HSNC University Mumbai

(2025-2026)
Ordinances and Regulations with Respect to

Choice Based Credit System (CBCS)

For the Programmes Under

The Faculty of Science and Technology

For the Course

Microbiology

Curriculum - Second Year Postgraduate Programmes

Semester-III and Semester -IV

Under NEP 2020

Part –I

Outline of Choice Based Credit System as outlined by University Grants Commission:

R. **** : The Definitions Of The Key Terms Used In The Choice Based Credit System And Grading System Introduced as per NEP 2020 implemented From The Academic Year 2024-2025 are as under:

1. Core Course: A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course.

2. Elective Course: Generally, a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/subject of study or which provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the candidate's proficiency/skill is called an Elective Course.

2.1 Discipline Specific Elective (DSE) Course: Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).

2.2 Dissertation/Project: An elective course designed to acquire special/advanced knowledge, such as supplement study/support study to a project work, and a candidate studies such a course on his own with an advisory support by a teacher/faculty member is called dissertation/project.
A Project/Dissertation work would be of 6 credits. A Project/Dissertation work may be given in lieu of a discipline specific elective paper.

2.3 Generic Elective (GE) Course: An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a Generic Elective.

P.S.: A core course offered in a discipline/subject may be treated as an elective by other discipline/subject and vice versa and such electives may also be referred to as Generic Elective.

3. Choice Base Credit System: CBCS allows students to choose inter- disciplinary, intra-disciplinary courses, skill oriented papers (even from other disciplines according to their learning needs, interests and aptitude) and more flexibility for students.

4. Honours Program: To enhance employability and entrepreneurship abilities among the learners, through aligning Inter Disciplinary / Intra Disciplinary courses with Degree Program. Honours Program will have 40 additional credits to be undertaken by the learner in fourth year.

5. Program: A Program is a set of course that are linked together in an academically meaningful way and generally ends with the award of a Degree Certificate depending on the level of knowledge attained and the total duration of study, B.Sc. Programs.

6. Course: A 'course' is essentially a constituent of a 'program' and may be conceived of as a composite of several learning topics taken from a certain knowledge domain, at a certain level.

All the learning topics included in a course must necessarily have academic coherence, i.e. There must be a common thread linking the various components of a course. A number of linked courses considered together are in practice, a 'program'.

7. Bridge Course: Bridge course is visualized as Pre semester preparation by the learner before commencement of regular lectures. For each semester the topics, whose knowledge is considered as essential for effective and seamless learning of topics of the Semester, will be specified. The Bridge Course can be conducted in online mode. The Online content can be created for the Bridge Course Topics.

8. Module and Unit: A course which is generally an independent entity having its own separate identity, is also often referred to as a 'Module' in today's parlance,

Especially when we refer to a 'modular curricular structure'. A module may be studied in conjunction with other learning modules or studied independently. A topic within a course is treated as a Unit. Each course should have exactly 3 Units.

9. Self-Learning: 20% of the topics will be marked for Self-Learning. Topics for Self-Learning are to be learned independently by the student, in a time- bound manner, using online and offline resources including online lectures, videos, library, discussion forums, fieldwork, internships etc.

Evaluative sessions (physical/online), equivalent to the credit allocation of the Self Learning topics, shall be conducted, preferably, every week for each course. Learners are to be evaluated real time during evaluative sessions. The purpose of evaluative sessions is to assess the level of the students' learning achieved in the topics earmarked for self-Learning.

The teacher's role in these evaluative sessions will be that of a Moderator and Mentor, who will guide and navigate the discussions in the sessions, and offer concluding remarks, with proper reasoning on the aspects which may have been missed by the students, in the course of the Self-Learning process.

The modes to evaluate self-learning can be a combination of the various methods such as written reports, handouts with gaps and MCQs, objective tests, case studies and Peer learning. Groups can be formed to present self- learning topics to peer groups, followed by Question-and-Answer sessions and open discussion. The marking scheme for Self-learning will be defined under Examination and Teaching.

The topics stipulated for self-learning can be increased or reduced as per the recommendations of the Board of Studies and Academic Council from time to time. All decisions regarding evaluation need to be taken and communicated to the stakeholders preferably before the commencement of a semester. Some

exceptions may be made in exigencies, like the current situation arising from the lockdown, but such ad hoc decisions are to be kept to the minimum possible.

10. Credit Point: Credit Point refers to the 'Workload' of a learner and is an index of the number of learning hours deemed for a certain segment of learning. These learning hours may discussing, attending lectures / counselling sessions, watching include a variety of learning activities like reading, reflecting, especially prepared videos, writing assignments, preparing for examinations, etc. Credits assigned for a single course always pay attention to how many hours it would take for a learner to complete a single course successfully. A single course should have, by and large a course may be assigned anywhere between 2 to 8 credit points wherein 1 credit in theory is construed as corresponding to approximately 15 learning hours.

11. Credit Completion and Credit Accumulation: Credit completion or Credit acquisition shall be considered to take place after the learner has successfully cleared all the evaluation criteria with respect to a single course. Thus, a learner who successfully completes a four CP (Credit Point) course may be considered to have collected or acquired 4 credits. Learner level of performance above the minimum prescribed level (viz. grades / marks obtained) has no bearing on the number of credits collected or acquired. A learner keeps on adding more and more credits as he completes successfully more and more courses. Thus, the learner 'accumulates' course wise credits.

12. Credit Bank: A Credit Bank in simple terms refers to stored and dynamically updated information regarding the number of Credits obtained by any given learner along with details regarding the course/s for which Credit has been given, the course-level, nature, etc. In addition, all the information regarding the number of Credits transferred to different programs or credit exemptions given may also be stored with the individual's history.

13. Credit Transfer: (performance transfer) When a learner successfully completes a program, he/she is allowed to transfer his/her past performance to another academic program having some common courses and Performance transfer is said to have taken place.

14. Course Exemption: Occasionally, when two academic programs offered by a single university or by more than one university, may have some common or equivalent course-content, the learner who has already completed one of these academic programs is allowed to skip these 'equivalent' courses while registering for the new program. The Learner is 'exempted' from relearning' the common or equivalent content area and from re-appearing for the concerned examinations. It is thus taken for granted that the learner has already collected in the past the credits corresponding to the exempted courses.

Part-II

The Scheme of Teaching and Examination
Semester End Examination shall evaluate the performance of the learners in two components for total 100 marks per Paper: Formative by way of continuous evaluation and Summative assessment.

Formative Assessment:- It is defined as the assessment of the learners on the basis of continuous evaluation as envisaged in the credit based system by way of participation of learners in various academic and correlated activities in the given semester of the programme.

Summative assessment: - It is defined as the assessment of the learners on the basis of Semester end assessment as envisaged in the credit based system by way of participation of learners in various academic and correlated activities in the given semester of the programme.

Distribution of Marks

Sr.	Particulars	Marks
1	End-Semester Examination	60 Marks
2	Self-Learning Evaluation	15 Marks
3	Practicals	25 Marks

A. Semester End Examination- 60 % of overall marks - 60 Marks

B. Practical Examination-25 percentage of overall marks - 25 Marks

1. Practical exam would be conducted over a period of 3 days; 25M for each practical paper (2 Majors and 1 Minor in each semester).
2. Each student to perform at least 1 major and 1 minor practical for Semester III and IV.
3. Viva would be conducted during the practical during the practical examination.

The marks will be given for all examinations and they will be converted into grade (quality) points. The semester-end, final grade sheets and transcripts will have only credits, grades, grade points, SGPA and CGPA.

Project and Assignment:

• Project or Assignment, which can in the following forms
  − Case Studies
− Videos
− Blogs
− Research paper (Presented in Seminar/Conference)
− Field Visit Report
− Presentations related to the subject (Moot Court, Youth Parliament, etc.)
− Internships (Exposition of theory into practice)
− Open Book Test
− Any other innovative methods adopted with the prior approval of Director Board of Examination and Evaluation.

4. Self-Learning Evaluation

− 20% of the topics of curriculum are learned by the student through self-learning using online / offline academic resource specified in the curriculum.

− hence 20% of the lectures shall be allocated for evaluation of Students on self learning topics

− The identified topics in the syllabus shall be learnt independently by the students in a time bound manner preferably from online resources.

Club the self-learning topics into 3-4 groups of topics only for evaluation.

• Prescribe time duration (in days) for completion of each group Of topic and earmark self learning evaluation lectures in the timetable. Hence, each group of topic can be Assigned 3 regular lectures for this evaluation for entire class

Methods for Evaluation of Self-learning topics:
− Seminars/presentation (PPT or poster), followed by Q&A − Objective questions /Quiz / Framing of MCQ questions.
− Debates
− Group discussion
− You-Tube videos (Marks shall be based on the quality and Viewership)
− Improvisation of videos
− Role Play followed by question-answers

Teachers can frame other methods of evaluation also provided that the method, duly approved by the college examination committee, is notified to the students at least 7 days before the commencement of the evaluation session and is forwarded for information and necessary action at least 3 days before the commencement of the evaluation session

− Viva Voce
− Any other innovative method

Preamble

This two- year M. Sc. program is designed by experts from Academia, Industry and research institution to develop skilled Microbiologists who can progress to diverse fields of microbiological interests that include industry, research, teaching, medical science and entrepreneurship.

The course is aimed at adding to the knowledge base of Microbiology graduates through significant inputs of the latest information on the subject. It also envisages that the students read original research publications and develop the ability of critical evaluation of the study. Development of communication skills - written and spoken - as well as laboratory work and teamwork, creativity, planning and execution are also a primary objective of this program.

In the core courses, the students study the basics of Microbiology along with the basics of subjects allied to and useful in Microbiology. The specializations include topics on various fields of Microbiology like Environmental, Food, cosmetic, Agricultural, Medical and Pharmaceuticals. It also encompasses advances in Bioinformatics, Virology and Biotechnology.

Students are required to undergo a training program and complete online courses as a part of their continuous internal evaluation. Students will also have to learn literature survey, writing a scientific report, and research proposal for their continuous evaluation. This will prepare them well for the Research Project in Semester IV.

The student should study Microbiological aspects in the Industry and submit their report. Students are also required to compulsorily undertake an educational tour organized by the Department each year (M. Sc. I and M. Sc. II) to various places of Microbiological interest and submit a Report.

MSc Part II Semester III - Units – Topics – Teaching Hours

Sr. no.	Subject Code		Subject Unit Title	Hours/ Lectures	Total No. of hours /lectures	Credits	Total Marks
1	MBO601B- Food, Cosmetic and Agricultural Microbiology	1	Food Microbiology	15	45 L	3	75 (60+15)
		2	Cosmetic Microbiology	15			
		3	Agricultural Microbiology	15			
2	MBO602B- Environmental Microbiology	1	Microbial Diversity	15	45 L	3	75 (60+15)
		2	Extremophiles	15			
		3	Biofilms	15			
3	MBO603B- Medical and Pharmaceutical Biotechnology	1	Diagnostics, Therapeutics and Nanotechnology	15	45 L	3	75 (60+15)
		2	Drug Discovery	15			
		3	Clinical Trials	15			
4	MBO604B- Bioinformatics, Entrepreneurship & Biostatistics	1	Bioinformatics	15	45 L	3	75 (60+15)
		2	Entrepreneurship and Intellectual Property Rights (IPR)	15			
		3	Biostatistics	15			
5	MBO601D- -		Practicals based on MBO601B-			1	25
6	MBO602D-		Practicals based on MBO602B-			1	25
7	MBO603D-		Practicals based on MBO603B-			1	25
8	MBO604D-		Practicals based on MBO604B-			1	25
9	Research project					4	100
			TOTAL			20	500

L: Lecture: Tutorials P: Practical Ct-Core Theory, Cp-Core Practical, SLE- Self learning evaluation CT- Commutative Test, SEE- Semester End Examination, PA-Project Assessment, AT- Attendance

1 credit + 15 hours theory/ 30 hours practicals

Course Objectives and Learning Outcomes:

Semester III

MBO601B- Food, Cosmetic and Agricultural Microbiology
Course Objectives

The course aims-

1. To interpret advanced techniques in food preservation.
2. To explain the role microorganisms in fermented food products, prebiotics and probiotics.
3. To establish the principles and practices of sampling and bioburden testing in the Cosmetics industry.
4. To examine the use of preservatives and its efficacy testing in cosmetics.
5. To explain different roles of microorganisms in enhancement of soil fertility and advance farming techniques.
6. To derive knowledge of various systemic resistance provided by plants and understand biological methods used to control the spoilage of crops.

Learning Outcomes-

After the completion of the course, the learner will be able to-

1. Evaluate health benefits of fermented foods.
2. Critique current regulatory frameworks and standards for prebiotic and probiotic products.
3. Develop a quality control program for a cosmetic production facility and Implement techniques for microbial load testing.
4. Describe the different methods used in organic farming.
5. Explain the process and significance of bioaugmentation and biostimulation.
6. Differentiate and create awareness between the use biopesticides and chemical pesticides and its effect on agriculture.

MBO602B- Environmental Microbiology Course

objectives-

The Course aims

1. To strengthen the understanding of factors affecting microbial diversity and different techniques for studying microbial diversity.
2. To explain the physiology, biochemistry and applications of extremophiles.

3. To explain the principle and methodology of nucleic acid based , physiological methods along with newer molecular approaches for measurement of microbial activity from an environmental sample including those of uncultivable organisms.
4. To comprehend the concepts of biocorrosion and bioleaching in soil.
5. To understand the structure, formation, development, composition and association of bacterial and fungal biofilms in the environment
6. To learn various biofilm eradication strategies.

Learning outcomes-

It will enable the learner

1. To plan experiments for studying microbial diversity and microbial activity of organisms from different environmental samples.
2. To summarize the types and applications of extremophiles and devise experiments to study microorganisms found in such environments.
3. To elaborate on how biofilms are formed, affects human health and thus be able to propose strategies for biofilm management and eradication.

MBO603B- Medical and pharmaceutical Biotechnology Course

Objectives

The course aims-

1. To explain stepwise process of drug discovery and to understand the use of softwares in drug designing.
2. To derive knowledge and understanding of pharmacodynamic and pharmacokinetic properties of drug.
3. To understand the different steps involved in clinical trials and to compare different study designs along with strategies used in clinical trials.
4. To comprehend the role of the ethics committee in clinical trials.
5. To derive knowledge of advanced diagnostic and therapeutic methods used in the medical field.
6. To describe the techniques of synthesis and applications of Nanotechnology.

Learning outcomes

After the completion of the course, the learner will be able to-

1. Understand and apply different methods used in drug designing
2. Comprehend and apply the study of the interaction of drug and metabolism
3. Choose appropriate study designs for a given clinical trial.
4. Understand the ethical guidelines in clinical trials.
5. Identify the need for newer approaches for therapeutics and diagnostics.
6. Analyze and plan practical approaches for the synthesis of nanoparticles

MBO604B- Bioinformatics, Entrepreneurship & Biostatistics Course

Objectives:

The course aims -

1. To explain the different approaches used for Sequence alignment and Phylogenetic analysis.
2. To differentiate between the various software and their applications in Bioinformatics.
3. To build Entrepreneurial skills that will allow identification and creation of Business Opportunities.
4. To derive knowledge and understanding of appropriate procedures for obtaining intellectual property protection.
5. To enable the students to classify and collate the quantitative and qualitative data.
6. To enable the learner to analyze the results of the experiments by different statistical tests.

Learning Outcomes:

After the completion of the course, the learner will be able to-

1. Comprehend the concepts and tools used in sequence alignment, phylogenetic analysis
2. Propose strategies for drug discovery using docking algorithms.
3. Build a business model as a case study.
4. Understand and apply IPR laws to various cases.
5. Understand the criteria that can be used to select an appropriate statistical test in a research problem and present statistically validated conclusions.
6. Compare results of different samples in a population by using Statistical tests.

Part-3 Detailed Scheme Theory

Curriculum Topics along with Self-Learning topics - to be covered, through self-learning mode along with the respective Unit. Evaluation of self-learning topics to be undertaken before the concluding lecture instructions of the respective UNIT

Course Code: MBO601B- (Food, Cosmetic and Agricultural Microbiology)

Unit	Topic	Credits	Lectures
1	**Food microbiology**	**01**	**15**
	1.1 Starter culture of bacteria, yeast & mold used in food fermentation [1L] 1.2 Fermented Foods [5L] 1.2.1 General methods of fermented food production and fermented foods of Indian Origin 1.2.2 Fermented cereals 1.2.3 Fermented vegetables 1.2.4 Production of microbial flavoring compounds 1.3 Prebiotic & Probiotic [3L] 1.3.1 Probiotics 1.3.2 Screening of Potential Probiotics 1.3.3 Industrial Aspects of Probiotic Production 1.3.4 Prebiotics 1.4 Food Preservation & Food safety [4L] 1.4.1 Advanced methods of food preservation 1.4.2 Advanced methods of detection of microorganisms in food 1.5 Controlling quality of food [2L] 1.5.1 Control at Source, Codes of Good Manufacturing Practice, The Hazard Analysis and Critical Control Point (HACCP) Concept Quality Systems: BS 5750 and ISO 9000 Series Risk Analysis		
2	**Cosmetic Microbiology**	**01**	**15**
	2.1 History of Cosmetic Microbiology, Preservation of cosmetics [3L] 2.2 Antimicrobial preservative efficacy & microbial content testing [9L] 2.2.1 Microbiology Laboratory methods in support of sterility Assurance System 2.2.3 Bioburden testing & Environmental monitoring 2.2.4 Sampling: Principles and Practice 2.3 Global regulations & toxicological aspects [3L]		
3	**Agricultural Microbiology**	**01**	**15**

	3.1 Introduction to Bioaugmentation and Biostimulation [1L] 3.2 Bio -intensive Nutrient Management, Use of Biofertilizers: Rhizobium, blue green algae, phosphate solubilizers, Mycorrhiza [2L] 3.3 Organic Farming and scope of organic farming in India [1L] 3.4 Biological control of Pests: Biological Control agent, mechanism of biocontrol, biopesticide, bioinsecticide, bioherbicide [2L] 3.5 Induced systemic resistance in Biocontrol of Plant diseases [3L] 3.5.1 Induction of systemic resistance by *Pseudomonas, Bacillus, Trichoderma,* Fungi and others 3.5.2 Mechanism of Induced systemic resistance 3.6 Microbial control strategies: Postharvest diseases of Fruits, Vegetables, Roots and Tubers [6L] 3.6.1 Mode of action of biocontrol agents 3.6.2 Extensive of use of biocontrol agents 3.6.3 Enhancing biocontrol efficacy of Microbial Antagonist 3.6.4 Biotechnological Approach		

Self-Learning topics (Unit wise)

Unit	Topics
1	Advanced methods of food preservation
2	Bioburden testing
3	Induced systemic resistance in Biocontrol of Plant diseases

Online Resources
Online module: Advanced methods of food preservation (Unit 1) https://nptel.ac.in/courses/126/105/126105011/ **Online module: methods of Bioburden testing (Unit 2)** https://ethidelabs.com/bioburden-testing-vs-sterility-testing/ **Online module: Induced systemic resistance in Biocontrol of Plant diseases** https://pubmed.ncbi.nlm.nih.gov/17974258/ **(Unit 3)**

Course Code: MBO602B- (Environmental Microbiology)

Unit	Topics	Credits	Lectures
1	**Microbial Diversity**	**01**	**15**
	1.1 Microbial Communities[1L] 1.2 Environmental Factors that Impact Microbial Diversity[1L] 1.3 Functional Diversity and the Resilience of Bacterial Communities [1L] 1.4 Nucleic acid-based methods of analysis [2L] 1.5 Gene Probes and Probing [2L] 1.5.1 Colony Hybridization or Lifts 1.5.2 FISH 1.5.3 Phylo Array 1.6 Reporter Genes [1L] 1.7 Carbon Respiration [4L] 1.7.1 Measurement of Respiratory Gases, CO_2 and O_2, in Laboratory and Field Studies. 1.7.2 The Application of Respiration Measurements in Environmental Microbiology. 1.7.3 Tracer Studies to Determine Heterotrophic Potential 1.7.4 Anaerobic Respiration as an Indicator of Microbial Activity 1.8 Incorporation of Radiolabeled Tracers into Cellular Macromolecules[3L] 1.8.1 Incorporation of Thymidine into DNA 1.8.2 Incorporation of Leucine into Protein 1.8.3 Adenylate Energy Charge 1.8.4 Enzyme Assays 1.8.5 Dehydrogenase Assay 1.8.6 Stable Isotope Probing		
2	**Extremophiles**	**01**	**15**
	2.1 Physiology, Biochemistry and Applications of [6L] 2.1.1 Thermophiles 2.1.2 Psychrophiles 2.1.3 Piezophiles 2.1.4 Radiation resistant organisms 2.2 Physiology, Biochemistry and Applications of [5L] 2.2.1 Acidophiles 2.2.2 Alkaliphiles 2.2.3 Halophiles 2.3 Geo Microbiology- Bio corrosion and Bioleaching [02L]		

	2.4 Identification of Unculturable Organisms [01L] 2.5 Overview of Bioinformatics Tools for studying Microbial Diversity [01L]		
3	**Biofilms**	**01**	**15**
	3.1 Structure and properties of biofilms. [1L] 3.2 Formation of biofilm in gram negative bacteria [3L] 3.2.1 Initial attachment events and its regulation 3.2.2 Maturation, detachment and return to the planktonic growth mode. 3.3 Cell-Cell signalling involved in biofilm formation, similarity with *M. xanthus* fruiting body development and *P. aeruginosa* biofilm formation. [1L] 3.4 Formation of biofilm in gram positive bacteria, Multispecies biofilm [1L] 3.5 Fungal Biofilms [1L] 3.6 Biofilms in plant-associated habitats (Phyllosphere and Rhizosphere) [2L] 3.7 Biofilm prevention and eradication: Methods and commonly used biocides [1L] 3.8 Biofilm management methods [3L] 3.8.1 Using probiotics and prebiotics 3.8.2 Correction of environmental conditions for enhanced bioremediation of biofilms (e.g., dental plaque). 3.8.3 Disadvantages of biofilm management strategies. 3.9 Risk of bacterial biofilm (Healthcare, food safety, drinking water distribution system, biofouling) and beneficial applications (bioremediation, wastewater treatment, bioleaching, microbial fuel cells and preventing corrosion) [2L]		

Self-Learning topics (Unit wise)

Unit	Topics
1	Data analysis, Culture based and culture independent tools
2	Bioinformatics Tools,
3	Formation of biofilm: Maturation of the Biofilm & Quorum sensing

Online Resources
Online module: Techniques in Environmental Microbiology (Unit7-1,2 lecture) https://nptel.ac.in/courses/105/107/105107173/ (**Unit-1)** **Online module**: Bioinformatic tools used in Applied Environmental Microbiology Unit12(1-5 lectures) https://nptel.ac.in/courses/105/107/105107173/ (**Unit-2)** **Online module :**Biofilms (Lec 10-11) https://nptel.ac.in/courses/102/106/102106057/ (**Unit 3**)

Course Code: MBO603B- (Medical and pharmaceutical Biotechnology)

Unit	Topic	Credits	Lectures
1	**Diagnostics, Therapeutics and Nanotechnology**	**01**	**15**
	1.1 Molecular Diagnostics [3L] 1.1.1 Genetic Testing of diseases and disorders- Sickle Cell Anemia, Cystic Fibrosis 1.1.2 Use of Molecular Beacons, 1.1.3 Prenatal diagnosis; Genetic Counselling		
	1.2 Protein Therapeutics [3L]		
	1.2.1 Monoclonal Antibodies- Anticancer antibodies, treatment of Viral Infections, Preventing Rejection of Transplanted Organs, Recombinant Antibodies		
	1.2.2 Enzymes as therapeutics - DNase I, Alginate Lyase, Phenylalanine Ammonia Lyase.		
	1.3 Nucleic Acids as Therapeutic Agents - Antisense Oligonucleotides, Ribozymes, Chimeric RNA–DNA Molecules, Aptamers, Interfering RNAs [2L]		
	1.4 Nanotechnology [7L] 1.4.1 Types of nanomaterials -Properties of nanomaterials 1.4.2 Biosynthesis of nanomaterials using bacteria, fungi and plants 1.4.3 Nanoparticular carrier systems, Micro and Nanofluidics 1.4.4 Applications of nanotechnology – Nanomedicine, nano bio - devices, nano implants, applications in agriculture, food and cosmetics		
2	**Drug Discovery**	**01**	**15**
	2.1 Drug discovery [2L] 2.1.1 Steps involved in drug discovery 2.1.2 Production and characterization 2.1.3 Preclinical studies and Validation studies 2.2 Computer-aided drug designing and docking [6L] 2.2.1 General Principles of CADD 2.2.2 Types of drug designing 2.2.3 Ligand-based molecular interactions		

	2.2.4 Structure-based Drug designing 2.2.5 Examples of Ligand and structure-based drug designing 2.2.6 Applications and importance of CADD 2.3 Principles of pharmacokinetics and pharmacodynamics [7L] 2.3.1 Physicochemical factors in transfer of drugs across the membrane. 2.3.2 Drug absorption, bioavailability and routes of administration 2.3.3 Distribution of drugs 2.3.4 Excretion of Drugs 2.3.5 Metabolism of drugs 2.3.6 Clinical pharmacokinetics		
3	**Clinical Trials**	**01**	**15**
	3.1 Introduction to Clinical Trials [4L] 3.1.1 Fundamentals of Clinical trials 3.1.2 Clinical Trial Phases (Phase I, Phase II, Phase III, Phase IV) 3.1.3 Definition of Study Population in clinical Trials 3.1.4 Clinical Trials in pediatrics, geriatrics, rare disease 3.2 Basic Study Designs [3L] 3.2.1 Randomized and Nonrandomized Control Studies 3.2.2 Historical control Studies 3.2.3 Cross over designs 3.2.4 Withdrawal Studies 3.2.5 Factorial Design 3.2.6 Group Allocation Design 3.2.7 Hybrid Design 3.2.8 Large, Pragmatic Clinical Trials 3.2.9 Studies of Equivalence and Noninferiority 3.3 The Randomization Process [3L] 3.3.1 Fixed Allocation, Simple, Blocked, Stratified Randomization 3.3.2 Baseline and Response Adaptive Randomization Procedures 3.3.3 Mechanics of Randomization 3.4 Blinding studies [3L] 3.4.1 Unblinded, Single blinded and Double blinded studies, +Triple blinded studies		

	3.4.2 Protecting the Double-Blind Design-(Matching of Drugs, Coding of Drugs, Official Unblinding, Inadvertent Unblinding) 3.5 Ethics in Clinical Trials [2L] 3.5.1 Composition of ethics committee, Control Group and Informed Consent 3.5.2 Safety, Efficacy Monitoring and Early Termination for Other than Scientific or Safety Reasons 3.5.3 Privacy and Confidentiality 3.5.4 Suppression and Delays 3.5.5 Regulatory Bodies, Framework and procedure 3.5.5 Regulatory requirements for clinical trials in India		

Self-Learning topics (Unit wise)

Unit	Topics
1	Applications of Nanotechnology
2	Drug development process
3	Phases of clinical trial, forms, and fees

Online Resources
Online module: Applications of nanotechnology **https://nptel.ac.in/courses/102/107/102107058/ (Unit 1)** **Online module: Drug development process (Unit 2)** https://nptel.ac.in/courses/127/106/127106137/ **Online module: Clinical trials** https://nptel.ac.in/courses/127/106/127106137/ **(Unit 3)**

Course Code: MBO604B- {Minor} (Bioinformatics, Entrepreneurship & Biostatistics)

Unit	Topic	Credits	Lectures
1	**Bioinformatics**	**01**	**15**
	1.1 Sequence alignment [9L] 1.1.1 Pairwise alignment- Dot plot, Dynamic programming, k-tuple methods 1.1.2 Measures of sequence similarity- Scoring schemes- Derivation of substitution matrices: PAM and BLOSUM matrices 1.1.3 Multiple alignment – Applications of multiple sequence alignments and database searching using Profiles, PSI-BLAST and Hidden Markov models 1.2 Phylogeny [3L] 1.2.1 Determination of taxonomic relationships from molecular properties 1.2.2 Phylogenetic trees- Clustering methods, Cladistic methods 1.3 Structural bioinformatics [3L] 1.3.1 Protein stability and folding 1.3.2 Superposition of structures, and structural alignments 1.3.3 Classifications of protein structures- CATH, SCOP 1.3.4 DeepMind- AlphaFold AI system for predicting 3D models of protein structures.		
2	**Entrepreneurship and IPR**	**01**	**15**
	2.1 Entrepreneurship- [10L] 2.1.1 Concept of Entrepreneur 2.1.2 Essentials of a Successful Entrepreneur 2.1.3 Role of Government and Financial Institutions in Entrepreneurship Development 2.1.4 Preparing a Business Plan 2.1.5 Launching the New Venture: Choosing the legal form of new venture, protection of intellectual property and marketing the new venture 2.1.6 Financing the New Venture and Managing Growth in New Venture 2.1.7 Marketing Plan for an Entrepreneur 2.2 Intellectual Property Rights [5L]		

	2.2.1 Types of intellectual property rights- Patents, Trademarks, Copyright and Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of New GMOs, International framework for the protection of IP Invention in context of "prior art" 2.2.2 Patents - Requirements for Patentability, Novelty, subject matter, invention, industrial applicability, databases, Indian Patent Act 1970, Recent Amendments 2.2.3 Implications of patents in biotechnology Chakraborty case, corn genetically engineered with an insecticide 2.2.4 Case studies- basmati rice, turmeric and neem		
3	**Biostatistics**	01	15
	3.1. Overview of Descriptive Statistics [1L] 3.2. Correlation & Regression analysis [3L] Types of Correlation, Degree of Correlation, Linear Regression Analysis, Regression Lines & Regression Equations. 3.3. Chi Square test [2L] 3.4. Comparison of means [6L] F-test (Testing homogeneity of variance), Parametric tests - For one or two samples - t test, z test. For three or more samples -ANOVA, Post Hoc tests. Non-Parametric tests - Wilcoxon, Mann-Whitney test, Kruskal-Wallis. 3.5. Use of statistical softwares (Excel, SPSS, Jamovi) [3L]		

Self-Learning topics (Unit wise)

Unit	Topics
1	Pairwise sequence alignment and scoring matrices
2	Marketing Plan for an Entrepreneur
3	Introduction to biostatistics - Testing of hypothesis - Type I and II error

Online Resources
Online module: Pairwise sequence alignment and scoring matrices https://nptel.ac.in/courses/102/106/102106065/ Week 3 (lectures 14-20) (**Unit1)** **Online module:** Marketing Plan for start-up Week-3 (lectures 11-15) https://nptel.ac.in/courses/127/105/127105007/ (**Unit2)** **Online module**: Biostatistics https://nptel.ac.in/courses/102/101/102101056/ https://www.youtube.com/watch?v=g9SJfZ-iqcI **(Unit 3)**

Detailed scheme Practicals

Course Code: MBO601D-

1	Isolation & Characterization of organisms with probiotic potential from food samples.
2	Effect of several prebiotic agents on growth of probiotic cultures
3	Efficacy testing of preservative as per ISO 11930
4	Quality control of microbial content of cosmetics as per IS 14648:2011 wrt to heterotrophic count, presence of *Pseudomonas sps, Staphyloccocci* sps & *P.acne*
5	Preparation and efficacy testing of biopesticide/ bioinsecticide/bioherbicide

Course Code: MBO602D-

1	Extraction of DNA from soil and checking its purity using agarose electrophoresis and UV 260/280 ratio
2	Isolation and characterization of thermophiles and thermotolerant organisms from hot spring water samples.
3	Screening of Halophilic bacteria from salt pans and identification of an isolate by conventional biochemical as well as by VITEK systems
4	Extraction of membrane lipids of halophilic archaea and its detection by TLC
5	Biofilm visualization by staining of a slide immersed in different environments such as soil, water, saliva (to emphasize compositional and structural variations in biofilms from different environments).
6	Determination of MIC of disinfectant/antimicrobials with sessile and planktonic bacteria (to show higher resistance of biofilms to antimicrobials as compared to planktonic cells) quantified using crystal violet assay

Course Code: MBO603D-

1	Isolation and Detection of organism producing enzyme - Alginate lyase and its effect on biofilms
2	Preparation, characterization and antibacterial activity of Silver Nanoparticles
3	Determination of serum antibiotic concentration by agar cup method.
4	Determination Of LC50 /LD50 using *Daphnia magna* larvae as a model system
5	Assignment: Case study on clinical trials

Course Code: PS-SMB – MBO604D- Minor paper

1	Use of NCBI BLAST Tool for homolog fishing, sequence alignment and phylogeny.
2	Classification of Proteins using CATH/SCOP.
3	Visualization PDB Molecules using SPDBV
4	Assignment/case studies on preparing business plan/marketing strategies
5	Case study on IPR
6	Solving problems using softwares- Excel and Jamovi a) Chi- square test b) Co-relation and Regression analysis c) F-test, T- test, Anova, post-hoc test

Semester IV

MBO605B –

Course Objectives:

The course aims -

1. To enhance the knowledge of different types of culture techniques, preservation methods and culture collections for plant and animal tissue culture.
2. To explain the principles and advantages of Stem Cell Technology, Cloning and Tissue engineering techniques.
3. To differentiate between the various methods of generation of transgenic animals.
4. To understand the methods and techniques for the cultivation of algae which can be applied during the practicals.
5. To understand the various algal, fungal and marine products and discuss their applications.

Learning Outcomes:

After the completion of the course, the learner will be able to-

1. Explain Applications of Genetically Engineered Plants.
2. Comprehend the techniques of Genetic engineering of Plants
3. Describe the concepts and techniques in animal tissue culture.
4. Explain the methods to create transgenic animals along with their applications.
5. Explain types and applications of algal, fungal, and marine metabolites
6. Discuss the techniques for cultivation and preservation of animal and algal cultures.

MBO606B –

Course Objectives:

The course aims

1. To enhance the knowledge of the applications of biotechnology in the fields of bioremediation and protein engineering.
2. To discuss Waste management, Environmental impact assessment and sustainable development.
3. To understand and apply biohazard and biosafety standards in laboratories and industries.
4. To understand Ethical issues and perspectives in the discipline of Microbiology, in research and industries.
5. To comprehend the different means of management of solid hazardous waste and to explain the process of sorting and extraction of key metals from e-waste.

Learning Outcomes:

After the completion of the course, the learner will be able to-

1. Explain the applications of biotechnology in environmental monitoring, management and protein engineering
2. Discuss the concept and significance of biohazards, Biosafety, and Bioethics.
3. Apply the principles of sustainable development and be able to reflect their role as global citizens, consumers and environment protectors.
4. Develop a problem-solving approach for handling solid , hazardous waste and e-waste.

MBO607B –

Course Objectives:

The course aims-

1. To discuss the different aspects considered in working and applications of the instruments.
2. To describe the advanced Microscopic, Chromatographic, X-ray crystallographic and Nucleic acid sequencing techniques.
3. To introduce Hyphenated techniques as an advancement to existing techniques.
4. To classify and compare the various classes of viruses based on characteristics, replication cycles and summarize the methods to control viruses.
5. To comprehend the genes, mutations and pathways leading to oncogenesis.
6. To comprehend the role of viruses in human cancers

Learning Outcomes:

After the completion of the course, the learner will be able to-

1. Explain the principles and applications of advanced Microscopic and chromatographic techniques.
2. Demonstrate the factors and precautions essential for preparation of a sample for analysis of biological specimens using advanced instruments.
3. Explain characteristics and steps of replication of classes of viruses.
4. Outline detection, enumeration methods and antiviral agents of viruses.
5. Explain and illustrate oncogenic pathways.
6. Discuss the role of viruses in oncogenesis.

Semester IV - Units – Topics – Teaching Hours

S. N	Subject Code	Subject Unit Title		Hours/ Lectures	Total No. of hours/lectures	Credit	Total Marks
1	MBO605B - Advances in Biotechnology	1	Plant Biotechnology	15	45 L	3	75 (60+15)
		2	Animal Biotechnology	15			
		3	Algal, Fungal and Marine Biotechnology	15			
2	MBO606B - Applied and Environmental Monitoring and Management	1	Applied Biotechnology	15	45 L	3	75 (60+15)
		2	Waste Management and Environmental Impact Assessment and Audit	15			
		3	Biohazards, Biosafety and Bioethics	15			
3	MBO607B - Virology, Oncology and Advanced Instrumentation	1	Virology	15	45 L	3	75 (60+15)
		2	Cellular and Viral Oncology	15			
		3	Advanced Instrumentation	15			
4	Research project					4	100
5	MBO605D-		Practicals based on MBO605B-			1	25
6	MBO606D-		Practicals based on MBO606B-			1	25
7	MBO607D-		Practicals based on PS-MBO607B-			1	25
8	Project report and presentation					4	100
			TOTAL			20	500

L: Lecture: Tutorials P: Practical Ct-Core Theory, Cp-Core Practical, SLE- Self learning evaluation CT-Commutative Test, SEE- Semester End Examination, PA-Project Assessment, AT- Attendance

Part 5: Detail Scheme Theory

MBO605B- (Advances in Biotechnology)

Unit	Topic	Credits	Lectures
1	**Plant Biotechnology**	**01**	**15**
	1.1 Applications of Genetically engineered plants [7L] 1.1.1. Resistance to biotic and abiotic stress: Insect resistance: Increasing expression of the *B.thuringiensis* protoxin, other strategies for protecting plants against insects, Virus resistance, Herbicide resistance, fungus and bacterium resistance, Oxidative stress, Salt and drought stress, Fruit ripening and Flower wilting 1.1.2 Improvement in plant quality and proteins. 1.1.3 Modification of plant nutritional content, Modification of plant taste and appearance 1.1.4 Plants as bioreactors, edible vaccines 1.2 Genetic engineering of Plants [8L] 1.2.1 Plant transformation with T DNA 1.2.2 Physical methods of transferring genes to plants 1.2.3 Plant genes cloning by using transposable elements, Use of reporter genes in transformed plant cells, Use of virus vectors for whole plants. 1.2.4 Manipulation of gene expression in plants: Gene targeting, Facilitating protein purification: Oleosins, Rhizosecretion, Glycosylation		
2	**Animal Biotechnology**	**01**	**15**
	2.1 Animal Tissue Culture: Primary culture, Organ culture, Embryo Culture, Established Cell lines [1L] 2.2 Scale up, Cryopreservation, Culture Collections [2L] 2.3 Risks and Safety, Bioethics [1L] 2.4 Stem Cell Technology, Cloning techniques and Applications [2L] 2.5 Transgenics and knockouts: Transgenic cattle, Transgenic birds, Transgenic fish [3L] 2.6 Methods and Applications of Transgenic mice: [4L] 2.6.1 Retroviral method		

	2.6.2 DNA microinjection method 2.6.3 Engineered Embryonic Stem cell method 2.7 Tissue Engineering, Methods of Synthesis, Biomolecular Engineering[2L]		
3	**Algal, Fungal and Marine Biotechnology**	**01**	**15**
	3.1 Algal Biotechnology [5L] 3.1.1 Types of Algae, Detection tools for Qualitative and Quantitative detection of algae 3.1.2 Collection, Storage, and Preservation, Culture Types, Culture Parameters (Temperature, Light, pH, Salinity, Mixing, Culture Vessels), Media Choice and Preparation 3.1.3 Isolation and growth measurement methods and techniques, Study of algal pigments 3.1.4 Algal Culture Methods- Batch Cultures, Continuous Cultures, Semicontinuous Cultures, Commercial-Scale Cultures (Outdoor Ponds, Photobioreactors, Culture of Sessile Microalgae 3.1.5 Applications of Algal Biotechnology 3.2 Fungal Biotechnology [5L] 3.2.1 Introduction to Fungal Technology- Mycology as a neglected megascience 3.2.2 Fungal Pigments and Mycotoxins 3.2.3 Fungal siderophores – structure, function and applications 3.2.4 Fungal Lipid production 3.3 Marine biotechnology [5L] 3.3.1 Diversity of microbes in the marine environment 3.3.2 Marine Biofouling and Biodeterioration, Marine Pollution- sewage, oil and chemical pollution 3.3.3 Applications of marine microbes in: Enzymes, polymers, Microalgal culture, pharmaceutical and biomedical products, food industry, biomimetics, nanotechnology and bioelectronics.		

Self-Learning topics (Unit wise)

Unit	Topics
1	Plant Transformation by T DNA
2	Tissue Engineering
3	Applications of Algal Biotechnology

Online Resources
Online module: Plant Transformation by T DNA https://www.youtube.com/watch?v=xbHK44TglR0 **(Unit 1)** **Online module:** Tissue Engineering https://nptel.ac.in/courses/102/106/102106081/ https://www.youtube.com/watch?v=bgRjFW5agvA **(Unit 2)** **Online module:** Applications of Algal Biotechnology https://onlinecourses.nptel.ac.in/noc19_bt20/preview **(Unit 3)**

MBO606B- (Applied and Environmental Monitoring and Management)

Unit	Topic	Credits	Lectures
1	**Applied Biotechnology**	**01**	**15**
	1.1 Bioremediation [5L] 1.1.1 Introduction to Bioremediation strategies for synthetic compounds, petrochemicals, inorganic waste. 1.1.2 Bioremediation of metals & gaseous ex situ. Environment modification for bioremediation 1.1.3 Approaches to bioremediation: Microbial seeding & bioengineering using rDNA technology 1.2 Biosensors [1L] 1.3 Bioleaching and Enhanced oil recovery [1L] 1.4 Biofuels [1L] 1.5 Biopolymers and Biosurfactants [1L] 1.6 Sustainable development [1L] 1.7 Protein engineering [5L] 1.7.1 Adding disulphide bonds 1.7.2 Changing asparagine to other amino acids 1.7.3 Reducing the number of free sulfhydryl residues 1.7.4 Increasing enzymatic activity, modifying metal cofactor requirement 1.7.5 Decreasing protease sensitivity 1.7.6 Modifying protein specificity 1.7.7 Increasing enzyme stability and specificity		
2	**Waste Management and Environmental Impact Assessment and Audit**	**01**	**15**
	2.1 Solid waste Management [03L] 2.1.1 Typical Issues in Solid Waste Management 2.1.2 Methods of Waste Disposal 2.1.3 Green Productivity of Solid Waste 2.2 Hazardous Waste Management [03L] 2.2.1 Commonly Used Terms in Hazardous Waste Management 2.2.2. Effect on Health 2.2.3. Treatment, Storage, And Disposal Facilities 2.2.4. Design of Landfill 2.2.5 Safety and Occupational Hygiene		

	2.3 Biomedical and electronic waste management, recovery of precious metals from electronic waste resources. [02L] 2.4 Environmental Impact Assessment and Sustainable Development [4L] 2.4.1 Environmental impact assessment in India 2.4.2 Elements of an Environmental Impact Assessment report (Project Description, Baseline Data Analysis, Anticipated Impacts and Mitigation Measures) 2.4.3 Environmental Monitoring Program and Environmental Management Plan (EMP) 2.5 Environmental Audit [3L] 2.5.1 Definition, principle element of an environmental audit and Components of auditing 2.5.2. Overview of Major steps involved in the process of Auditing. 2.5.3. Environmental audit report and Waste audit.		
3	**Biohazards, Biosafety and Bioethics**	**01**	**15**
	3.1 Biohazards: [5L] 3.1.1 Introduction 3.1.2 Levels of biohazards, 3.1.3 Risk assessment in Industries and Laboratories, proper cleaning procedures 3.2 Biosafety: [5L] 3.2.1 Historical background and introduction need of biosafety levels, 3.2.2 Biosafety guidelines for GMOs and LMOs. 3.2.3 Role of Institutional biosafety committee. RCGM, GEAC, etc. for GMO applications in food and agriculture. Environmental release of GMOs. 3.2.4 Overview of national regulations and relevant international agreements. Ecolabelling, IS 22000, Generally Recognized as Safe (GRAS). 3.2.5 Biosafety in laboratories (Microbiological, Biomedical). 3.3 Bioethics [5L] 3.3.1 Ethical issues and perspectives in the discipline of Microbiology 3.3.2 Ethics perspectives from India 3.3.3 Bioethics, bioweapons and the microbiologist 3.3.4 Ethical guidelines for biomedical research on human subjects 3.3.5 Public Perception of biotechnology: Genetic engineering- safety, social, moral and ethical considerations		

Self-Learning topics (Unit wise)

Unit	Topics
1	Bioremediation of metals and Sustainable Development
2	Electronic and biomedical waste management
3	Risk assessment in industries

Online Resources

Online module: Bioremediation of metals and Sustainable Development

https://youtu.be/NP_HqYXnYAI

https://youtu.be/6_ENzdBfJTE

Online module: Biomedical Waste Management
https://dth.ac.in/medical/courses/Microbiology/block-9/3/index.php (**Unit2)**

Online module: Safety reviews and Risk assessment I & II : (Lec 39-40)

https://nptel.ac.in/courses/103/107/103107156/ **(Unit-3)**

MBO607B- (Virology, Oncology and Advanced Instrumentation)

Unit	Topic	Credits	Lectures
1	**Virology**	01	15
	3.1 General characters and genomic structure, and replication for: [12L] 3.1.1 Class I: Double stranded DNA (dsDNA) viruses- Herpesvirus. 3.1.2 Class II: Single stranded DNA (ssDNA) viruses- Parvovirus. 3.1.3 Class III: Double stranded RNA (dsRNA) viruses-Reovirus 3.1.4 Class IV: Single stranded RNA (ssRNA) viruses positive-sense RNA genome-Coronavirus 3.1.5 Class V: Single stranded RNA (ssRNA) negative-sense RNA genome viruses-Influenza virus. 3.1.6 Class VI: Positive-sense ssRNA reverse transcriptase viruses-HIV. 3.1.7 Class VII: Double stranded DNA (dsDNA) reverse transcriptase viruses-Hepatitis B. 3.2 Detection, Enumeration of viruses: [1L] Direct methods, Immunodiagnosis, Nucleic acid based methods, infectivity assays (tabular) 3.3 Antivirals: [2L] Interferons, designing and screening for antivirals, mechanisms of action, antiretrovirals — mechanism of action and drug resistance		
2	**Cellular and Viral Oncology**	01	15
	3.1 Cellular oncogenesis [8L] 3.1.1 Basic properties of Cancer cells and its causes 3.1.2 Cancer: A genetic disorder 3.1.3 Oncogenic mutations in growth-promoting proteins 3.1.4 Mutations causing loss of growth-inhibiting proteins and cell-cycle controls 3.1.5 Role of carcinogens and DNA repair in cancer		

	3.2 Viral Oncogenesis [7L] 3.2.1 Activation of cellular signal transduction pathways by viral transforming proteins 3.2.2 Disruption of cell cycle control pathways by viral oncogene products 3.2.3 Mechanisms of transformation and oncogenesis by Human Tumor Viruses- Oncogenic Retroviruses, Hepatitis Viruses		
3	**Advanced Instrumentation**	01	15
	4.1 Advanced Microscopy [5L] 4.1.1 Scanning tunnelling microscope (STM), magnetic force microscope (MFM), Scanning near field microscope (SNOM) 4.1.2 Advanced Fluorescence Microscopy techniques: Fluorescence Lifetime imaging microscopy (FLIM), Fluorescence Correlation Spectroscopy (FCS) 4.2. Current chromatographic techniques: High-Performance Thin Layer Chromatography (HPTLC), Supercritical Fluid chromatography, Gas Chromatography and Hyphenated techniques [4L] 4.3. X-ray crystallography (1L) 4.4. Nucleic acid sequencing technologies: [5L] Maxam Gilbert sequencing, Sanger's dideoxy sequencing, Pyrosequencing, Next-Generation Sequencing (automated sequencing), Application of Next-Gen Sequencing technologies.		

Self-Learning topics (Unit wise)

Unit	Topics
1	DNA viruses
1	Oncogenes, tumor suppressor genes, cancer and cell cycle
3	Advanced Fluorescence Microscopy techniques

Online Resources
Online module: DNA viruses https://www.youtube.com/watch?v=73nXMQO-new&feature=youtu.be https://www.classcentral.com/course/virology-952 **(Unit 1)** **Online module: Oncogenes, tumor suppressor genes, cancer and cell cycle** https://onlinecourses.swayam2.ac.in/cec20_ma14/preview **(Unit 2)** **Online module: Advanced Fluorescence Microscopy techniques (Unit 3)** https://nptel.ac.in/noc/courses/noc21/SEM1/noc21-cy14/

Detailed scheme Practicals

MBO605D

1	Plant tissue culture –callus initiation
2	Chick embryo fibroblast/ Lymphocyte culture, viable staining
3	Cultural and morphological studies of algae.
4	Assignment on Medically relevant Mycotoxins
5	Isolation and enumeration of pigment producing bacteria from marine environment and extraction of pigments through solvent extraction procedure.

MBO606D

1	Isolation of biosurfactant producing bacteria and screening of biosurfactant.
2	Isolation of biopolymer producing bacteria and quantify the biopolymer produced.
3	Analysis of sludge: sewage and industrial for the following parameters: Sludge Volume Index (SVI), Mixed Liquor suspended solids (MLSS), Mixed volatile suspended solids (MLVSS), Food to Microorganism (F/M ratio).
4	Demonstration of Analysis of heavy metal (Cd/Cr) pollutants using volumetric/spectrophotometric methods.
5	Study of degradation of added phenol in the soil sample a) Growth of phenol degraders and study of its degradation efficiency b) To study the effect of glucose on the rate of phenol degradation.
6	Problems/ Assignment on Biohazards and biosafety or Case study: EIA report of a polluted ecosystem

MBO607D

1	Enumeration of viruses by plaque assay.
2	Hemagglutination inhibition test for detection of Influenza detection
3	Use of Western blotting viral detection
4	Assignment on Oncogenic viruses
5	Virtual lab exercise to understand the instrumentation, experimentation and interpretation of data obtained using HPTLC, GC, STM and hyphenated techniques.
6	Virtual lab exercise for Next generation sequencing.

REFERENCES:

Semester III

MBO601B

1. Robert W. Hutkins (2006) Microbiology and Technology of fermented foods 1st Edition, Blackwell Publishing
2. James M.Jay (2005) Modern Food Microbiology 7th Edition Food Science Text series, Springer Science
3. Petra Foerst, Chalat Santivarangkna 2016 Advances in Probiotic Technology ,CRC Press A Science Publishers Book
4. Yuan Kun Lee ,Seppo Salminen (2009) Handbook Of Probiotics And Prebiotics Second Edition John Wiley & Sons.
5. Okafor Nkuda and Benedict C.Okeke 2017; 'Modern Industrial Microbiology and Biotechnology', CRC press.
6. Stanbury P. F., Whitaker A. & HaII--S. J., 1997, "Principles of Fermentation Technology", 3rd Edition, Butterworth-Heinemann publications.
7. Osman Erkmen, T. Faruk Bozoglu, Food Microbiology - Principles into Practice Volume I and II, John Wiley (2016)
8. Adams and Moss , Food Microbiology, 3rd edition, RSC Publishing (2008)
9. Robert E.C. , Wildman 2nd Ed. " Handbook of Nutraceuticals & Functional Foods " CRC Press A SCIENCE PUBLISHERS BOOK
10. Ronald Ross Watson, Victor R. Preedy 1st Edition 2010 "Bioactive Foods in Promoting Health: Probiotics and Prebiotics" Academic Press is an imprint of Elsevier
11. Cosmetic Microbiology: A practical Approach, 2nd edition. Philip A Geiss. Taylor & Francis group page
12. A.K. Sharma. A handbook of Organic Farming. 2004. Agrobios India.
13. A. Singh, A. Parmar and R.C.Kuhad. Bioaugmentation, Biostimulation and Biocontrol. Soil Biology Volume 28. Springer.

MBO602B

1. R.M Maier, I. L. Pepper and C. P. Gerba 2010, Environmental Microbiology Academic Press
2. R. M. Atlas and R. Bartha - 1998 - Microbial Ecology - Fundamentals and Applications. Addison Wesley Longman, Inc
3. Microbial Diversity in Ecosystem Sustainability and Biotechnological Applications, Volume1, Tulasi Satyanarayana Bhavdish Narain Johri Subrata Kumar Das(editors) ISBN 978-981-13- 8314-4 ISBN 978-981-13-8315-1 (eBook) https://doi.org/10.1007/978-981-13-8315-1
4. Principles of Microbial Diversity, James W. Brown,2015
5. Davies DG, Parsek MR, Pearson JP,Iglewski BH, Costerton JW, Greenberg EP. 1998. The involvement of cell-to cell signals in the development of a bacterial biofilm. Science 280 (5361):295–98
6. O'"Toole GA, Kolter R. 1998. The initiation of biofilm formation in Pseudomonas aeruginosa WCS365 proceeds via multiple, convergent signaling pathways: a genetic analysis. Mol. Microbiol. 28:449–61

7. Morris, C. E. and Monier, J. M. 2003.The ecological significance of biofilm formation by plant-associated bacteria. Annu. Rev. Phytopathol. 41:429–53
8. O"Toole, G., Kaplan, H. B. and Kolter, R., 2000. Biofilm formation as microbial development. Annu. Rev. Microbiol. 2000. 54:49–79
9. Bacterial biofilms: from the Natural environment to infectious diseases. Nature Reviews Microbiology 2, 95-108 (February 2004)
10. Gerday, C., Glansdorff, N., & American Society for Microbiology. (2007). Physiology and biochemistry of extremophiles. Washington, D.C: ASM Press.
11. Horikoshi, K., Antranikian, G., Bull, A.T., Robb, F.T., Stetter, K.O. (Eds.) (2011), Extremophiles Handbook. Springer
12. Fred A. Rainey and Aharon Oren (2006). Methods in Microbiology - Volume 35, Extremophiles, 1st edi., Academic Press.
13. S.K.Kawatra and K.A. Natarajan,"Mineral Biotechnology- Microbial Aspects of Mineral Beneficiation, Metal Extraction, and Environmental Control", published by SME, Littleton, CO (USA) 2001
14. S.W.Borenstein, Microbiologically influenced corrosion handbook, Woodhead pub. Ltd., Cambridge (1994)
15. Microorganisms In Biofouling and Biocorrosion: https://nptel.ac.in/courses/113108055/module7/lecture

MBO603B

1. Snustad & Simmons, Principles of Genetics, 6th edition, 2012, John Wiley & Sons Inc
2. Jogdand S. N., Medical Biotechnology, Himalaya Publishing House, Mumbai, (2008)
3. Bionanotechnology –concepts and applications. Madhuri Sharon, Maheshwar Sharon, Sunil Pandey,Goldie Oza
4. Nanotechnology- Principles and Practices 2nd edition Sulabha K. Kulkarni Capital Publishing Company
5. Nanotechnology- Nanomaterials and Nanodevices G.Mohan Kumar, Narosa Publications
6. Environmental Biotechnology by Alan Scragg, 2nd edition
7. Ronald M. Atlas and Richard Bartha- Microbial ecology– Fundamentals and Applications (4th edition), Pearson education
8. Modern Methods of drug discovery, Hillisch A. and Hilgenfeld R., 2009, Springer International Edition
9. Daan J. A. Crommelin, Robert D. Sindelar. (2002) Pharmaceutical Biotechnology: An Introduction for Pharmacists and Pharmaceutical Scientists. Taylor & Francis
10. Gary Walsh. (2007) Pharmaceutical Biotechnology Concepts and Applications John Wiley & Sons.
11. Oliver Kayser, Rainer H. Müller. (2006) Pharmaceutical Biotechnology. John Wiley & Sons.
12. Tommy Liljefors, Povl Krogsgaard-Larsen, Ulf Madsen. (2010) Textbook of Drug Design and Discovery. 4th Edition. CRC Press
13. Fundamentals of Clinical Trials. Lawrence M. Friedman, Curt Furberg, David L. DeMets · 4th edition
14. A Concise Guide to Clinical Trials. Allan Hackshaw, wiley (2011)
15. Clinical Trials- A Practical Approach. Stuart J. Pocock , wiley (2013)

MBO604B

1. S. Ignacimuthu, (2012), ―Basic Bioinformatics, 2nd edition, Narosa publishing house.
2. Arthur Lesk, (2013) ―Introduction to Bioinformatics, 4th Edition, Oxford University
3. Research Methodology - Methods and Techniques, Kothari, C.R., (2011), New Delhi, Wishwa prakashan
4. Methods in Biostatistics, Mahajan B. K., 7 Th edition, 2010, JPB publishers
5. Fundamentals of Biostatistics, Rosner B.A., 2011, Cengage Learning
6. Biostatistics: A foundation for analysis in health sciences. Daniel WW, Cross CL. 10th Edn,2013, Wiley

Semester IV

MBO605B

1. B.R. Glick, J.J. Pasternak and C.L. Patten. Molecular Biotechnology: Principles and Applications of Recombinant DNA. 4th Edition. ASM Press, Washington D.C.
2. Sudha Gangal- Animal Tissue Culture, University Press, 2nd edition
3. Ian Freshney- Culture of Animal Cells: A manual of basic techniques and specialized applications, Seventh Edition, Wiley Publication
4. Applied Mycology by Mahendra Rai, Paul Dennis Bridge, 2009, CAB International.
5. Fungal Biomolecules – sources, Applications and Recent developments by Vijay Kumar Gupta, Robert L. Mach, S. Sreenivasaprasad2015, Published by John Wiley & Sons .ltd.
6. Sharma, P., Sharma, N. (2017) Industrial and Biotechnological Applications of Algae: A Review. Journal of Advances in Plant Biology - 1(1):01-25. (Review Paper)
7. Barsanti, L. and Gualtieri P. (2014). Algae: Anatomy, Biochemistry, and Biotechnology, 2ed. CRC Press
8. Dinabandhu Sahoo, Joseph Seckbach; the Algae world; Springer

MBO606B

1. Environmental Management- Science and Engineering for Industry, 2017,by Iyyanki V. Muralikrishna & Valli Manickam
2. Muralikrishna, I. V., & Manickam, V. (2017). Environmental Impact Assessment and Audit. Environmental Management, 77–111. doi:10.1016/b978-0-12-811989- 1.00006-3
3. R.M Maier, I. L. Pepper and C. P. Gerba 2010, Environmental Microbiology Academic Press
4. R. M. Atlas and R. Bartha - 1998 - Microbial Ecology - Fundamentals and Applications. Addison Wesley Longman, Inc
5. Evidence-Based Biosafety: a Review of the Principles and Effectiveness of Microbiological Containment Measures, 2008: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2493080
6. Biological safety manual, Chapter 2: Biological Risk Assesment https://policies.unc.edu/TDClient/2833/Portal/KB/ArticleDet?ID=131877
7. Biosafety in Microbiological and Biomedical Laboratories, 6th ed. CDC & NIH. https://www.cdc.gov/labs/BMBL.html
8. Industrial hygiene and safety. M. H. Fulekar
9. LMOs, Biodiversity and Biosafety National and International Regulations Prepared by Ministry of Environment, Forest and Climate Change (MoEFCC) and Biotech Consortium India Limited, New Delhi under the UNEP/GEF supported

Phase II Capacity Building Project on Biosafety, 2019.
10. Textbook for Environmental Studies For Undergraduate Courses of all Branches of Higher Education by Erach Bharucha for University Grants Commission
11. Essential environmental studies, S.P.Mishra, S.N.Pandey,Ane books pvt ltd
12. Environmental Biotechnology (Industrial Pollution Management) by S N Jogdand, Himalaya publishing house
13. Environment and Ecology, S.P.Mishra, S.N.Pandey, Ane books pvt ltd
14. Technical EIA guidance manual for Common Hazardous Waste Treatment, Storage and Disposal Facilities, Prepared by Ministry of environment and forests, Government of India, 2010: http://environmentclearance.nic.in/
15. Guidelines for environmentally sound management of e-waste, ministry of environment & forests central pollution control board, Delhi,2008: http://www.cpcb.nic.in/latest/e waste pdf
16. Iyyanki V. Muralikrishna, Valli Manickam,Chapter Three - Natural Resource Management and Biodiversity Conservation,Environmental Management, Butterworth- Heinemann,2017,Pages 23-35,ISBN 9780128119891,https://doi.org/10.1016/B978-0-12- 811989-1.00003-8.
17. Munn, C.B., 2019. Marine microbiology: ecology & applications. CRC Press. 3rd edtn 2. Gasol, J.M. and Kirchman, D.L. eds., 2018.
18. Natural Polymers for Pharmaceutical Applications,Volume 2: Marine- and Microbiologically Derived Polymers ,Edited by Amit Kumar Nayak, PhD Md Saquib Hasnain, PhD Dilipkumar Pal, PhD© , 2020 by Apple Academic Press, Inc
19. Marine Microbiology: Bioactive Compounds and Biotechnological Applications,Edited by Se-Kwon Kim,Publisher Wiley-VCH,2013

MBO607B

1. Understanding Viruses – Teri Shors. Jones and Bartlett pub.
2. Basic Virology, Wagner E,K; Hewlett, M.J, Bloom, D.C., Camerini, D, 3rded, 2008, Blackwell Publishing
3. Principles of Virology – Flint, Enquist, Racaniello&Skalka, Vol I and II. ASM
4. Cell Biology. Karp G.7thEdn. International Student Version, Wiley. 2013
5. Molecular Cell Biology. Lodish ,Birk, and Zipursky. Freeman
6. Pattabhi, V. and Gautham, N. (2002) Biophysics. Kluwer Academic Publishers, New York and Narosa Publishing House, Delhi.
7. Nölting, B. (2006) Methods in modern biophysics. Second Edition. Springer, Germany.
8. Wilson Keith and Walker John (2005) Principles and Techniques of Biochemistry and Molecular Biology, 6th Ed.Cambridge University Press, New York
9. Narayanan, P. (2000) Essentials of Biophysics. New Age International Publication, New Delhi
10. Juan Carlos Stockert, Alfonso Blázquez-Castro (2017) Fluorescence Microscopy in Life Sciences Bentham Science Publishers,UAE
11. Michal Holcapek, Craig Byrdwell (2017) Handbook of Advanced Chromatography/Mass Spectrometry Techniques AOCS Press. Published by Elsevier Inc.

12. David J Holme, Hazel Peck (1998) Analytical Biochemistry, 3rd Ed. Prentice Hall, Pearson Education Limited, Harlow England.
13. Rodney F. Boyer (2000) Modern Experimental Biochemistry3d edition., Benjamin Cummings
14. A handbook book of Organic analysis: qualitative and quantitative 4th edition, Hans Thacher Clarke, CBS publishers & distributors, New Delhi
15. A textbook of Biotechnology, Dubey R. C., 2001, S. Chand Publishers.
16. Biotechnology, 2nd Edition-Volume 12- Legal, Economic and Ethical Dimensions, Volume Editor-D. Brauer (A multi-Volume Comprehensive Treatise), Rehm H. J.Ethical issues in microbiology, P Desikan, A Chakrabarti, V Muthuswamy. Indian Journal of Medical and Reed G., Puhler A., Stadler P. (1995) VCH Publishers
17. Jianping Xu (2014). Next-generation Sequencing: Current Technologies and Applications. Edited by: Published: 2014 Book: 978-1-908230-33-1. Ebook: 978-1-908230-95-9. Caister Academic Press.
18. S. B. Primrose (2002). Principles of Genome Analysis. A Guide to Mapping and Sequencing DNA from Different Organisms. Blackwell publishing.