viz. agriculture, food, medicine and pharmaceutical, etc. The students will acquire skill to write, compile and analyze data, and present the detailed technical/scientific report. At the end of successful project semester training, potentially the students become employable in the industries/organizations.

It is expected that the students will design experiments and collect experimental data to deduce conclusions. At the end, they will submit a detailed thesis for evaluation. The students should be introduced to research methodology in the beginning through few lectures.

The systematic approach towards the execution of project should be as follows:

1. Selection of topic relevant to priority areas of biotechnology.
2. Collection of literature on the topic of research from libraries, internet, on-line journals, Planning of research experiments
3. Performing the experiments with scientific and statistical acceptability.
4. Presentation of observations and results.
5. Interpretation of results and drawing important conclusions.
6. Discussion of obtained results with respect to literature reports.
7. Writing monthly progress report
8. Preparation of report (Dissertation) containing introduction, materials and methods, results and discussion, conclusions, bibliography and submission of at least 3 copies (1 copy retained in the department and after examination submitted to Library, 1 copy submitted to the guide and 1 copy kept with the candidate).
9. Presentation of research data during university examination and submission of project dissertation in a bound form.

1. Internal examination (40 marks): Components of continuous internal assessment: Submission of monthly progress report and signed by supervisor (at least 4 reports) (2 marks per report = 8 marks), Literature collected, experiment planning and design (10 marks), Experiments conducted (10 marks), outcome of the experiments and viva (8 marks) and regular attendance (4 marks) recorded: Research Supervisors
2. External examination (60 marks) and Components of external assessment: Subject matter (5 marks), Review of literature (10 marks), Writing of dissertation submitted in bound form at the time of examination (Title page, Certificate, Plagiarism report, Main content: Abstract, Introduction, Literature, Materials and methods, results and discussion and conclusion with relevant references) (15 marks), Presentation structure (PPT format) (8 marks), Overall presentation reflecting contribution of work (4 marks), Response to questions (15 marks).

Suggested readings: Refer the topic in research papers, review articles published in peer reviewed and SCI indexed journals, reference books, abstracts, etc. related to topic of project dissertation

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C405.1	Conceive a problem based on published research and carry out comprehensive survey of literature	4
C405.2	Plan and carry out task in given framework of dissertation and present the work in written and viva	6
C405.3	Use a holistic view to critically, independently and creatively identify, formulate and deal with complex issues.	6
C405.4	Learn handling of instruments, use of chemicals and how to conduct the experiments	3
C405.5	Learn how to present the project in power point and answer the queries to examiners as well as science of writing	6

M.Sc. Part II Semester IV (Microbiology): Elective Course

MB – 403: Agricultural Microbiology

	<p>Course Objectives:</p> <ol style="list-style-type: none"> 1. To introduce various attributes of microbial ecology and plant microbe interactions 2. To learn the student about how plant elicit defence against pathogens 3. To know biocontrol, biofertilizers for plant nutrition, remediation of salt-affected soils 	
Unit I	<p>Microbial ecology</p> <ul style="list-style-type: none"> • Basic microbial ecology and its components • Microbial interactions: Positive and Negative interactions with examples • Microbial communities: Concept, Elements and methods of analysis (CLPP, PLFA, DGGE, SSCP, ARDRA and FISH) • Methods to quantitative microbial ecology 	10 L
Unit II	<p>Microbial interactions with plant roots</p> <ul style="list-style-type: none"> • Rhizosphere and its anatomy • Mycorrhizae: VAM, OM, Endo- and Ecto-mycorrhiza • Plant Growth Promoting Rhizobacteria (PGPR) • Strategies for rhizosphere and mycorrhizae community study <p>Microbial interaction with aerial plant structure</p> <ul style="list-style-type: none"> • Phylloplane, Stems/ flowers, leaf buds • Strategies for microbial interaction studies with aerial plant structures <p>Leguminous root nodules</p> <ul style="list-style-type: none"> • Nodulation process and mechanism of nitrogen fixation • Strategies to study infection process, root nodulation and N₂ fixation 	10 L
Unit III	<p>Pathogenic interactions with plants</p> <ul style="list-style-type: none"> • Plant defence mechanisms (structural, biochemical, HR, SAR) • Microbial pathogenicity mechanisms in virus, bacteria, fungal pathogens • Genetic basis of plant-pathogen interactions • Methods of plant disease detection: Traditional and innovative • Region-specific plant diseases (Etiology, symptoms and control): Red rot of sugarcane, Sigatoka disease of banana, Banana bunchy top, Tikka disease of groundnut, Powdery mildew, Smut and Rust of Jawar 	10 L
Unit IV	<p>Microbial control for plant diseases</p> <ul style="list-style-type: none"> • Plant disease control: Strategies, principles, IDM • Biopesticides: BT, Siderophore and <i>Trichoderma</i>; <i>Pseudomonas</i>, <i>Beauveria bassiana</i> and NPV • Biocontrol of post-harvest diseases • Control of plant pathogens by genetic engineering 	10 L
Unit V	<p>Current microbial interventions in agriculture</p> <ul style="list-style-type: none"> • Integrated Plant Nutrition through biofertilizers • Phytoremediation: Rhizodegradation • Rhizosphere engineering • Microbiome • Microbial reclamation of saline and sodic soils • Genetically modified microbes and crops 	10 L

Suggested Readings:

- Stanier, RY, Ingraham, JL, Wheelis, ML and Painter, PR (1993) General Microbiology, 5th edn., The McMillan Press Ltd., London (ISBN: 0-333-41768-2)
- Atlas, RM ad Bartha, R (1998) Microbial Ecology-Fundamental and Applications, Addison Wesley Longman Inc.
- Lynch and Poole (1984) Microbial Ecology- A Conceptual Approach, Blackwell Scientific Publ.

- Streips, UN and Yasbin, RE (2002) Modern Microbial Genetics, 2nd edn., Wiley-Liss, USA (ISBN: 0-471-38665-0)
- Coyne, MS (2004) Soil Microbiology: An Explanatory Approach, Delmar/Thomson Asia Pvt. Ltd., Singapore (ISBN: 981-240-203-9)
- Kumar, HD and Kumar, S (2004) Modern Concepts of Microbiology, 2nd edn., Vikas Publishing House Pvt. Ltd., New Delhi (ISBN: 81-259-1000-X)
- Hurst, CJ, Crawford, RL, Knudsen, GR, McInerey, MJ and Stetzenbach, LD (2002) Manual of Environmental Microbiology, 2nd edn., ASM Press, Washington (ISBN: 1-55581-199-X)
- Ciancio, A and Mukerji, KG (2007) General Concepts in Integrated Pest and Disease Management, Springer, The Netherlands (ISBN: 978-1-4020-6060-1)
- Buchanan, BB, Gruissem, W and Jones, RL (2000) Biochemistry and Molecular Biology of Plants, IK International Pvt. Ltd., New Delhi (ISBN:81-88237-11-6)
- Boland, GJ and Kuykendall, LD (1998) Plant-Microbe Interactions and Biological Control, Marcel Dekker Inc., NY, USA (ISBN: 0-8247-0043-0)
- Chincholkar, SB and Mukerji, KG (2007) Biological Control of Plant Diseases, Haworth Press Inc., London (ISBN: 1-56022-328-6)
- Ben Lugtenberg (2015) Principles of Plant-Microbe Interactions: Microbes for Sustainable Agriculture. Leiden: Springer. ISBN: 978-3-319-08574-6

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C403.1	Understand ecology and how plant microbe interaction occurs	2
C403.2	Describe pathogenic interactions with plant and how biocontrol arrest pathogens	2
C403.3	Gain insight into genetics of host pathogen relation, plant resistance to pathogens.	4

M.Sc. Part II Semester IV (Microbiology): Audit Courses

AC-401(A): Human Rights (Professional and Social + Value Added Audit course; Practical; 2 Credits) (Optional: Campus-level)		
	Course Objectives (COs):	
	<ul style="list-style-type: none"> • To make students aware about human rights and human values. 	
Unit 1	Introduction to Human Rights 1.1 Concept of Human Rights 1.2 Nature and Scope of Human Rights 1.3 Fundamental Rights and Fundamental Duties 1.4 Interrelation of Rights and Duties	6 hrs.
Unit 2	Human Rights in India 2.1 Meaning and Significance of : 1) Right to Equality 2) Right to Freedom, 3) Right against Exploitation, 4) Right to Freedom of Religion, 5) Cultural and Educational Rights, and 6) Right to Constitutional Remedies. 2.2 Constitutional Provisions for Human Rights 2.3 Declaration of Human Rights	8 hrs.

	2.4: National Human Rights Commission	
Unit 3	Human Values 3.1: Meaning and Definitions of Values 3.2: Importance of values in the life of Individual 3.3: Types of Values 3.4: Programmes for conservation of Values	8 hrs.
Unit 4	Status of Social and Economically Disadvantaged people and their rights 4.1: Rights of women and children in the context of Social status 4.2: The Minorities and Human Rights 4.3: Status of SC/ST and other Indigenous People in the Indian Scenario 4.4: Human rights of economically disadvantaged Society	8 hrs.
Suggested readings:		
<ol style="list-style-type: none"> 1. Human rights education – YCMOU, Nasik 2. Value education – SCERT, Pune 3. Human rights reference handbook – Lucille whare 		

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC401A.1	Practice the learned issues under human rights and human values in real life.	3
AC401A.2	Provide social justices to people around them and provide guidance about human rights to their friends, parents and relatives.	5

AC-401(B): Current Affairs (Professional and Social + Value Added Audit course; Practical; 2 Credits) (Optional: Campus-level)			
		Course Objectives (COs): • To make students updated about current affairs of India and world.	
	Title	Content	Hours
Unit 1	Politics & Economy	<ul style="list-style-type: none"> National & International Political Activity, Organization. Economy & Business, Corporate world 	08
Unit 2	Awards and recognitions	<ul style="list-style-type: none"> National & International Awards and recognitions Books and authors 	07
Unit 3	Science & Technology	<ul style="list-style-type: none"> Software, Automobile, Space Research New inventions and discoveries 	07
Unit 4	Environment & Sports	<ul style="list-style-type: none"> Summit & conference, Ecology & Climate, Organization. National & International Games, Olympics, commonwealth etc. 	08
Suggested readings (Use recent years' data and current literature):			
<ol style="list-style-type: none"> India 2019, by Publications Division Government of India Manorama Year Book by Philip Mathew, India 2019, Rajiv Maharshi Quick General Knowledge 2018 with Current Affairs Update, Disha Experts General Knowledge 2018: Latest Who's Who & Current Affairs by RPH Editorial Board. 			

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC401B.1	Identify important issues currently/ recently happening in India or world.	5
AC401B.2	Summarize current affairs regularly.	6

AC-401(C): Seminar + Review Writing

(Technology + Value added Audit course; Optional: Program-level; Practical; 2 Credits)

Course Objectives (COs):

- To motivate students to develop skills to search, retrieve, interpret, organize, and present relevant biological information.

Writing a Scientific Literature Review:

- Choosing a topic, Deciding the scope of topic, Significance and impact of scientific problem being addressed, Relevance to subject, current issues and social relevance, Strengths and limitations of the study, Enticing broad audience.
- Literature Survey and Information to consider in the review:
 - Literature search using authentic library resources (print and non-print, digital and virtual) for Almanacs, Encyclopaedia, Dissertations, Theses, Research papers, Review articles, Reference/ Textbooks, and Popular articles (INFLIBNET, Google Scholar, PubMed, Highwire, Google patents, Indian patent database, etc.)
 - Analyzing the literature quality (indexing, peer review, citations, journal impact factor, etc.)
- Deciding a writing approach (theoretical, experimental, interpretive, clinical, etc.), prepare the highlights and drawing important conclusion from literature

- Sections to include and tips for writing them: Abstract, Introduction, Body, Discussion, Conclusion, References
- Reference styles (MLA, APA, etc.), Use of bibliography/ reference/ citation managers and generators (Reference Manager, EndNote, RefWorks, Mendeley, Zotero, Qiqqa, etc.)
- Ethics of publication: Approval and consent, Data ethics (accuracy, falsification, fabrication, and confidentiality), Plagiarism and self-plagiarism, collaborative authorship, conflict of interest, legal consequences
- Content similarity detection, Use of anti-plagiarism services (Urkund, iThenticate, Turnitin, Copyscape, Grammarly, etc.)

Seminar Activity:

- Students are encouraged to deliver seminars on the topics of research, preferably published research paper in a reputed and indexed journal to develop presentation skills and enable to build confidence which will lead them to read different themes and enhance their scientific approach and knowledge assimilation abilities.
- Presentations must be created and presented by students using digital platform using a suitable software in the presence of student audience and faculty for evaluation

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC401C.1	Retrieve, analyse, comprehend the scientific information on a given topic and derive logical inferences.	4
AC401C.2	Compile the scientific information on a topic, verify for similarity index or plagiarism.	2
AC401C.3	Deliver the interactive presentation of scientific data before audience and participate in open discussion with confidence.	2

AC-401(D): Intellectual Property Rights (IPR) (Professional and Social + Value Added Audit course; Practical; 2 Credits) (Optional: Program-level)		
	<i>Course Objectives (COs):</i> <ul style="list-style-type: none"> • To provide basic knowledge on intellectual property rights and their implications. • To understand ethical issues relevant to biology from the perspective of national and international law. 	
Unit 1	History and Introduction to Intellectual Property Rights: Evolution of patent Laws, History of Indian Patent System, Concept of IPR, Designs, Trademarks TM, Trade Secret (TS), Domain Names, Geographical Indications, Copyright	6 hrs.
Unit 2	Classification of patents and ownership: Classification of patents in India, Classification of patents by WIPO, Categories of Patent, Special Patents Ownership of patent, Rights of patent holder and co-owners, Duties of patent holder and co-owners, Transfer of patent Rights, Limitations of patent Rights, Restoration of Patents, Infringement of patent Rights and Offences, Actions against Infringement and Remedies and Relief	6 hrs.
Unit 3	Protection of biological materials and Biodiversity Methods of protection of plant and plant products, Essentialities of plant protection,	6 hrs.

	Plant variety protection and Farmers' Right Act, UPOV convention (plant Varieties) 1961, National Biodiversity Act- 2002, Protection of environment and biodiversity	
Unit 4	Biosafety and good laboratory practices Overview of biosafety, Risk assessment, Cartagena protocol on Biosafety, Biosafety Levels, GMOs and LMOs, Gene flow and environmental impact, opportunities and challenges Roles of Institutional Biosafety Committee, RCGM, GEAC in food and agriculture Risk analysis, assessment and management, International regulatory bodies Importance of good laboratory practices, General good laboratory practices	6 hrs.
Unit 5	Bioethics Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies etc Bioethics in research – cloning and stem cell research in human, animal rights/welfare in experimentation Agricultural biotechnology - Genetically engineered food, environmental risk, labeling and public opinion. Sharing benefits and protecting future generations, biopiracy	6 hrs.

Suggested readings:

1. Complete Reference to Intellectual Property Rights Laws. (2007). Snow White Publication Oct.
2. Deepa Goel, Shomini Parashar (2013) IPR, Biosafety and Bioethics Always learning, Pearson Education India, ISBN 9332514240, 9789332514249
3. Department of Biotechnology <http://dbtindia.gov.in/guidelines-biosafety>
4. Ganguli, P. (2001). Intellectual property rights: Unleashing the knowledge economy. New Delhi: Tata McGraw-Hill Pub.
5. International Union for the Protection of New Varieties of Plants. <http://www.upov.int>
6. Kuhse, H. (2010). Bioethics: An anthology. Malden, MA: Blackwell.
7. National Biodiversity Authority. <http://www.nbaindia.org>
8. National Portal of India. <http://www.archive.india.gov.in>
9. Office of the Controller General of Patents, Design & Trademarks; Government of India. <http://www.ipindia.nic.in/>
10. Wolt, J. D., Keese, P., Raybould, A., Fitzpatrick, J. W., Burachik, M., Gray, A., Wu, F. (2009). Problem formulation in the environmental risk assessment for genetically modified plants. *Transgenic Research*, 19(3), 425-436. doi:10.1007/s11248-009-9321-9
11. World Intellectual Property Organisation. <http://www.wipo.int>
12. World Trade Organisation. <http://www.wto.org>

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC401D.1	Understand to classify, identify advantages of intellectual property and IPR	3
AC401D.2	Understand the need to protect biological diversity and follow bioethical practices in research work, awareness to protect intellectual property relevant to biology	2

Epilogue

Skills imparted:

This is the first-year syllabus of the two-year post-graduate course in Microbiology. Overall, the curriculum is designed in such way that the student will get basic and applied knowledge of the subject. One of the major objectives considered during designing is to create human resource which is technically sound with knowledge having practical utility. The included basic subjects in theory and practical would be helpful to find out unseen facts in various problems in day to day life. The subjects like genetic engineering, and bioinstrumentation are designed in such a way that students will get theoretical and practical knowledge of modern scientific advances in the field. To make skillful human resource with precision, the important allied courses are also included. This course after completion of 2 years would give not only the practical knowledge of industry and industrial processes but also make aware the students with the global environmental problems like pollutions, contamination, infections and food quality.

Practical courses are based on theory courses and are designed to improve research-oriented skills of students.

Job opportunity: The designed curriculum offers job opportunities in various sectors like,

- Pharmaceutical industry: Clinical, medicine, vaccine, QC division
- Biotech industry: Recombinant product, QC, QA
- Agrochemical & pesticide industry
- Chemical industry: synthesis, testing
- Environmental protection industry & Agencies
- Research leading up to Ph. D. degree
- Marketing of biological & pharmaceutical products
- Food and nutraceutical industry, Govt. agencies

Entrepreneurship: This is another avenue available for the candidates making them sound in technical knowledge of Microbiology upon completion of this two year post graduate course that could be useful in Entrepreneurship in Microbiology.

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Equivalence

Old Syllabus (AY 2018-2019)	New Syllabus (CBCS pattern AY 2021-22)
SEM-I	
MB-101: Microbial Taxonomy and Diversity (T)	MB-101: Microbial Taxonomy and Diversity (T)
MB 102: Microbial Biochemistry (T)	MB 102 - Microbial Physiology and Biochemistry (T)
MB-103: Bioanalytical Techniques (T)	MB-105: Bioinstrumentation (T)
MB 104: Methods in Microbiology (P)	MB 103: Methods in Microbiology (P)
MB 105: Methods in Biochemistry (P)	MB 104: Methods in Microbial Chemistry (P)
SEM-II	
MB-201: Microbial Genetics (T)	MB 201: Molecular Biology and Bioinformatics (T)
MB-202: Microbial Enzymology (T)	MB 202: Microbial Enzymology (T)
MB-203: Immunology (T)	MB 203: Immunology (T)
MB-204: Methods in Enzymology (P)	MB 205: Methods in Enzymology (P)
MB-205: Methods in Molecular Biology & Immunology (P)	MB 204: Methods in Molecular Biology & Immunology (P)

M.Sc. Microbiology (Affiliated Colleges)

AY: Academic Year, (T) : Theory, (P): Practical

Equivalence for MSc-II (Microbiology) Syllabus 2022-23:

Old Syllabus (w. e. f. June 2019 -20) (Pattern 60:40)	New Syllabus (w. e. f. June 2022 -23) (Pattern 60:40)
Semester III	Semester III
MB-301: Applied and Environmental Microbiology	MB-303: Applied and Environmental Microbiology
MB-302: Molecular Biology and Bioinformatics	MB-402: Microbial Genetics
MB-303: Pharmaceutical Microbiology	MB-301: Pharmaceutical Microbiology
MB-304: Methods in Biostatistics and Bioinformatics	MB-304: Methods in Bioinformatics
MB-305: Methods in Applied Microbiology	MB-305: Methods in Applied Microbiology
Semester IV	Semester IV
MB-401: Fermentation Technology	MB-401: Fermentation Technology
MB-402: Applied Molecular Biology	MB-302: Applied Molecular Biology
MB-403: Agricultural Microbiology	MB-403: Agricultural Microbiology
MB-404: Methods in Biotechnology	MB-404: Methods in Biotechnology
MB-405: Laboratory course (Project Dissertation)	MB-405: Laboratory course (Project Dissertation)

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