HSNC UNIVERSITY, MUMBAI

Ordinances and Regulations

With Respect to

National Education Policy, 2020

(NEP)

For the Programmes Under

The Faculty of Science and Technology

In the subject of

Microbiology

Semester-V and Semester -VI

With effect from the Academic year 2025-2026

HSNC UNIVERSITY, MUMBAI
Board of Studies in Faculties of Science & Technology
Board of Studies in Microbiology Subject

1.) Name of **Chairperson**/Co-Chairperson/Coordinator: -

a.) **Dr. Sejal Rathod (**Professor and Head, Department of Microbiology, K.C college, Churchgate) sejal.rathod@kccollege.edu.in 9930082028

2.) Two to five teachers each having minimum five years teaching experience amongst the full-time teachers of the Departments, in the relevant subject.

a.) Dr. Pratibha Shah (Professor, Department of Microbiology, K.C college, Churchgate) pratibha.shah@kccollege.edu.in 9773321760

b.) Dr. Rajitha Satish (Assistant Professor, Department of Microbiology, K.C college, Churchgate) rajitha.satish@kccollege.edu.in 9833716190

c.) Ms. Amina Dholkawala (Assistant Professor, Department of Microbiology, K. C college, Churchgate) amina.dholkawala@kccollege.edu.in 7208724194

3.) One Professor / Associate Professor from other Universities or professor / Associate Professor from colleges managed by Parent Body; nominated by Parent Body; -

a.) Dr Bela Nabar (Professor, HOD of Microbiology, Department of Microbiology, CHM College, Ulhasnagar) belamsn23@gmail.com 9322760417

b.) Dr. S. Raut (Professor, Department of Microbiology, Bhavans college, Andheri West, Mumbai, Maharashtra 400058) svrmicro@yahoo.co.in 9869053676 2

4.) Four external experts from Industry / Research / eminent scholar in the field relevant to the subject nominated by the Parent Body;

a.) Mrs. Prabha Padmanabha (former Associate Professor, Department of Microbiology, KC College Mumbai- 400 020) prabhapadmanabha@hotmail.com 9820860049

b.) Dr. Sahayog Jamdar (Scientific Officer G, Food and Technology Division BARC) snjam2@gmail.com 2225595375

c.) Dr. Mehul Rajpurkar (Regional Medico Marketing Manager, SRL Diagnostics, Goregaon West) mehul.rajpurkar@gmail.com 9819107505

d.) Dr. Surekha Zingde (Former Dy. Director, Cancer Research Institute, ACTREC,) Tata Memorial Centre, Kharghar) surekha.zingde@gmail.com 9820633284

5.) Top rankers of the Final Year Graduate and Final Year Post Graduate examination of previous year of the concerned subject as invitee members for discussions on framing or revision of syllabus of that subject or group of subjects for one year.

a.) Ms. Uzma Shaikh (Undergraduate student- 18-19) Contact – 9004718231 , uzma25.shaikh@gmail.com

b.) Ms. Soni Gupta (Postgraduate student -18-19) Contact - 9167147185 , sonigupta445@gmail.com

Dr. Sejal Rathod
Chairperson- BOS Microbiology

Part 1- Preamble

This syllabus is meticulously designed for the Bachelor of Science (B.Sc.) in Microbiology program, in full adherence to the progressive guidelines of the National Education Policy (NEP). This comprehensive structure is aimed at transforming undergraduate education by fostering a research-intensive, multidisciplinary, and holistic learning environment.

The program's core philosophy is to establish a strong foundational knowledge in scientific principles and methodologies, providing deep insight into the various disciplines of Microbiology, including Genetics, Medical Microbiology, Industrial Microbiology, and Biochemistry.

A key objective of this curriculum is to cultivate an interdisciplinary approach. Students are encouraged to integrate knowledge from allied fields such as Molecular Biology, Biotechnology, Environmental Microbiology, Immunology, Bioinformatics, and Biostatistics to analyze and understand complex biological phenomena. The teaching-learning process emphasizes hands-on experience by training students to design and conduct laboratory investigations and experiments, ensuring proficiency in good laboratory practices and biosafety.

The course is structured to bridge the divide between theoretical concepts and practical, real-world applications. Through mandatory projects, internships, and research opportunities, graduates will be equipped to develop innovative microbiological strategies that address global challenges in areas like public health, food safety, and environmental sustainability.

Furthermore, the syllabus is committed to cultivating ethical behavior and social responsibility, ensuring that students are prepared to evaluate the ethical dimensions and societal impact of research and technological innovations. By focusing on enhanced skills for entrepreneurship and employability, including critical thinking, collaboration, and effective communication, this program prepares students for professional success, entrepreneurial ventures, and a lifelong commitment to learning and staying updated with scientific advancements.

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 2023-2024 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 Interdisciplinary / IntraDisciplinary 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 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 a 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
● For Major subjects and DSE -(4 credits)- 60 marks
● For Indian Knowledge System major (2 credits)-50 marks
● For DSC- Advances in Biotechnology -(2 credits) -50 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 DSE in each semester).
2. Each student has to perform at least 1 major and 1 minor practical for Semester V and VI.
3. Viva would be conducted during the practical examination.
4. VOC 1 and 2 practical evaluation will be conducted internally.
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
− 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 the 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

PROGRAM EDUCATION OBJECTIVES	BACHELOR OF SCIENCE
PEO 01	Strong Foundation in Science: Graduates will have a robust understanding of core scientific principles and methodologies, enabling them to analyse and solve complex problems in their field.
PEO 02	Effective Communication Skills: Graduates will be equipped with the ability to communicate scientific ideas clearly, both in writing and speaking, and will be able to collaborate effectively with others.
PEO 03	Practical Application of Knowledge: Graduates will be able to apply their scientific knowledge to real-world situations, gaining hands-on experience through projects, internships, or research
PEO 04	Ethical and Social Responsibility: Graduates will demonstrate ethical behaviour and social responsibility, considering the impact of their work on society and the environment.
PEO 05	Commitment to Lifelong Learning: Graduates will be motivated to pursue ongoing learning and professional development to stay updated with new developments in their field.
PEO 06	Leadership and Teamwork: Graduates will be capable of working well both as leaders and team members, contributing to successful collaborative efforts in professional settings.
PEO 07	Preparation for Further Studies and Research: Graduates will be ready to pursue graduate studies or engage in research, advancing their knowledge and contributing to scientific progress.

PROGRAM OUTCOMES	BACHELOR OF SCIENCE
PO 01	Understanding Core Scientific Concepts- Students will gain clear insight and understanding to recall key scientific principles across various fields. A well-established foundational knowledge of the subject will play a crucial role for deeper learning and future studies
PO 02	Commit to Lifelong Scientific Learning- Students will cultivate a habit of continuous learning and shall learn to stay updated with the latest scientific and technological advancements. This mindset will ensure that they remain relevant, engaged and informed throughout their future academic journey.
PO 03	Abilities to Analyse and Evaluate- Students will learn to classify and scrutinize complex problems into manageable parts, critically analyse data, and evaluate potential solutions to scientific problems.

PO 04	Assessing Ethical Implications- Students will be trained to evaluate the ethical dimensions of research and technological innovations, ensuring that their decisions consider societal impacts and they adhere to ethical standards. This is vital for responsible and sustainable practices.
PO 05	Design Experiments and Innovate- Students will learn to design and conduct experiments, developing innovative solutions to challenges through Research Projects. They will also learn to evaluate their results and refine their experimental approaches over time.
PO 06	Application of Scientific and Technical Knowledge to Real-World Problems- Students will use their scientific and Technical knowledge and expertise to identify and solve real-world problems. This would involve applying theoretical concepts to practical situations, bridging the gap between classroom learning, Industry-academia and real-life applications.
PO 07	Communicating Scientific Findings Effectively- Students will develop the ability to communicate scientific information clearly and effectively, both in writing and verbally. Whether presenting research findings or writing technical reports, clear communication is key to knowledge sharing and collaboration.
PO 08	Foster an Interdisciplinary Approach- Students will cultivate leadership and teamwork skills, enabling them to collaborate effectively in diverse, interdisciplinary teams. Leadership qualities such as decision-making and delegation will help them achieve successful outcomes in various projects.
PO 09	Promote Environmental Sustainability- Students will understand the environmental impact of scientific activities and advocate for sustainable practices. By considering environmental factors in their work, they will contribute to the long-term health of the planet.
PO 10	Enhanced Skills for Entrepreneurship and Employability- Students will be equipped with essential skills for entrepreneurship and employability, focusing on job readiness, soft skills, and practical business knowledge. Hands-on experience through internships and mentorship will further enhance their readiness for the job market and entrepreneurial ventures.

PROGRAM SPECIFIC OUTCOMES	BACHELOR OF SCIENCE (MICROBIOLOGY)
PSO 01	Understand Core Microbiological Concepts: Understand the principles of various disciplines of microbiology like Genetics, Medical Microbiology, Immunology, Biochemistry, Industrial microbiology, Environmental Microbiology, Cell Biology, and modern-day diagnostic methods and instrumentation.
PSO 02	Integrate interdisciplinary approaches: Apply knowledge from Biochemistry, Molecular Biology, Immunology, Epidemiology, Pharmaceuticals, Food and Dairy Technology, Nanotechnology, Bioanalytical techniques, Bioinformatics, and Biostatistics to understand complex biological phenomena.
PSO 03	Conduct microbiological investigations: Design and perform Laboratory techniques and experimentation, collect and analyze data, and interpret results using statistical, scientific methods and literature. Exhibit knowledge of good laboratory practices and biosafety, and ethical considerations in Microbiology.
PSO 04	Application of Microbiological concepts: Applying theoretical concepts to practical situations, bridging the divide between classroom learning, Industry-academia and real-life applications.
PSO 05	Developing innovative solutions: Engaging in research projects and internships to develop microbiological strategies that address global challenges in areas like medicine, public health, food safety, ecological science, environmental sustainability, agriculture, industry, and biotechnology, along with protecting intellectual property.
PSO 06	Development of Technical and Analytical Skills: Critical thinking, problem-solving abilities, collaboration and teamwork skills, Proficiency in data analysis and interpretation, ability to effectively communicate and present microbiological concepts and scientific data.
PSO 07	Promoting Entrepreneurship and employability: Fostering a culture of continuous learning among students, enabling them to stay relevant and updated about the latest scientific and technological advancements. Thereby, preparing them for the job market and entrepreneurial opportunities.

Third Year Semester V - Units – Topics – Teaching Hours

S. N	Subject Code		Subject Unit Title	Hours/Lectures	Total No. of hours/lectures	Credit	Total Marks
1	MBO301B **Microbial Genetics**	1	**Introduction to genetics and DNA Replication**	15	45 L	3	100
		2	**Gene Expression**	15			
		3	**DNA Mutations and Repair**	15			
	MBO301D	4	Practicals based on MBO301B	30		1	
2	**MBO302B Bioprocess technology**	1	**Upstream processing I**	15	45 L	3	100
		2	**Upstream processing II**	15			
		3	**Advances in Bioprocess Technology**	15			
	MBO302D		Practicals based on MBO302B	30		1	
3	**MBO303C IKS Vedic and Modern Indian Microbiology**	1	**Vedic Microbiology**	15	30 L	2	50
		2	**Modern Indian Microbiology**	15			
4	MBO303B **Microbial Biochemistry**	1	**Solute transport and Bioenergetics**	15	45 L	3	100
		2	**Analysis of Metabolism & Catabolism of Carbohydrates**	15			
		3	**Fermentative Pathways & Anabolism of Carbohydrates**	15			
	MBO303D		Practicals based on MBO303B	30		1	
5	MBO304B **Marine Microbiology**	1	**Introduction to Marine Microbiology**	15	45 L	3	100
		2	**Marine Microbes**	15			
		3	**Marine Pollution and Microbial Remediation**	15			
	MBO304D		Practicals based on MBO304B	30		1	
5	**MBO301C VOC I Clinical Microbiology**	1	**Microbial Pathogenicity & Infections**	15	15 L	1	50
	VOC I Practical		Practicals based Clinical Microbiology	30		1	
6	**MBO302C VOC II Immunohematology**	1	**Immunohematology**	15	15 L	1	50
	VOC II Practical		Practicals based on Immunohematology	30		1	
			TOTAL			16	450

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

- **Lecture Duration – I hour**
- **One Credit =15 hours theory/ 30 hours practical**

Semester V - Major I
Course Code: MBO301B (Microbial Genetics)

COURSE OUTCOMES	BACHELOR OF MICROBIOLOGY NAME OF THE COURSE: Microbial Genetics
After completion of the course the student will be able to-	
CO 01	Explain the fundamental principles of genetics, including DNA replication, gene expression mechanisms in prokaryotes and eukaryotes, the nature and causes of DNA mutations, and the basic mechanisms of DNA repair.
CO 02	Compare and contrast the molecular processes of DNA replication and gene expression across different organisms.
CO 03	Analyze and evaluate the intricate roles of various enzymes and regulatory elements involved in DNA replication, gene expression, and DNA repair, in maintaining genomic integrity and cellular function.
CO 04	Elucidate fundamental genetic principles and apply theoretical knowledge to execute and interpret relevant experiments using molecular biology laboratory techniques and instrumentation.
CO 05	Evaluate the significance of genetic processes in microbial systems, including the impact of mutations, the regulation of gene expression in response to environmental changes, and the applications of mutagenesis techniques in research.

Unit	Topic	Credits	Lectures	References
1	**Introduction to genetics and DNA Replication**	01	15	Concepts of Genetics Eleventh Edition By Pearson – 1 January 2019 by William S. Klug, Michael R. Cummings, Charlotte A.

	1.1 Branches of Genetics - Transmission genetics, Molecular genetics, Population genetics, Quantitative genetics **1.2 Model Organisms** 1.2.1 Characteristics of a model organism 1.2.2 Examples of model organisms used in study **1.3 Semi-discontinuous, Semiconservative mode of replication** **1.4 Theta mode of replication, Rolling circle mode of replication** **1.5 Enzymes and proteins involved in bacterial DNA replication** **1.6 Initiation, elongation and termination of DNA replication in prokaryotes.** **1.7 Cell cycle and control** **1.8 Eukaryotic DNA replication -** Molecular details of DNA synthesis, replicating the ends of the chromosomes assembling newly replicated DNA into nucleosomes.		1L 1L 2L 2L 3L 2L 1L 3L	Spencer, Michael A. Palladino iGenetics: A Molecular Approach by Russell Lehninger-Principles of biochemistry-7th edn 2017 David L. Nelson Michael M. Cox
2	**Gene Expression**	01	15	
	2.1 Transcription in Prokaryotes- Promoters, sigma factors, RNA polymerase, Initiation, Elongation and termination of mRNA chain in bacteria. **2.2 Expression and control of lac operon in *E.coli*** **2.3 Transcription in Eukaryotes -** Eukaryotic RNA polymerase, Transcription of protein-coding genes by RNA polymerase II, Transcription initiation, The structure and production of Eukaryotic mRNAs, Production of mature mRNA in Eukaryotes, Processing of Pre-mRNA to mature mRNA. Self Splicing of Introns, RNA editing **2.4 Translation process -** Transfer RNA, structure of tRNA, tRNA genes, Recognition of the tRNA anticodon by the mRNA codon, Adding of amino acid to tRNA, Ribosomal RNA and Ribosomes, Ribosomal RNA Genes, Initiation of translation, Initiation in Bacteria, Initiation in eukaryotes, Elongation of the polypeptide chain, termination of translation, protein sorting in the cell.		4L 2L 4L 5L	iGenetics: A Molecular Approach by Russell

3	**DNA Mutations and Repair**	01	15	
	3.1 Mutation 3.1.1 **Terminology:** alleles, homozygous, heterozygous, genotype, phenotype, Somatic mutation, Germline mutation, Gene mutation, Chromosome mutation, random mutations, site specific mutations, phenotypic lag, hotspots and mutator genes 3.1.2 Fluctuation test. 3.1.3 **Types of mutations:** Point mutation, reverse mutation, suppressor mutation, frameshift mutation, conditional lethal mutation, base pair substitution, transition, transversion, missense mutation, nonsense mutation, silent mutation, neutral mutation, pleiotropic mutations. 3.1.4 **Causes of mutation:** Natural/spontaneous mutation- replication error, depurination, deamination. Induced mutation: principle and mechanism with illustrative diagrams for: 3.1.4.1 Chemical mutagens - base analogues, nitrous acid, hydroxyl amine, intercalating agents and alkylating agents. 3.1.4.2 Physical mutagens 3.1.4.3 Biological mutagens (only examples) 3.1.5 Ames test 3.1.6 Detection of mutants 3.1.7 Lac operon and its mutations **3.2 DNA Repair** 3.2.1 Mismatch repair, 3.2.2 Light repair 3.2.3 Repair of alkylation damage 3.2.4 Base excision repair 3.2.5 Nucleotide excision repair 3.2.6 SOS repair		1L 1L 2L 5L 1L 1L 1L 4L	iGenetics: A Molecular Approach by Russell Lehninger-Principles of biochemistry-7th edn 2017 David L. Nelson Michael M. Cox

MBO301D- Practicals based on MBO301B

1.	UV survival curve – determination of exposure time leading to 90% reduction
2.	Isolation of mutants using UV mutagenesis a. pigment deficient mutants of *Serratia sp*. b. Antibiotic resistant mutants
3.	Gradient plate technique (dye resistant mutants)
4.	Lac operon problems
5.	Ames test (demonstration)

6.	Beta-galactosidase assay
7.	Visit to a Molecular Biology Research laboratory

Semester V - Major II
Course Code: MBO302B (BIOPROCESS TECHNOLOGY)

COURSE OUTCOMES	**BACHELOR OF MICROBIOLOGY** **NAME OF THE COURSE: Bioprocess Technology**
After completion of the course the student will be able to-	
CO 01	Comprehend the fundamental principles of upstream bioprocessing, including microbial screening, strain improvement, culture preservation, and inoculum development for industrial fermentations.
CO 02	Apply knowledge of fermentation media formulation, sterilization techniques, and aseptic practices to design and execute effective upstream processing strategies.
CO 03	Experiment with techniques of industrial culture isolation, improvement, preservation, sterilization, Animal tissue culture, plant tissue culture and immobilized enzymes.
CO 04	Evaluate the applications and techniques of advanced bioprocess technologies such as ATC, PTC and immobilized enzymes and cells.
CO 05	Critically assess the significance of various bioprocess technologies in industrial applications, including pharmaceuticals, agriculture, and other biotechnological sectors.

Unit	**Topic**	**Credits**	**Lectures**	**References**
1	**Upstream processing I**	**01**	15	

	1.1 Screening of Industrial Cultures- 1.1.1 Primary and secondary screening 1.1.2 High throughput screening methods **1.2 Strain improvement** 1.2.1 The improvement of industrial microorganisms 1.2.2 The selection of induced mutants synthesizing improved levels of primary metabolites 1.2.3 The isolation of induced mutants producing improved yields of secondary metabolites. 1.2 .4 The improvement of strains by modifying properties other than the yield of product **1.3 Preservation of cultures** 1.3.1 Preservation of industrially important organisms 1.3.2 Quality control of preserved stock 1.3.2.1. Key Criteria 1.3.2.2. Development of a master culture bank (MCB) 1.3.2.3. Variability test to ensure reproducibility of the MCB 1.4 **The development of inocula for industrial fermentations** 1.4.1 Introduction 1.4.2 Development of inocula for yeast process 1.4.3 Development of inocula for unicellular bacterial process 1.4.4 Development of inocula for mycelial process 1.4.5 Aseptic inoculation of plant fermenter		2L 7L 3L 3L	Industrial Microbiology by Casida Principles of Fermentation Technology- 2nd edition by Stanbury and Whitaker Principles of Fermentation Technology Stanbury and Whitaker- 3rd edition Bioprocess Technology by H. A. Modi- Volume 1
2	**Upstream Processing II**	**01**	15	
	2.1 Fermentation media formulation and raw materials 2.1.1 Media formulation and Optimization- Classical approach – One factor at a time, Full factorial design 2.1.2 Raw materials for fermentation media **2.2 Sterilization and achievement of aseptic conditions** 2.2.1 Introduction		3L 6L	Bioprocess Technology by H. A. Modi- Volume 1 & Fermentation Medium Optimization; Research Journal of Microbiology 2 (3), 201-208,

	2.2.2 Medium sterilization (concept of nabla factor) 2.2.3 Methods of batch sterilization 2.2.4 The design of continuous sterilization process 2.2.5 Sterilization of the Fermenter 2.2.6 Sterilization of the Feeds 2.2.7 Filter Sterilization 2.2.7.1 Filter sterilization of fermentation media 2.2.7.2 Filter sterilization of air 2.2.8 Achievement of aseptic conditions **2.3 Scale up and scale down** 2.3.1 Objective of scale-up 2.3.2 Criteria of scale-up for critical parameters (aeration and agitation, broth rheology and sterilization) (Tabular) 2.3.3 Scale-down **2.4 Measurement and control** 2.4.1 Introduction to sensors and its types 2.4.2 Measurement and control of: pH, temperature, pressure, foam sensing, dissolved oxygen, inlet and exit gas analysis.		1L 5L	2007 Bioprocess Technology by H. A. Modi- Volume 2 Principles of Fermentation Technology- 2nd edition by Stanbury and Whitaker
3	**Advances in Bioprocess Technology**	**01**	15	
	3.1 Animal tissue culture 3.1.1 Primary cell culture and Established cell lines cultures 3.1.2 Equipment's and Materials for ATC 3.1.3 Basic Techniques of Mammalian Cell culture 3.1.3 Growth media 3.1.4 Cell viability and Cytotoxicity 3.1.5 Manipulation of cultured cells and tissue 3.1.6 Applications of Animal cell culture in India: Vaccines, somatic cell fusion, valuable products. **3.2 Plant tissue culture** 3.2.1 Introduction 3.2.2 Requirements for in vitro culture, Methods of plant cell and tissue culture 3.2.3 Types of cultures of plant materials: explants, callus, organogenesis, root culture, shoot culture, micro-propagation, suspension		5L 5L 5L	Text of Biotechnology by H. K. Das; 5th edition Textbook of Biotechnology by R. C. Dubey

	culture, protoplast culture, protoplast fusion and somatic hybridization. 3.2.4 Applications of PTC: production of disease resistant plants, production of virus free plant, In vitro selection of cell lines for disease resistance, micro-propagation, secondary metabolites from cell culture, transgenic plants for crop improvement **3.3 Immobilized enzyme and cells** 3.3.1 Introduction and Definitions 3.3.2 Methods 3.3.3 Immobilized Enzyme Reactors 3.3.4 Applications			Bioprocess Technology by H. A. Modi- Volume 2

MBO302D - Practicals based on MBO302B

1. Determination of antimicrobial spectrum for a fungal antibiotic producer using agar strip method.
2. Determination of antimicrobial spectrum for a bacterial antibiotic producer using agar streak method.
3. Determine the alcohol tolerance for yeast.
4. Determine the sugar tolerance for yeast.
5. Plant tissue culture – Callus culture (Demo).
6. Perform immobilization of yeast cells for invertase activity - making of beads, Determination of enzyme activity and Standardization of count by haemocytometer and viable count
7. Animal cell culture (Demo)

SEMESTER V - INDIAN KNOWLEDGE SYSTEM (IKS)
Course code: MBO303C (Vedic and Modern Indian Microbiology)

COURSE OUTCOMES	**BACHELOR OF MICROBIOLOGY** **NAME OF THE COURSE: Vedic and Modern Indian Microbiology**
After completion of the course the student will be able to-	
CO 01	Explain Vedic concepts of microorganisms, their health relevance, and traditional prophylaxis.
CO 02	Demonstrate understanding of traditional pathogen elimination methods and their relation to modern microbiology.
CO 03	Critically evaluate the importance of national microbiological infrastructure and IPR for research, biodiversity, and recognizing Indian scientists' contributions.

Unit	**Topics**	**Credits**	**Lectures**	**References**
1	**Vedic Microbiology**	**1**	**(15)**	
	1. Prevalence of microorganisms (krmis) 2. Human health and pathogens 3. Prophylaxis according to Vedas, Texts of Ayurveda 4. Use of Sun rays for elimination of pathogens 5. Eradication of pathogens by Medicinal plants. 6. Contributions of Indian Scientists - (Charaka, Sushruta, Vagbhata, Atreya)	2L 2L 3L 2L 4L 2L		**Vedic Microbiology- A scientific approach by R.C Dubey 2021**
2	**Modern Indian Microbiology**	**1**	**(15)**	
	2.1 Role of AYUSH (Ayurveda, Yoga and Naturopathy, Unani, Siddha, Sowa Rigpa and Homoeopathy) in healthcare 2.2 National Microbial repositories 2.3 National Institutes involved in Microbiology research. 2.4 Analytical techniques used in Research Institutes	1L 2L 2L 6L		**Ayurvedic Inheritance : A readers Companion MS. Valiyathan 2017**

	2.5 Biosafety level facilities, Biobanking, Preservation of cultures to maintain national biodiversity. Indian priority pathogen list. 2.6 Intellectual Property Rights (IPR) guidelines in India Patents - Requirements for Patentability, Novelty, subject matter, invention, industrial applicability Indian Patent Act 1970 & recent amendments, CSIR-Unit for Research and Development of Information Products (URDIP). Patent Case study: - Basmati rice, turmeric and neem 2.7 Contribution of Indian Scientists; Dr Indira Nath, GP Talwar, Kamal Ranadive, Prof. Panchanan Maheshwari, MS Valiyathan	2L 2L		

SEMESTER V DSE I-

Course Code: MBO303B (Microbial Biochemistry)

COURSE OUTCOMES	**BACHELOR OF MICROBIOLOGY** **NAME OF THE COURSE: DSE I: Microbial Biochemistry**
After completion of the course the student will be able to-	
CO 01	Explain the mechanisms of solute transport across membranes and the fundamental processes of ATP generation, alongside the principles of oxidative and fermentative metabolism.
CO 02	Apply knowledge of transport and bioenergetics to specific systems and metabolic pathways, and demonstrate practical skills in biochemical estimations and detection assays.
CO 03	Analyze differences in transport systems, electron flow, and fermentative pathways, and interpret experimental results from techniques in microbial biochemistry.
CO 04	Evaluate the significance of transport mechanisms, ATP production efficiency and apply enzyme end-product analysis for microbial characterization.
CO 05	Design experiments to study solute transport, metabolic pathways, and demonstrate proficiency in studying oxidative/fermentative metabolism in the lab.

Unit	**Topic**	**Credits**	**Lectures**	**References**
1	**Solute transport and Bioenergetics**	**01**	15	

	1.1 Solute transport across membrane 1.1.1 Properties of phospholipid membranes, Integral & peripheral proteins, aquaporins and mechanosensitive channels. 1.1.2 Study of solute transport using Liposomes and Proteoliposomes. 1.1.3 Passive transport and facilitated diffusion by membrane proteins. 1.1.4 Active transport – primary and secondary 1.1.5 Shock sensitive system –Role of binding proteins, histidine uptake. 1.1.6 Phosphotransferase system. 1.1.7 Iron transport: A special problem. 1.2 **Bioenergetics** 1.2.1 Mechanism of generating ATP: Substrate-Level Phosphorylation, Oxidative Phosphorylation & Photophosphorylation. 1.2.2 Electron transport chain (E.T.C.)- Universal Electron acceptors and Carriers in E.T.C. 1.2.3 Mitochondrial ETC 1.2.4 Prokaryotic ETC - Pattern of electron flow in *E. coli* - aerobic and anaerobic 1.2.5 ATP synthesis -Explanation of terms – Proton motive force, Proton pump, Coupling sites, P:O ratio, Redox potential, Standard reduction potential, electrochemical energy. 1.2.6 Chemiosmotic theory 1.2.7 Structure & function of Mitochondrial ATP synthase (No Kinetics) 1.2.8 Rotational catalysis mechanism. 1.2.9 Inhibitors of ETC, uncouplers and ionophores (Tabular).		6L 9L	White, D., The Physiology and Biochemistry of Prokaryotes, 4th edition, Stanier, R. Y., M. Doudoroff and E. A. Adelberg. General Microbiology, 5th edition, Gottschalk,G., (1985), Bacterial Metabolism, 2nd edition Nelson, D. L. and M.M. Cox, Lehninger, Principles of biochemistry. 8th Edition,
2	**Analysis of Metabolism & Catabolism of Carbohydrates**	**01**	15	

	2.1 Experimental Analysis of metabolism 2.1.1 Levels of organization at which metabolism is studied 2.1.2 Use of probes and radioisotopes in biochemistry- Pulse labelling, Application of radiorespirometry to differentiate EMP & ED, Biochemical mutants **2.2 Catabolism of Carbohydrates** 2.2.1 Breakdown of polysaccharides – Glycogen, Starch, Cellulose 2.2.2 Breakdown of oligosaccharides - Lactose, Maltose, Sucrose, Cellobiose. 2.2.3 Utilization of monosaccharides - Fructose and Galactose. 2.2.4 Major pathways – (with structure and enzymes) 2.2.4.1 Glycolysis (EMP) 2.2.4.2 HMP Pathway 2.2.4.3 ED pathway 2.2.4.4 TCA cycle and its significance 2.2.4.5 Incomplete TCA in anaerobic bacteria 2.2.4.6 Anaplerotic reactions **2.3** Amphibolic role of EMP; Amphibolic role of TCA cycle **2.4** Energetics of Glycolysis and TCA.		2L 11L 1L 1L	Mathews, C.K., K.E. van Holde, D.R. Appling, S, J, Anthony-Cahill Biochemistry, 4th edition. White, D., The Physiology and Biochemistry of Prokaryotes, 4th edition, Stanier, R. Y., M. Doudoroff and E. A. Adelberg. General Microbiology, 5th edition, Gottschalk,G., (1985), Bacterial Metabolism, 2nd edition Nelson, D. L. and M.M. Cox, Lehninger, Principles of biochemistry. 8th Edition, Conn, E.E., P. K .Stumpf, G. Bruening and R. Y. Doi. Outlines of Biochemistry, 5th edition,
3	**Fermentative Pathways & Anabolism of Carbohydrates**	**01**	15	
	3.1 Fermentative pathways (with structure and enzymes) 3.1.1 Lactic acid fermentation - Homofermentation and Heterofermentation 3.1.2 Bifidium pathway 3.1.3 Alcohol fermentation – by ED pathway (bacteria) and EMP (yeasts). **3.2 Other modes of fermentation in microorganisms** 3.2.1 Mixed acid		4L 5L	White, D., The Physiology and Biochemistry of Prokaryotes, 4th edition, Stanier, R. Y., M. Doudoroff and E. A. Adelberg. General Microbiology, 5th edition,

	3.2.2 Butanediol 3.2.3 Butyric acid 3.2.4 Acetone-Butanol 3.2.5 Propionic acid (Acrylate pathway) **3.3 Anabolism of Carbohydrates** 3.3.1 General pattern of metabolism from glucose 3.3.2 Sugar nucleotides 3.3.3 Gluconeogenesis 3.3.4 Biosynthesis of glycogen 3.3.5 Calvin Benson cycle (Dark reaction) 3.3.6 Reductive TCA cycle (Dark reaction)		6L	Gottschalk,G., (1985), Bacterial Metabolism, 2nd edition Nelson, D. L. and M.M. Cox, Lehninger, Principles of biochemistry. 8th Edition, Conn, E.E., P. K .Stumpf, G. Bruening and R. Y. Doi. Outlines of Biochemistry, 5th edition,

MBO303D- Practicals based on MBO303B

1. Study of oxidative and fermentative metabolism
2. Isolation of Lactic acid bacteria - Homo – Heterofermentation in microbes
3. Mixed acid fermentations- Detection of organic acids by TLC
4. Chemical estimation of sugar by Cole's ferricyanide method
5. Chemical estimation of alcohol
6. Isolation and detection of Mitochondria
7. Glucose detection by GOD/POD
8. Study of biochemical pathway and study of end products of enzymes in characterization of microorganisms.

SEMESTER V – DSE 2
Course code: MBO304B (Marine Microbiology)

COURSE OUTCOMES	**BACHELOR OF MICROBIOLOGY** **NAME OF THE COURSE: DSE 2- Marine Microbiology**
After completion of the course the student will be able to-	
CO 01	Explain the key characteristics of oceanography, diverse marine habitats, and the fundamental growth and physiology of marine microorganisms.
CO 02	Apply knowledge of microbial roles in ocean processes and describe common sampling methods and molecular tools used to study marine microbial diversity.
CO 03	Analyze the effects of various pollutants on marine ecosystems and compare different microbial strategies for energy acquisition and bioremediation of marine contaminants.
CO 04	Evaluate the significance of marine microbes in global nutrient cycles and primary productivity, and assess the utility of biomonitoring and biotechnological applications of marine microorganisms for pollution control.
CO 05	Demonstrate practical skills and design basic research approaches for investigating microbial communities in specific marine environments and propose microbial-based solutions for addressing marine pollution challenges.

Unit	**Topic**	**Credits**	**Lectures**	**References**
1	**Introduction to Marine Microbiology**	01	15	Mitchell, R. and Kirchman, D.L. Microbial ecology of the oceans, Wiley.
	1.1 Introduction to oceanography: the world's oceans and seas, **1.2 Properties of seawater**, **1.3 Physico-chemical factors in the marine environment** -temperature, density, nutrients, salinity, dissolved gases, waves, tides, oceanic currents. **1.4 Marine microbial habitats**: estuaries, mangroves, salt marshes, beach and coastal ecosystems, reef and coral reefs, water column, sediments.		1L 2L 5L 7L	
2	**Marine microbes**	01	15	
	2.1 Growth, physiology and contribution of Marine microbes to ocean processes **2.2 Modes of microbial growth:** viable but non-culturable (VBNC) microorganisms, biofilms, microbial mats, epibiosis		1L 2L 4L	Cavera, J.H., Karl, D. and Buckley, M. Marine microbial diversity: Key to earth's habitability, ASM.

	2.3 Physiology of marine microbes: metabolic diversity and energyyielding processes: microbial loop; marine snow; phototrophy and primary productivity, fermentation, aerobic respiration, anaerobic respiration (denitrification, sulphate reduction, methanogenesis); nitrification, annamox, sulphur oxidation, methanotrophy; carbon dioxide fixation in autotrophs; the role of microorganisms in biogeochemical cyling: carbon, nitrogen, phosphorous, sulphur, iron, manganese. **2.4 Sampling equipment:** water samplers such as Niskin sampler, HydroBios sampler, Rosette samplers; sediment samplers such as van Veen grabs and corers **2.5 Tools to study marine microbial diversity:** flow cytometry (bacteria, picoplankton, picoeukaryotes, viruses); molecular approaches such as metagenomics, community fingerprinting and Fluorescence in situ hybridization (FISH).		3L 5L	Mitchell, R. and Kirchman, D.L. Microbial ecology of the oceans, Wiley. Belkin, S and Cowell, R.R. Ocean & health: Pathogens of the marine environment, Springer
3	**Marine Pollution and Microbial Remediation**	01	15	
	3.1Impacts of marine pollution on marine ecosystems and community structure- Eutrophication, anaerobiosis, biomagnification, biofouling, bioadhesion, biocorrosion. 3.2 **Effect of marine pollutants on productivity and sustainability of marine econiche-** 3.2.1 Effect of marine pollution (toxicity) on phytoplankton (primary producers), zooplankton, fishes, coral reefs, barnacles, crabs, mussels, humans. 3.2.2 Environmental impact assessment (EIA). 3.2.3Application of marine microorganisms towards pollution abatement and sustainable development. **3.3 Biomonitoring of marine pollutants** -Bioindicators		1L 5L 3L 4L 2L	Prince, R. C. Bioremediation of marine oil spills. In: Handbook of hydrocarbon and lipid microbiology, Springer. Judith, S.W. Marine pollution: What everyone needs to know. Oxford University Press

	(bioindicator bacteria), biotracers and biosensors 3.4 **Bioremediation of metals mediated by marine bacteria:** 3.4.1 Heavy metal resistant marine bacteria from coastal waters, marine sediments, hydrothermal vent. 3.4.2 Biochemical and molecular mechanisms of lead, cadmium & mercury resistance in marine bacteria/fungi and phytoplankton which can be harnessed for bioremediation technologies **3.5 Biodegradation**: Bioremediation of hydrocarbons in marine environments, oil spill/tar ball management. Biosurfactants (bioemulsifier), bioaugmentation, biostimulation.			

MBO304D- Practicals based on MBO304B

1	Isolation and identification of microbes from mangroves, coastal waters and sediments.
2	Assessment of salt tolerance of marine isolates from different ecosystem.
3	Nitrification and denitrification by the marine bacterial isolates.
4	Enrichment and isolation of crude oil degrading marine bacteria.
5	Isolation of biosurfactant producing microorganisms.
6	Visit to National institute of Oceanography.
7	Case studies on Marine pollution.

Semester V Vocational I
Course Code: MBO301C (Clinical Microbiology)

COURSE OUTCOMES	**BACHELOR OF MICROBIOLOGY** **NAME OF THE COURSE: Vocational-I - Clinical Microbiology**
After completion of the course the student will be able to-	
CO 01	Explain the mechanisms of microbial pathogenicity.
CO 02	Describe the pathogenesis, clinical features, laboratory diagnosis, treatment, and prevention of respiratory tract, gastrointestinal tract, skin and urinary tract infections.
CO 03	Apply fundamental microbiological techniques, serological tests, culture-based identification, and biochemical testing, to characterize and presumptively identify pathogens from standard cultures and simulated clinical samples, thereby gaining insight into diagnostic procedures of a clinical laboratory.

	Vocational I - Clinical Microbiology			
Unit	**Topic**	**Credits**	**Lectures**	**References**
1	**Unit I: Microbial Pathogenicity and Infections**	01	15	
	1.1. Bacterial Pathogenicity with examples 1.1.1 Pathogenicity islands 1.1.2 Exotoxins (tabular form- examples with mode of action) 1.1.3 Endotoxins (tabular form - examples with mode of action)		2L	Jawetz, Medical Microbiology, 29th Edition, Lange publication
	1.2. Study of A Few Infectious Diseases of the Upper and Lower Respiratory Tract (wrt.Cultural Characteristics of the etiological agent, pathogenesis & clinical features, laboratory diagnosis, treatment and prevention only) 1.2.1 Tuberculosis 1.2.2 Bacterial Pneumonia caused by *K.pneumoniae* 1.2.3 List of Viruses with examples. 1.2.4 List of emerging pathogens		4L	
	1.3 Study of skin infections 1.3.1 Pyogenic skin infections caused by *Pseudomonas* , *S.aureus and S.pyogenes*.. 1.3.2 Leprosy		4L	Ananthanarayan and Panicker's, Textbook of Microbiolog

	1.3.3 Fungal infections- Candidiasis 1.3.4 Viral Infections- Herpes simplex 1.3.5 List of Viruses with examples. **1.4 Study of gastrointestinal tract infections** 1.4.1 Infections due to Enteropathogenic *E.coli* strains 1.4.2 Enteric fever- *Salmonella* 1.4.3 Dysentery- Bacillary (Shigella) and amoebic (*Entamoeba histolytica*) dysentery 1.4.4 List of Viruses with examples. 1.4.5 Cholera **1.5 Study of urinary tract infections (only pathogens and factors involved)**		4L 1L	y, 12th Edition 2022

Practicals based on Vocational I

1	Acid fast staining –To detect *Mycobacteria* spp.
2	Identification of Candida species using the germ tube test and growth on Chrom agar.
3	Study of standard cultures – E*. coli, Klebsiella spp., Proteus spp., Pseudomonas spp., Salmonella typhi, S. paratyphi A, S. paratyphi B, Shigella spp., S .pyogenes, Vibrio cholera,, S. aureus*
4	Identification of isolates obtained from the following samples by morphological, cultural and biochemical properties i) pus ii) sputum iii) stool iv) urine
5	Detection of Antigen-Antibody interaction using Demonstration of Widal test (Qualitative and Quantitative)
6	Visit to Diagnostic Laboratory

Semester V Vocational II
Course Code: MBO302C (Immunohematology)

COURSE OUTCOMES	**BACHELOR OF MICROBIOLOGY** **NAME OF THE COURSE: Vocational-II – Immunohematology**
After completion of the course the student will be able to-	
CO 01	Describe the structure and function of lymphoid organs, antigens, immunoglobulins, and cytokines in the immune system.
CO 02	Explain the role of the major histocompatibility complex (MHC) in antigen presentation and recognition.
CO 03	Perform and apply the principles of immunohaematology, including detection of blood group systems, assess compatibility for transfusion reactions and serological assays based on antigen-antibody reactions.

2	**Vocational II- Immunohematology**	01	15	
	2.1 Structure of lymphoid organs - function of Thymus, Bone marrow, Spleen and Lymph Node		2L	Kuby Immunology, WH Freeman, 8th Edition, 2018
	2.2 Antigens 2.2.1. Definition: Immunogenicity, Antigenecity, Haptens, 2.2.2 Types of antigens – heterophile antigens, isophile antigens, sequestered antigens, super antigens, bacterial and viral antigens, 2.2.3 Factors that influence immunogenicity - Foreignness, Molecular size, Chemical composition, Heterogeneity, Susceptibility of antigen to be processed and presented, Contribution of the biological system to immunogenicity, Genotype of the recipient		4L	
	2.3 Immunoglobulins 2.3.1 Immunoglobulins – basic structure of Immunoglobulins, types of heavy and light chains; constant and variable regions, Immunoblobulin domains-hinge region, hypervariable region, complementarity-determining regions (CDRs), framework regions (FRs) and their importance. 2.3.2 Immunoglobulin classes and biological activities - Immunogloublin G, Immunogloublin M, Immunogloublin A, Immunogloublin E, Immunogloublin D, (including diagrams). 2.3.2 2.3.2 Application of Antibodies- Monoclonal Antibodies (production by Hybridoma Technology).		3L	Kuby Immunology, WH Freeman, 8th Edition, 2018

	2.4 Cytokines- Properties and Attributes **2.5 Major histocompatibility complex** 2.5.1 Introduction 2.5.2 Three major classes of MHC encoded molecules 2.5.3 The basic structure and functions of Class I and Class II MHC Molecules 2.5.4 Peptide binding by Class I and Class II MHC molecule **2.6 Immunohaematology** **2.6.1 Human blood group systems**, ABO, secretors and nonsecretors, Bombay Blood group. Rhesus system and list of other blood group systems, transfusion reactions.		1L 3L 2L	Kuby Immunology, WH Freeman, 8th Edition, 2018 Ananthanarayan and Panicker's, Textbook of Microbiology, 12th Edition 2022

Practicals based on Vocational II

1	Blood grouping – Direct & Reverse typing
2	Coomb's Direct test
3	Determination of Isoagglutinin titer
4	Detection of cytokines - ELISPOT Assay (Demonstration)
5	Major and Minor Cross Matching

Third Year Semester VI - Units – Topics – Teaching Hours

S. N	Subject Code		Subject Unit Title	Hours/Lectures	Total No. of hours/lectures	Credit	Total Marks
1	**MBO305B** Molecular Biology and Virology	**1**	Recombinant DNA Technology	**15**	45 L	3	100
		2	Virology	**15**			
		3	Genetic Exchange & Homologous Recombination	**15**			
	MBO305D		Practicals based on MBO305B	**30**		1	
2	**MBO306B** Medical Microbiology and Immunology	**1**	Study of a vector-borne, STD's and central nervous system infections	**15**	60 L	3	100
		2	Chemotherapy and Immunization	**15**			
		3	Immunology –I	**15**			
	MBO306D		Practicals based on MBO306B	**30**		**1**	
3	**MBO306C** Biotechnology Advances and Applications	**1**	Biotechnology Advances and Applications	**15**		2	50
		2	Practicals	**30**			
4	**MBO307B** DSE I - Microbial Metabolism	**1**	Lipid and Nucleic Acid Metabolism	**15**	45 L	3	100
		2	Metabolism of Proteins and Inorganic compounds	**15**			
		3	Metabolic Regulation and Photosynthesis	**15**			
	MBO307D		Practicals based on MBO307B	**30**		**1**	
4	**MBO308B** DSE II - Bioethics, Biosafety and IPR	**1**	Bioethics	**15**	45 L	3	100
		2	Biosafety	**15**			
		3	Intellectual Property Rights (IPR)	**15**			
	MBO308D		Practicals based on MBO308B	**30**		**1**	
5	**MBO304C** VOC I	1	Downstream Processing	15	15 L	1	50
			Practicals based on Downstream Processing	30		1	

	Fermentation technology						
6	**MBO305C** VOC II Industrial Fermentations	1	Traditional Fermentations	15	15 L	1	50
			Practicals based on Industrial Fermentation	30		1	

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

- **Lecture Duration – I hour**
- **One Credit =15 hours theory/ 30 hours practical**

Part 6: Detail Scheme Theory

Semester VI Major I
Course Code: MBO305B (Molecular Biology and Virology)

COURSE OUTCOMES	**BACHELOR OF MICROBIOLOGY** **NAME OF THE COURSE: Molecular Biology and Virology**
After completion of the course the student will be able to-	
CO 01	Explain the fundamental principles of recombinant DNA technology, virology, and bacterial genetic exchange.
CO 02	Analyze the molecular mechanisms underlying genetic exchange in bacteria, the role of plasmids and transposable elements, and the process of homologous recombination.
CO 03	Compare and contrast different types of cloning vectors, viral replication strategies, and bacterial genetic transfer mechanisms, evaluating their advantages and limitations for specific applications.
CO 04	Apply theoretical knowledge to perform and interpret common laboratory techniques in molecular biology and virology.
CO 05	Evaluate the diverse applications of recombinant DNA technology and establish the relationship between viral architecture and life cycles with methodologies for their propagation, identification, and enumeration.

Unit	**Topic**	**Credits**	**Lectures**	**References**
1	**Recombinant DNA Technology**	1	15	Primrose and Twyman, (2001), "Principles of gene manipulation and genomics", 6th edition, Blackwell Publishing
	1.1 Basic steps in Gene Cloning. **1.2 Cutting and joining DNA molecules** - Restriction and modification systems, restriction endonucleases, DNA ligases, Adapters and linkers **1.3 Vectors** 1.3.1 Plasmids as cloning vectors. plasmid vectors, pBR322 vector, Cloning genes into pBR322 1.3.2 Phage as cloning vectors, cloning genes into phage vector 1.3.3 Cosmids 1.3.4 Shuttle vectors		1L 3L 5L	

	1.3.5 Artificial chromosomes- YAC, BAC 1.3.6 Expression Vectors **1.4 Methods of transformation** **1.5 Screening and selection methods for identification and isolation of recombinant cells** **1.6 Applications of recombinant DNA technology:** Site-specific mutagenesis of DNA, Uses of DNA polymorphism, STRS and VNTRS, DNA molecular testing for human genetic diseases (Only RFLP), DNA typing, gene therapy, Genetic engineering of plants and animals.		2L 1L 3L	iGenetics by Russell 3rd edition
2	**Virology**		15	
	2.1 Viral architecture and Viral classification (Baltimore classification) **2.2 Structure** and **Life cycle** of TMV, T4 phage, Lambda phage (with regulation), Influenza virus, HIV. **2.3 Cultivation of viruses**- cell culture techniques, embryonated egg, laboratory animals.		2L 5L 3L	Edward Wagner and Martinez Hewlett, (2005) "Basic Virology", 2nd edition, Blackwell Publishing
	2.4 Visualization and enumeration of virus particles - 2.4.1 Measurement of infectious units - Plaque assay, fluorescent focus assay, Infectious center assay, Transformation assay, Endpoint dilution assay. 2.4.2 Measurement of virus particles and Measurement of viral enzyme activity. **2.5 Prions:** Definition, Examples of diseases caused by prions, Kuru, PrP protein and protein only hypothesis **2.6 Viroids**		2L 2L 1L	Teri Shors,.(2009), "Understanding viruses", Jones and Bartlett publishers. Flint, Enquist, Racanillo and Skalka, "Principles of virology", 2nd edition. ASM press.
3	**Genetic Exchange & Homologous Recombination**	01	15	
	3.1 Genetic analysis of Bacteria **3.2 Transposable Elements in Prokaryotes** 3.2.1 Insertion sequences 3.2.2 Transposons: Types, Structure and properties, Mechanism of transposition, Integrons **3.3 Transformation** - Introduction and History, Types of transformation in prokaryotes-Natural transformation in *Streptococcus pneumoniae,*		1L 2L 3L	iGenetics: A Molecular Approach January 2016 by Russell

	Haemophilus influenzae, and *Bacillus subtilis*. Mapping of bacterial genes using transformation. **3.4 Plasmids -**Physical nature, Detection and isolation of plasmids, Plasmid incompatibility and Plasmid curing, Cell to cell transfer of plasmids, Types of plasmids- Resistance Plasmids, Plasmids encoding Toxins and other Virulence characteristics, Colfactor, Degradative plasmids **3.5 Conjugation-** Discovery of conjugation in bacteria, Properties of F plasmid/Sex factor, The conjugation machinery, Hfr strains, their formation and mechanism of conjugation, F' factor, origin and behavior of F' strains, Sexduction. Mapping of bacterial genes using conjugation (Wolman and Jacob experiment). **3.6 Transduction -**Introduction and discovery, Generalized transduction, Use of Generalized transduction for mapping genes, Specialized transduction **3.7 Recombination in bacteria -** General/Homologous recombination, Holliday model of recombination, Enzymes required for recombination		2L 4L 2L 1L	Snustad, Simmons, "Principles of genetics", 3rd edition. John Wiley & sons, Inc.

Course Code: MBO305D (Practicals based on MBO305B)

1	Isolation and detection of plasmid DNA of *E. coli*
2	Enrichment of coliphages, phage assay.
3	Restriction digestion of lambda phage / plasmid DNA
4	Preparation of competent cells and transformation
5	Demonstration of conjugation.
6	Genetic recombination problems
7	Blue white screening (demonstration)

Semester VI Major II
Course Code: MBO306B (Medical Microbiology and Immunology)

COURSE OUTCOMES	**BACHELOR OF MICROBIOLOGY** **NAME OF THE COURSE: Medical Microbiology and Immunology**
After completion of the course the student will be able to-	
CO 01	Describe the etiology, pathogenesis, laboratory diagnosis, and prevention of major vector-borne, sexually transmitted, and central nervous system infections.
CO 02	Discuss the mechanisms of action of antimicrobial agents, the development of antimicrobial resistance, and the principles of antibiotic susceptibility testing.
CO 03	Explain the processes of antigen presentation and T cell activation, differentiation, and effector functions in cell-mediated immunity and fundamental principles of vaccination and types of vaccines.
CO 04	Understand the processes of B cell activation, differentiation, and the development of the humoral immune response, including antibody production, memory formation and activation pathways of the complement system.
CO 05	Perform experiments and determine the antibiotic susceptibility profiles of bacterial isolates, synergy testing, interpret MIC and MBC values and fundamental microbiological and serological techniques.

Unit	**Topic**	**Credits**	**Lectures**	**References**
1	**Study of a vector-borne, STD's and central nervous system infections**	01	15	
	(Emphasis on Cultural Characteristics of the Etiological Agent, Pathogenesis, Laboratory Diagnosis and Prevention). 1.1 **Study of vector-borne infection** - Malaria 1.2 **Study of sexually transmitted infectious diseases** 1.2.1 Syphilis 1.2.2 AIDS 1.2.3 Gonorrhoea 1.2.4 Chlamydial infections 1.3 **Study of central nervous system infectious diseases** 1.3.1 Tetanus 1.3.2 Polio 1.3.3 Rabies 1.3.4 Meningitis (Bacterial and Viral)		1L 7L 7L	Jawetz, Medical Microbiology, 29th Edition, Lange publication Ananthanarayan and Panicker's, Textbook of Microbiology, 12th Edition 2022

2	**Chemotherapy and Immunization**	01	15	
	2.1 Mode of action of antibiotics on: a) Bacteria 2.1.1 Cell wall (Beta-lactams- Penicillin, Cephalosporins and Carbapenems) 2.1.2 Cell Membrane (Polymyxin and Imidazole) 2.1.3 Protein Synthesis (Streptomycin, Tetracycline and Chloramphenicol) 2.1.4 Nucleic acid (Quinolones, Nalidixic acid, Rifamyicn 2.1.5 Enzyme inhibitors (Sulfa drugs, Trimethoprim) 2.1.6 Antifungal, Antiviral, Antiprotozoal agents (Tabular- examples and mode of action) **2.2 Antimicrobial Resistance** 2.2.1 Reasons and mechanisms of drug resistance 2.2.2 Prevention and Control of AMR 2.3 **Selection and testing of antibiotics for bacterial isolates-** by Kirby Bauer method, E-test. **2.4 Vaccines** 2.4.1 Active and passive immunization 2.4.2 Types of vaccines - Killed and attenuated vaccines, Whole organism vaccines, Purified macromolecules as vaccines, recombinant viral vector vaccines, DNA vaccines, Conjugant or Multivalent vaccine 2.4.3 New vaccine strategies 2.4.4 Use of Adjuvants to Enhance the Immune Response to a Vaccine 2.4.5. Routes of Administration **2.5 Complement System** **2.5.1** Functions and components of complement 2.5.2 Complement Activation—classical, alternative and lectin pathway		6L 7L 2L	Prescott's microbiology 12th edition 2023 Jawetz, Medical Microbiology, 29th Edition, Lange publication Introduction to diagnostic microbiology for lab Science, Maria Dannessa Delost 2020 Prescott's microbiology 12th edition 2023 Jawetz, Medical Microbiology, 29th Edition, Lange publication Kuby Immunology, WH Freeman, 8th Edition, 2018
3	Immunology – I	01	15	
	3.1 Antigen presenting cells 3.1 Types of APC's 3.2 Endogenous antigens: The cytosolic pathway 3.3 Exogenous antigens: The endocytic pathway **3.2 T cells**		2L	Kuby Immunology, WH Freeman, 8th Edition, 2018

	3.2.1 T Cell Receptor-structure (alpha-beta, gamma-delta TCR) 3.2.2 TCR-CD3 complex - structure and functions. Accessory molecules 3.2.3 T cell activation 3.2.3.1 TCR mediated signaling – Overview 3.2.3.2 Costimulatory signals 3.2.3.3 Superantigens induced T cell activation 3.2.4 T cell differentiation (Memory and Effector cells) **3.3 Cell mediated effector response** 3.3.1 General properties of effector T cells 3.3.2 Cytotoxic T cells and destruction of target cell by perforin/granzyme pathway and Fas pathway 3.3.3 Killing mechanism of NK cells 3.3.4 Antibody mediated cell cytotoxicity (ADCC) **3.4 B cells** 3.4.1 B cell receptor and co-receptor-structure and function 3.4.2 B cell activation and Differentiation 3.4.2.1 Thymus dependant and independent antigens 3.4.2.2 Signal transduction pathway activated by BCR overview 3.4.2.3 Role TH cell in B cell response-Formation of T-B conjugates, CD40/CD40L interaction, TH cells cytokine signals **3.5 Humoral Response** 3.5.1 Primary and secondary responses 3.5.2 In vivo sites for induction of Humoral response 3.5.3 Germinal centers and antigen induced B cell Differentiation 3.5.3.1 Cellular events within germinal centers-Overview 3.5.3.2 Affinity maturation, somatic hyper-mutation and class switching 3.5.3.3 Generation of plasma cells and memory cells		3L 3L 2L 5L	

Course Code: MBO506D (Practicals based on MBO506B)

1	Demonstration of malarial parasite in blood films (Demo)
2	Demonstration experiments – VDRL Test

3	Selection and testing of antibiotics using the Kirby-Bauer method.
4	Determination of MIC and MBC of an antibiotic
5	Synergy testing of antibiotics.
6	Vaccine Preparation: O & H antigen preparation of Salmonella. Confirmation by slide agglutination
7	Determination of MIC of an antibiotic by E-test

Semester VI DSE I
Course Code: MBO307B (Microbial Metabolism)

COURSE OUTCOMES	**BACHELOR OF MICROBIOLOGY** **NAME OF THE COURSE: DSE I: Microbial Metabolism**
After completion of the course the student will be able to-	
CO 01	Understand roles of biomolecules (lipid, protein, nucleic acids), metabolism of biomolecules, inorganic metabolism, and metabolic/transcriptional regulation.
CO 02	Apply knowledge of metabolic pathway to predict biomolecule fate and explain operon functions, and light reactions.
CO 03	Analyze differences in metabolic pathways (fatty acid, nucleotide, amino acid), their regulatory mechanisms, and photosynthetic mechanisms.
CO 04	Evaluate the significance of storage molecules, energetic efficiency, regulatory mechanisms, and lithotrophic/photosynthetic diversity.
CO 05	Design experiments to estimate production and breakdown of macromolecules along with their regulatory mechanisms.

Unit	Topic	Credits	Lectures	References
1	**Lipid and Nucleic Acid Metabolism**	01	15	White, D., The Physiology and Biochemistry of Prokaryotes, 4th edition, Gottschalk,G., (1985), Bacterial Metabolism, 2nd edition Nelson, D. L. and M.M. Cox, Lehninger, Principles of biochemistry. 8th Edition, Conn, E.E., P. K .Stumpf, G. Bruening and
	1.1 Introduction to Lipids 1.1.1 Types and role of fatty acids found in bacteria, role of lipase. 1.1.2 Common phosphoglycerides in bacteria		1L	
	1.2 Catabolism of Fatty Acids and Poly Hydroxybutyric acid (PHB) 1.2.1 Oxidation of saturated fatty acid by β oxidation pathway 1.2.2 Energetics of β oxidation of Palmitic acid 1.2.3 Oxidation of propionyl CoA by acrylyl-CoA pathway and methylcitrate pathway 1.2.4 PHB as a food reserve and its degradation		4L	
	1.3 Anabolism of Fatty Acids & Lipids 1.3.1 Biosynthesis of straight chain even			

	carbon saturated fatty acid 1.3.2 Biosynthesis of phosphoglycerides in bacteria 1.3.3 Biosynthesis of PHB **1.4 Catabolism of aliphatic hydrocarbons** 1.4.1 Organisms degrading aliphatic hydrocarbons 1.4.2 Hydrocarbon uptake mechanisms 1.4.3 Omega oxidation pathway in *Corynebacterium* and Yeast **1.5 Catabolism of Nucleotides** 1.5.1 Degradation of purine nucleotides up to uric acid formation. 1.5.2 Salvage pathway for purine and pyrimidine nucleotides. **1.6. Anabolism of nucleotides** 1.6.1 Metabolic origin of atoms in purine and pyrimidine ring 1.6.2 Biosynthesis of pyrimidine nucleotides 1.6.3 Biosynthesis of deoxyribonucleotides		4L 1L 2L 3L	R. Y. Doi. Outlines of Biochemistry, 5th edition,
2	**Metabolism of Proteins and Inorganic compounds** **2.1 Protein / amino acid catabolism** 2.1.1 Enzymatic degradation of proteins. 2.1.2 General reactions of amino acids- decarboxylases, deaminases, transaminases and racemases. 2.1.3 Metabolic fate of amino acids - Glucogenic and ketogenic amino acids. 2.1.4 Fermentation of single amino acid - Glutamic acid by *Clostridium tetanomorphum* 2.1.5 Fermentation of a pair of amino acids - Stickland reaction. **2.2 Anabolism of amino acids** 2.2.1 Schematic representation of amino acid families 2.2.2 Biosynthesis of amino acids of Serine		15 6L 2L	G. Moat, J.W. Foster, M, P. Spector. Microbial Physiology, 4th edition WILEY-LISS White, D., The Physiology and Biochemistry of Prokaryotes, 4th edition, Stanier, R. Y., M. Doudoroff and E. A. Adelberg. General Microbiology, 5th edition,

	family (Serine, Glycine and Cysteine) **2.3 Inorganic Metabolism** 2.3.1 Assimilatory pathways: 2.3.1.1 Assimilation of nitrate, 2.3.1.2 Ammonia fixation – Glutamate dehydrogenase, glutamine synthetase and glutamate synthase (GS-GOGAT) 2.3.1.3 Biological nitrogen fixation – nitrogenase reaction. 2.3.1.4 Assimilation of sulphate 2.3.2 Dissimilatory pathways: 2.3.2.1 Nitrate as an electron acceptor (Denitrification in *Paracoccus denitrificans*) 2.3.2.2 Sulphate as an electron acceptor **2.4 Lithotrophy**–Tabular-oxidation of Hydrogen, carbon monoxide, Ammonia, Nitrite, Sulphur, Iron		6L 1L	Gottschalk,G., (1985), Bacterial Metabolism, 2nd edition Nelson, D. L. and M.M. Cox, Lehninger, Principles of biochemistry. 8th Edition,
3	**Metabolic Regulation and Photosynthesis**	01	15L	Madigan, M.T. and J.M. Martinko 15th edition, Brock Biology of Microorganisms. Pearson Prentice Hall. Nelson, D. L. and M.M. Cox, Lehninger, Principles of biochemistry. 8th Edition, Conn, E.E., P. K .Stumpf, G. Bruening and R. Y. Doi. Outlines of Biochemistry, 5th edition,
	3.1 Definition of terms and major modes of regulation **3.2 Regulation of enzyme activity** 3.2.1 Noncovalent enzyme inhibition 3.2.2 Covalent modification of enzymes with examples (without structures) 3.2.3 Regulation of Glutamine synthetase **3.3 DNA binding proteins and regulation of transcription by positive & negative control** 3.3.1 DNA binding proteins 3.3.2 Negative control of transcription: Repression and attenuation in trp operon 3.3.3 Positive control of transcription: Maltose operon **3.4 Global regulatory mechanisms** 3.4.1 Global control & catabolite repression 3.4.2 Stringent response		1L 3L 5L 1L	

	3.5 Regulation of EMP and TCA cycle - (Schematic) **3.**6 **Photosynthesis** - Definition light reaction, Hill reaction & reagent, Photophosphorylation. 3.6.1 Photosynthetic pigments 3.6.2 Location of photochemical apparatus 3.6.3 Light reactions: (Schematic) 3.6.3.1 Purple photosynthetic bacteria 3.6.3.2 Green sulphur bacteria 3.6.3.3 Cyanobacteria		1L 4L	Stanier, R. Y., M. Doudoroff and E. A. Adelberg. General Microbiology, 5th edition, White, D., The Physiology and Biochemistry of Prokaryotes, 4th edition,

Practicals based on DSE I

1. Detection of PHB producing bacteria
2. Determination of degree of unsaturation of fats and oils.
3. To study catabolite repression by diauxic growth curve.
4. Protein estimation by Lowry‘s method
5. Estimation of uric acid
6. Qualitative and Quantitative assay of Protease
7. Study of Lithotrophs – Nitrosification and Nitrification

SEMESTER VI –DSE II

Course Code: MBO308B (Bioethics, Biosafety and IPR)

COURSE OUTCOMES	**BACHELOR OF MICROBIOLOGY** **NAME OF THE COURSE: DSE II: BIOETHICS, BIOSAFETY AND IPR**
After completion of the course the student will be able to-	
CO 01	Identify core bioethical principles, biotech ethics, biosafety levels, and IPR types.
CO 02	Explain ethical issues in research, biosafety regulations, and biotech patentability
CO 03	Analyze ethical arguments in microbiology, compare biosafety guidelines, and aIPR case studies.
CO 04	Evaluate effectiveness of ethical guidelines, stringency of biosafety, and arguments for biotech patents.
CO 05	Formulate solutions to ethical dilemmas, biosafety protocols, or IPR strategies.

Unit	**Topic**	**Credits**	**Lectures**	**References**
1	**Bioethics**	01	15	S. Ignacimuthu, Bioethics, Alpha Science International, Limited (2009) Ethical issues in microbiology, P Desikan, A Chakrabarti, V Muthuswamy. Indian Ethics in medical research: General principles with special reference to psychiatry research., Ajit Avasthi,
	1. 1 Nature, Concept, Need and Relevance of Bioethics, paradigms of Bioethics – National & International. **1.2.** Bioethical guidelines in plants, animals and microbial research. **1.3.** Bioweapons: Social and ethical implication of biological weapons. **1.4**. Ethical guidelines for biomedical research on human subjects and use of animals, Ethical issues in molecular technologies and cloning. **1.5**. Ethical issues in Healthcare, Informed Consent		3L 6L 4L 2L	
2	**Biosafety**	01	15	
	2.1 Biosafety – Introduction to biosafety and health hazards concerning biotechnology, Good Laboratory Practices (GLP) and Good Manufacturing Practices (GMP). **2.2**. Introduction to the concept of containment level and Biological Safety Cabinets & their types; Biohazards, Principles and Practices in Microbial and Biomedical Labs.		3L 6L 3L	Diane O. Fleming, Debra L. Hunt Biological Safety: Principles and Practices, 4th Edition. ASM 2006

	2.3 Biosafety guidelines and regulations (National and International); Cartagena Protocol on Bio-safety, Nagoya Protocol, Laws relating to Bio-safety in India; GMOs/LMOs- Concerns and Challenges. **2.4.** Role of Institutional Biosafety Committees (IBSC), RCGM, GEAC for GMO applications in food and agriculture.		3L	
3	**Intellectual Property Rights (IPR)**	01	15	
	3.1 Intellectual Property Rights -History and Necessity of IPR **3.2.** Terminologies-Patents, Trademarks, Copyright , Trade secrets, Industrial Design and Rights, Traditional Knowledge, Industrial Design, Geographical Indications, Protection of Plant Varieties. **3.3.** Patentable and non-patentable, patenting life-legal protection of biotechnological inventions. Pros and Cons of IP protection. **3.4** Patents organizations and Acts - World Intellectual Property Rights Organization (WIPO), Trade Related Aspects of Intellectual Property Rights (TRIPS); General Agreement on Trade and Tariff (GATT), WIPO Treaties; Budapest Treaty on international recognition of the deposit of microorganisms; Patent Co-operation Treaty (PCT), Indian Patent Act 1970 & recent amendments. **3.5** Types of patent applications: An introduction to Patent Filing Procedures; Patent infringement. **3.6.** Patent Case study: Basmati Case, Neem Controversy, Turmeric Case.		1L 3L 2L 5L 2L 2L	Verkey, Elizabeth, Intellectual Property Law and Practice, Eastern Book Company, Lucknow Shomini Parashar, Deepa Goel IPR, Biosafety and Bioethics Pearson India 2013 Ahuja, V.K., Law Relating to Intellectual Property Rights, 3 rd Ed. Lexis Nexis Intellectual Property Rights by K. R. G. Nair, Ashok Kumar

Unit	Topic	Credits	Lectures	References
1	**Bioethics**	01	15	

	1. 1 Nature, Concept, Need and Relevance of Bioethics, paradigms of Bioethics – National & International. **1.2.** Bioethical guidelines in plants, animals and microbial research. **1.3.** Bioweapons: Social and ethical implication of biological weapons. **1.4**. Ethical guidelines for biomedical research on human subjects and use of animals, Ethical issues in molecular technologies and cloning. **1.5**. Ethical issues in Healthcare, Informed Consent		3L 6L 4L 2L	S. Ignacimuthu, Bioethics, Alpha Science International, Limited (2009) Ethical issues in microbiology, P Desikan, A Chakrabarti, V Muthuswamy. Indian Ethics in medical research: General principles with special reference to psychiatry research., Ajit Avasthi,
2	**Biosafety**	01	15	
	2.1 Biosafety – Introduction to biosafety and health hazards concerning biotechnology, Good Laboratory Practices (GLP) and Good Manufacturing Practices (GMP). **2.2**. Introduction to the concept of containment level and Biological Safety Cabinets & their types; Biohazards, Principles and Practices in Microbial and Biomedical Labs. **2.3** Biosafety guidelines and regulations (National and International); Cartagena Protocol on Bio-safety, Nagoya Protocol, Laws relating to Bio-safety in India; GMOs/LMOs- Concerns and Challenges. **2.4.** Role of Institutional Biosafety Committees (IBSC), RCGM, GEAC for GMO applications in food and agriculture.		3L 6L 3L 3L	Diane O. Fleming, Debra L. Hunt Biological Safety: Principles and Practices, 4th Edition. ASM 2006
3	**Intellectual Property Rights (IPR)**	01	15	

	3.1 Intellectual Property Rights -History and Necessity of IPR **3.2.** Terminologies-Patents, Trademarks, Copyright , Trade secrets, Industrial Design and Rights, Traditional Knowledge, Industrial Design, Geographical Indications, Protection of Plant Varieties. **3.3.** Patentable and non-patentable, patenting life-legal protection of biotechnological inventions. Pros and Cons of IP protection. **3.4** Patents organizations and Acts - World Intellectual Property Rights Organization (WIPO), Trade Related Aspects of Intellectual Property Rights (TRIPS); General Agreement on Trade and Tariff (GATT), WIPO Treaties; Budapest Treaty on international recognition of the deposit of microorganisms; Patent Co-operation Treaty (PCT), Indian Patent Act 1970 & recent amendments. **3.5** Types of patent applications: An introduction to Patent Filing Procedures; Patent infringement. **3.6.** Patent Case study: Basmati Case, Neem Controversy, Turmeric Case.		1L 3L 2L 5L 2L 2L	Verkey, Elizabeth, Intellectual Property Law and Practice, Eastern Book Company, Lucknow Shomini Parashar, Deepa Goel IPR, Biosafety and Bioethics Pearson India 2013 Ahuja, V.K., Law Relating to Intellectual Property Rights, 3 rd Ed. Lexis Nexis Intellectual Property Rights by K. R. G. Nair, Ashok Kumar

Practicals based on DSE II

1.	Searching of Patent databases
2.	Drafting and filing of Patent application
3.	Case studies on the patent infringements
4.	Case study on Revocations of Patents
5.	Drafting and filing application for bioethical clearance.
6.	Assignment- on Compulsory licensing
7.	Project on setting up of Biosafety and Bioethical committees.

SEMESTER VI DSC

Course Code: MBO306C (Biotechnology Advances and Applications)

Subject code	Details	Credits	Lectures (30)
	Unit 1 **1.1 Environmental biotechnology** 1.1.1 Biological fuels: Petroleum prospecting and Microbially Enhanced Oil Recovery (MEOR) 1.1.2 Environmental monitoring, Biosensor, DNA Probes **1.2 Food biotechnology** 1.2.1 Introduction of functional foods and nutraceuticals 1.2.2 Production: nutraceuticals (lycopene), Prebiotics & Probiotics 1.2.3 Food additives and ingredients: Food additives- definitions and functions, (Preservatives, antioxidants, colours, emulsifiers, sequestrants, natural and microbial flavours) 1.2.4 Encapsulation and Controlled Release of Bio functional Ingredients in Functional Foods, Bioactive Compounds, Antimicrobial Bioactive Agents 1.2.5 Application of Enzymes in the Food Industry- Glycoside hydrolases, Cellulase, Pectinase, Proteases, Lipases. **1.3 Applications in Marine Biotechnology** 1.3.1 Bioprospecting 1.3.2 Applications of Marine biotechnology - Bioactive compounds, Marine Nutraceuticals, Marine Probiotics, Marine Components in Cosmetics and Sources, Cosmeceuticals) **1.4 Medical biotechnology** 1.4.1 Introduction to Genetic testing and disorders, Medical Prenatal diagnosis, Genetic counselling 1.4.2 Protein therapeutics- Hormones, cytokines.	**1**	**15**

Practicals

1.	Determination of antimicrobial activity of bioactive agents from functional foods
2.	Estimation of Lycopene.
3.	Estimation of Antioxidant activity
4.	Microbiological analysis of probiotics.

5.	Isolation of pigment producing and bioluminescent microbes from marine environments

SEMESTER VI VOC 1 –
Course Code: MBO304C (Fermentation Technology)

COURSE OUTCOMES	**BACHELOR OF MICROBIOLOGY** **NAME OF THE COURSE: VOC 1 Fermentation Technology**
After completion of the course the student will be able to-	
CO 01	Understand fundamental downstream processing, effluent, QA/QC, and sterilization concepts.
CO 02	Analyze and compare the role of various techniques and processes of recovery, effluent treatment, enzyme immobilization and fermentations.
CO 03	Apply downstream processing, immobilization strategies, patenting, bioassays, quality control and assurance and sterility assurance.

Unit	Topic	Credits	Lectures	References
1	**Downstream Processing**	01	15	
	1.1 Recovery and purification 1.1.1 Introduction 1.1.2 Methods of Downstream Processing 1.1.2.1 Removal of microbial cells and other solid matter 1.1.2.2 Foam separation 1.1.2.3 Precipitation 1.1.2.4 Filtration- Theory, Use of filter aids, Batch filters- Plate and frame filters, Continuous filters- Rotary vacuum filter 1.1.2.5 Centrifugation 1.1.2.6 Cell Disruption- Physical-mechanical and Chemical methods (Tabular) 1.1.2.7 Liquid-Liquid Extraction 1.1.2.8 Solvent Recovery 1.1.2.9 Chromatography- Adsorption and Ion Exchange 1.1.2.10 Membrane Processes 1.1.2.11 Drying 1.1.2.12 Whole Broth Processing		8L 2L 2L	Principles of Fermentation Technology - 2nd edition by Stanbury and Whitakar Pharmaceutical Microbiology, Hugo and Russell, 7 th edition

	1.2 Effluent treatment 1.2.1 Introduction 1.2.2 Dissolved oxygen concentration as indicator of water quality 1.2.3 Treatment process: Physical processes**,** Chemical processes, Biological processes(Tabular) 1.2.4 Introduction to carbon credits **1.2 Quality assurance and quality control** 1.2.1 Definitions- Manufacture, Quality, Quality Control, In-Process Control, Quality Assurance, Good Manufacturing Practices. Chemicals, Pharmaceuticals, Nutraceuticals 1.2.2 Variables of batch process 1.2.3 Q.A and Q.C w.r.t Raw materials, finished products, label and labeling, packaging materials 1.2.4 Control of microbial contamination during manufacturing **1.3 Sterilization control and assurance** 1.3.1 Introduction 1.3.2 Bioburden determinations 1.3.3 Environmental Monitoring 1.3.4 Sterilization Monitoring 1.3.5 Sterility Testing 1.3.6 Viruses (phages) in Industrial Microbiology **1.4 Bioassay** 1.4.1 Introduction 1.4.2 Types: Diffusion, End Point, Turbidometric, Metabolic Response, Enzymatic 1.4.3 Modern methods for assay of fermentation products		1L 2L	Bioprocess Technology by H. A. Modi- Volume 2 Industrial Microbiology by Casida

Practicals based on VOC I

1.	Bioassay of an antibiotic (Ampicillin / Penicillin).
2.	Bioassay of Cyanocobalamin
3.	Bioautography
4.	Sterility testing of injectable/ vaccine.
5.	Quality assurance of media.
6.	Estimation of phenol

SEMESTER VI VOC 2 -Industrial Fermentations

COURSE OUTCOMES	**BACHELOR OF MICROBIOLOGY** **NAME OF THE COURSE: VOC 2: Traditional fermentations**
After completion of the course the student will be able to-	
CO 01	Outline and describe the core biochemistry, technology behind industrial fermentations and their basic production and recovery.
CO 02	Analyze key factors affecting fermentation efficiency and recovery methods.
CO 03	Apply the principles of upstream and downstream processing in fermentations.

Unit	Topic	Credits	Lectures	References
1	**Industrial Fermentations**		15	
	1.1 Alcohol and Alcoholic Beverages **1.1.1 Alcohol from Molasses:** Introduction, Biosynthesis of ethanol, Production process, Recovery by distillation. **1.1.2 Wine – Red, White:** Composition of grape juice, Sulphur dioxide addition, Factors affecting wine fermentation, Examples and role of yeasts involved in fermentation, Malolactic fermentation, Technological aspects of red and white wine making		6L 2L	Textbook of Industrial Microbiology by Crueger Prescott and Dunn's 'Industrial Microbiolo

	1.1.3 Beer – Ale and Lager: Elements of brewing process, Mash preparation, Use of cylindro-conical vessel, Primary fermentation, continuous fermentation, aging and finishing, Yeasts involved in fermentation.		3L	gy' (1982) 4th edition
	1.2 Organic acid fermentation **1.2.1 Vinegar (acetic acid):** Introduction, Biosynthesis, production using Generator, Production using submerged fermenter, Recovery		3L	
	1.2.2 Citric acid: Introduction, Strains used for production, Biosynthesis, Nutrient media, Production processes- surface and submerged, Product recovery.			
	1.3 Antibiotic fermentation **1.3.1 Penicillin and semisynthetic penicillins:** Introduction, Biosynthesis and regulation, Strain development, Production and recovery methods, Semisynthetic penicillins: Examples and advantages		1L	
	1.4 Microbial Biomass production **1.4.1 Baker's yeast:** Outline of production, Yeast strains and their properties, Factors important in production-oxygen, concentration of sugar, pH, temperature, Preparation of substrate, fermentation, harvesting of yeast cells, Production of compressed and active dry yeast. **1.4.2 Mushroom cultivation (Agaricus):** Edible mushroom species, Preparation of substrate- composting- phase I and phase II, Factors affecting composting, Preparation of spawn, casing, induction of fruiting body formation, harvesting			
	1.5 Vitamin B 12: Occurrence and economic significance, Structure and biosynthesis, Production based on media containing carbohydrates by-			

	Propionibacteria and *Pseudomonas,* Recovery.			

Practicals based on VOC 2

1.	Production of wine
2.	Alcohol Fermentation a) Preparation and standardization of yeast inoculums for alcohol fermentation b) Laboratory Alcohol fermentation using jaggery medium, c) Calculation of efficiency of fermentation.
3.	Estimation of citric acid using titrimetric method
4.	Chemical estimation of Penicillin.
5.	Mushroom cultivation