TUMKUR UNIVERISTY

TUMKUR 572103

B.Sc. MICROBIOLOGY Curriculum

for

Four-Year Undergraduate Multidisciplinary Programme (Honours)

As per Frame work of NEP-2020 Curriculum for the Third and Fourth Semester

Board of Studies in Microbiology

Department of Microbiology

University college of Science

Tumkur University

Tumkur 572103 Karnataka, India

2022 Onwards

PREAMBLE

The role of education is paramount in nation building. One of the major objectives of UGC is maintenance of standards of higher education. Over the past decades the higher education system of our country has undergone substantive structural and functional changes resulting in both quantitative and qualitative development of the beneficiaries. Such changes have gained momentum with the introduction of Choice Based Credit System (CBCS) which further expects Learning Outcome-Based curriculum to maximize the benefits of the newly designed curriculum. The Learning Outcome- Based Curriculum in Microbiology will help the teachers of the discipline to visualize the curriculum more specifically in terms of the learning outcomes expected from the students at the end of the instructional process. The commission strives to promote the link of students with the society/industry such that majority of the students engage in socially productive activities during their period of study in the institutions and at least half of the graduate students will secure access to employment/self-employ mentor engage themselves in pursuit of higher education. The model curriculum envisages to cater to the developmental trends in higher education, incorporating multi- disciplinary skills, professional and soft skills such as teamwork, communication skills, leadership skills, time management skills and inculcate human values, professional ethics, and the spirit of Innovation /entrepreneurship and critical thinking among students and promote avenues for display of these talents, linking general studies with professional courses. Besides imparting disciplinary knowledge to the learners, curriculum should aim to equip the students with competencies like problem solving, analytical reasoning and moral and ethical awareness. Introduction of internship and appropriate fieldwork/case studies are embedded in the curriculum for providing wider exposure to the students and enhancing their employability.

Learning outcomes specify what exactly the graduates are expected to know after completing a Programme of study. The expected learning outcomes are used as reference points to help formulate graduate attributes, qualification descriptors, Programme learning outcomes and course learning outcomes. Keeping the above objectives of higher education in mind the Learning Outcome-Based Curriculum Framework (LOCF) for the discipline of Microbiology was prepared and presented here.

Model Curriculum

Program Name	**B.Sc. Discipline**	Total Credits for the Program	**176**
Core	**Microbiology**	Starting year of implementation	**2021-22**

Program Outcomes: At the end of the program the student should be able to:

(Refer to literature on outcome-based education (OBE) for details on Program Outcomes)

PO1. Knowledge and understanding of concepts of microbiology and its application in pharma, food, agriculture, beverages, nutraceuticals industries.

PO2. Understand the distribution, morphology and physiology of microorganisms and demonstrate the skills in aseptic handling of microbes including isolation, identification and maintenance

PO3. Competent to apply the knowledge gained for conserving the environment and resolving the environmental related issues.

PO4. Learning and practicing professional skills in handling microbes and contaminants in laboratories and production sectors.

PO5. Exploring the microbial world and analyzing the specific benefits and challenges

PO6. Applying the knowledge acquired to undertake studies and identify specific remedial measures for the challenges in health, agriculture, and food sectors.

PO7. Thorough knowledge and application of good laboratory and good manufacturing practices in microbial quality control

PO8. Understanding biochemical and physiological aspects of microbes and developing broader perspective to identify innovative solutions for present and future challenges posed by microbes.

PO9. Understanding and application of microbial principles in forensic and working knowledge about clinical microbiology

PO10. Demonstrate the ability to identify ethical issues related to recombinant DNA technology, GMOs, intellectual property rights, biosafety and biohazards.

PO11. Demonstrate the ability to identify key questions in microbiological research, optimize research methods, and analyze outcomes by adopting scientific methods, thereby improving the employability.

PO12. Enhance and demonstrate analytical skills and apply basic computational and statistical techniques in the field of microbiology.

CURRICULUM

Name of the Degree Program	**:**	**BSc (Basic/Hons.)**
Discipline Core	**:**	**Microbiology**
Total Credits for the Program	**:**	**B.Sc. Basic - 136 and B.Sc. Hons. - 176**
Starting year of implementation	**:**	**2021-22**

Program Outcomes:
Competencies need to be acquired by the candidate
Securing B.Sc. (Basic) or B.Sc. (Hons)

By the end of the program the students will be able to:

1. Knowledge and understanding of concepts of microbiology and its application in pharma, food, agriculture, beverages, nutraceuticals industries.
2. Understand the distribution, morphology and physiology of microorganisms and demonstrate the skills in aseptic handling of microbes including isolation, identification and maintenance.
3. Competent to apply the knowledge gained for conserving the environment and resolving the environmental related issues.
4. Learning and practicing professional skills in handling microbes and contaminants in laboratories and production sectors.
5. Exploring the microbial world and analyzing the specific benefits and challenges.
6. Applying the knowledge acquired to undertake studies and identify specific remedial measures for the challenges in health, agriculture, and food sectors.
7. Thorough knowledge and application of good laboratory and good manufacturing practices in microbial quality control.
8. Understanding biochemical and physiological aspects of microbes and developing broader perspective to identify innovative solutions for present and future challenges posed by microbes.
9. Understanding and application of microbial principles in forensic and working knowledge about clinical microbiology.
10. Demonstrate the ability to identify ethical issues related to recombinant DNA technology, GMOs, intellectual property rights, biosafety and biohazards.
11. Demonstrate the ability to identify key questions in microbiological research, optimize research methods, and analyze outcomes by adopting scientific methods, thereby improving the employability.
12. Enhance and demonstrate analytical skills and apply basic computational and statistical techniques in the field of microbiology.

Assessment:
Weightage for assessments (in percentage)

Type of Course	Formative Assessment / IA	Summative Assessment
Theory	**30%**	**70%**
Practical	**30%**	**70%**
Projects	**40%**	**60%**
Experiential Learning (Internships/MOOC/ Swayam etc.)	**30%**	**70%**

Curriculum Structure for the Undergraduate Degree Program
B.Sc. (Basic / Hons.)

Total Credits for the Program : 176
Starting year of implementation : 2021-22
Name of the Degree Program : B.Sc. (Basic/Hons.) Microbiology

Program Articulation Matrix:

Semester	Title /Name Of the course	Program outcomes that the course addresses (not more than 3 per course)	Pre-requisite course(s)	Pedagogy	Assessment
1	DSC-1T MBL 101 General Microbiology 4 Credits 100 Marks	1. Knowledge and understanding of concepts of microbiology. 2. Learning and practicing professional skills in handling microbes. 3. Thorough knowledge and application of good laboratory and good manufacturing practices in microbial quality control.	PUC or +2 (Life sciences as one of the core disciplines)	The general pedagogy to be followed for theory and practical are as under. Lecturing, Tutorials, Group/Individual Discussions, Seminars, Assignments, Counselling, Remedial Coaching. Field/Institution/Industrial visits, Hands on training, Case observations, Models/charts preparations, Problem solving mechanism, Demonstrations, Project presentations, Experiential documentation and Innovative methods.	LSSSDC (NSDC) assessment and certification for lab technician or Lab assistant job role
	DSC-1P MBL 101 General Microbiology 2 Credits 50 Marks				
2	DSC-2T MBL 102 Microbial Biochemistry and Physiology 4 Credits 100 Marks	Thorough knowledge and understanding of concepts of microbiology and its application in different microbiological industries.		The general pedagogy to be followed for theory and practicals are as under. Lecturing, Tutorials, Group/Individual Discussions, Seminars, Assignments, Counselling, Remedial Coaching. Field/Institution/Industrial visits, Hands on training, Case observations, Models/charts preparations, Problem solving mechanism, Demonstrations, Project presentations,	LSSSDC (NSDC) assessment and certification for lab technician or Lab assistant job role

				Experiential documentation and Innovative methods.	
	DSC-2P MBL 102 Microbial Biochemistry and Physiology 2 Credits 50 Marks				

3	DSC-3T MBL 103 Microbial diversity 4 Credits 100 Marks				
	DSC-3P MBL 103 Microbial diversity 2 Credits 50 Marks				

4	DSC-4T MBL 104 Microbial Enzymology and Metabolism 4 Credits 100 Marks				
	DSC-4P MBL 104 Microbial Enzymology and Metabolism 2 Credits 50 Marks				

	DSC-5T MBL 105 Microbial genetics and Molecular biology 3 Credits 100 Marks				
5	DSC-5P MBL 105 Microbial genetics and Molecular biology 2 Credits				

	50 Marks				
	DSC-6T MBL 106 Immunology and Medical microbiology 3 Credits 100 Marks				
	DSC-6P MBL 106 Immunology and Medical microbiology 2 Credits 50 Marks				

6	DSC-7T MBL 107 Food and Dairy Microbiology 3 Credits 100 Marks				
	DSC-7P MBL 107 Food and Dairy Microbiology 2 Credits 50 Marks				
	DSC-8T MBL 108 Industrial Microbiology and Bioprocess Technology 3 Credits 100 Marks				
	DSC-8P MBL 108 Industrial Microbiology and Bioprocess Technology 2 Credits 50 Marks				

	DSC-9T MBL 109 Microbial Genetic Engineering 3 Credits 100 Marks				
	DSC-9P MBL 109				

7	Microbial Genetic Engineering 2 Credits 50 Marks				
	DSC-10T MBL 110 Environmental and Agricultural Microbiology 3 Credits 100 Marks				
	DSC-10P MBL 110 Environmental and Agricultural Microbiology 2 Credits 50 Marks				
	DSC-11T MBL 111 Pharmaceutical and Forensic Microbiology 4 Credits 100 Marks				

8	DSC-12T MBL 112 Biosafety, Bioethics & IRP 4 Credits 100 Marks				
	DSC-13T MBL 113 Genomics, Proteomics and Metabolomics 4 Credits 100 Marks				
	DSC-14T MBL 114 Aquatic Microbiology 3 Credits 100 Marks				

9	DSC-15T MBL 115 Microbial Genetic Engineering 3 Credits 100 Marks				
	DSC-15P MBL 115 Microbial Genetic Engineering 2 Credits 50 Marks				
	DSC-16T MBL 116 Environmental and Agricultural Microbiology 3 Credits 100 Marks				
	DSC-16P MBL 116 Environmental and Agricultural Microbiology 2 Credits 50 Marks				
	DSC-17T MBL 117 Pharmaceutical and Forensic Microbiology 4 Credits 100 Marks				

10	DSC-18T MBL 118 Emerging Microbial Technologies 4 Credits 100 Marks				
	DSC-19T MBL 119 Extremophylic Microbes and Extremolytes 4 Credits 100 Marks				
	DSC-20T MBL 120 Molecular Diagnosis, Drug Designing and Advanced Vaccines 3 Credits 100 Marks				

Note:

Pedagogy for student engagement is predominantly lectures. However, other pedagogies enhancing better student engagement to be recommended for each course. The list includes active learning/ course projects/ problem or project based learning/ case studies/self-study like seminar, term paper or MOOC.

Every course needs to include assessment for higher order thinking skills (Applying/ Analyzing/ Evaluating/ Creating). However, this column may contain alternate assessment methods that help formative assessment (i.e. assessment for learning).

Pedagogy:

The general pedagogy to be followed for theory and practicals are as under.
Lecturing, Tutorials, Group/Individual Discussions, Seminars, Assignments, Counseling, Remedial coaching. Field/Institution/Industrial visits, Hands on training, Case observations, Models/charts preparations, Problem solving mechanism, Demonstrations,
Project presentations, experimental documentation and Innovative methods

Formative Assessment : 30%	
Assessment Occasion/ type	**Weightage in Marks**
IA (2 Tests)	10% : 10 Marks
Assignments/Visits	10% : 10 Marks
Seminars/Group Discussion	10% : 10 Marks
Total	30% : 30 Marks

Assessment

Weightage for assessments (in percentage)

Type of Course	Formative Assessment/IA	Summative Assessment
Theory	40	60
Practical	25	25
Projects	-	-
Experiential Learning (Internships etc.)	-	-

Contents of Courses for B.Sc. Microbiology as Major

Model II A

Semester	Course code	Course Category	Theory/ Practical	Credits	Paper Title	Marks	
						S.A	I.A
3.	MBL-103	DSC- 7	Theory	4	Microbial Diversity	60	40
			Practical	2	Microbial Diversity	25	25
		OE-3	Theory	3	Microbial Entrepreneurship	60	40
4.	MBL-104	DSC- 8	Theory	3	Microbial Enzymology and Metabolism	25	25
			Practical	2	Microbial Enzymology and Metabolism	60	40
		OE-4	Theory	3	Human Microbiome	25	25

Model Curriculum

Program Name	**B.Sc. Microbiology**		Semester	**Third Semester**
Course Title	**Microbial Diversity**			
Course No.	**MBL-103**	**DCS-3T**	No. of Theory Credits	**4**
Contact hours	**56 hrs.**		Duration of ESA/Exam	**2 Hours**
Formative Assessment Marks			Summative Assessment Marks	

Course Pre-requisite(s):

Course Outcomes(COs): At the end of the course the student should be able to:

1. Knowledge about microbes and their diversity
2. Study, characters, classification and economic importance of prokaryotic and eukaryotic microbes.
3. Knowledge about viruses and their diversity

Content	**56Hrs**
Unit–I	**14Hrs**
Biodiversity and Microbial Diversity Concept, definition, and levels of biodiversity; Major classification systems- Whittaker's Five Kingdom Classification, Carl Woese Three Domain classification. Microbial Taxonomy and Systematics-Microbial Taxonomy: General introduction and overview of Taxonomic hierarchy: Concept of species, sub-species, variant, types and strain. General Methods used in Microbial taxonomy: I) Polyphasic taxonomy: a) Phenotypic classification b) Phylogenetic classification c) Genotypic classification. Chemotaxonomy and Numerical taxonomy Major Characteristics of Microorganisms used nomenclature, classification and identification: Morphological Characteristics; Chemical Characteristics; Cultural Characteristics; Physiological and metabolic Characteristics; Genetic Characteristics; Ecological Characteristics; Molecular Characteristics; Nucleic Acid Hybridization; Nucleic acid Sequencing. Genomic Finger Printing. Phylogenetic Tree for the illustration of evolution of microbial diversity.	
Unit-II	**14Hrs**
Diversity of Prokaryotic Microorganisms: An overview of Bergey's Manual of Systematic Bacteriology (Brief account of major clades of **Bacteria and Archaea).** **General characters, Structure, classification and economic importance of the following :** Diversity of Archaea with example of Methanogenes. Diversity of Eubacteria with examples of *–Escherichia coli, Staphylococcus aureus* Diversity of Photosynthetic bacteria with examples of - *Nostoc, Microcystis* and *Spirulina,* Purple and green sulphur bacteria Diversity of Actinobacteria (actinomycetes) with *Streptomyces* as example. Diversity of Rickettsia with *Rickettsia rickettsii* as example. Diversity of Chlamydiae with *Chlamydia trachomatis* as example Diversity of Spirochetes with *Treponema pallidum* as example. Diversity of Mollicutes with *Mycoplasma* as example	

Unit -III	14Hrs
Diversity of Eukaryotic Microorganisms: **A brief overview of Fungal classification with Alexopoulos and Mim's/Ainsworth classification.** General characters; Classification and Economic importance of the following Eukaryotic microorganisms Study up to the level of classes, Salient features, thallus structure, reproduction and economic importance of: *Rhizopus, Aspergillus, Saccharomyces, Penicillium, Agaricus* and *Fusarium* Salient features, Classification, thallus structure, reproduction and economic importance of the following algae: *Chlorella*, Diatoms and *Gracilaraia.* Salient features, Classification, thallus organization, reproduction and symbiotic association of Lichens. Salient features, Classification, structure, reproduction of the following Protozoa: *Trichomonas*, *Trypanosoma*, *Entamoeba.*	
Unit-IV	**14Hrs**
Diversity of Virus General properties, structure, replication cultivation and significance of virus. Isolation, purification, and assay of viruses. Principles of Viral Taxonomy-Baltimore and ICTV and the recent trends. Capsid symmetry-Icosahedral, helical complex Structure **Replication and Significance of the following:** **Human & Animal viruses:** HIV, Corona, Oncogenic virus and FMDV **Plant viruses:** TMV, Ring spot virus **Microbial viruses:** T4/lambda/cyano/mycophages. Sub viral particles, Viriods, Virusoids, satellite virus and Prions.	

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs1-12)

Course Outcomes(COs)/Program Outcomes(POs)	Program Outcomes(POs)											
	1	2	3	4	5	6	7	8	9	10	11	12
Knowledge about microbes and their diversity		✓			✓			✓				
Study,characters,classification and economic importance of Prokaryotic and Eukaryotic microbes		✓	✓		✓							
Knowledge about viruses and their diversity		✓				✓				✓		

Pedagogy: Lectures, Seminars, Industry Visits, Debates, Quiz and Assignments

Summative Assessment=60 Marks	
Formative Assessment Occasion/type	**Weightage in Marks**
Attendance	10
Seminar	10
Debates and Quiz	10
Test	10
Total	**60marks+40marks=100marks**

Course Title	**Microbial Diversity**		Practical Credits	**2**
Course No.	**MBL-103**	**DSC-3P**	Contact hours	

Content

1.Preparation of microbiological media : Nutrient agar, nutrient broth, Potato dextrose agar Martin's Rose Bengal agar
2. Isolation and enumeration of bacteria from soil and water using serial dilution technique.
3. Isolation and identification of fungi from soil using serial dilution technique
4.Isolation of bacteria from air by Petri plate exposure method
5.Study of morphology and colony characteristics of bacteria
6. Cultivation of Actinomycetes
7. Measurement of microbial cell size by Micrometry
8. Study of cyanobacteria -*Nostoc, Microcyctis* and *Spirulina*
9. Study of Algae –*Chlorella, Diatoms* and *Gracilaria*
10. Study of Fungi – *Rhizopus, Aspergillus, Saccharomyces, Penicillium, Agaricus* and *Fusarium*
11. Study of Protozoa – *Trichomonas,Trypanosoma and Entamoeba*
12.Study of HIV, Corona, Oncogenicvirus, H1N1, FMDV, TMV, Ringspotvirus, T4/lambda/cyano/mycophages Subviral particles (Viroids and Prions)
14. Study of Archaea-methanogens, cyanobacteria: *Nostoc, Microcystis, Spirulina*; Eubacteria-*E. coli*, *Staphylococcus aureus*, Actinobacteria; *Streptomyces, Nocardia, Frankia*; Rickettsiae-*Rickettsia rickettsi*-Chlamydiae- *Chlamydia trachomatis*; Spirochetes-*Treponema pallidum*
15. Identification and characterization bacteria (*Staphylococcus* spp.)

Practical assessment

Assessment			
Formative assessment		**Summative Assessment**	**Total Marks**
Assessment Occasion /type	**Weightage in Marks**	**Practical Exam**	
Record	5	25	**50**
Test	10		
Attendance	5		
Performance	5		
Total	**25**	**25**	

References	
1	Black, J. G.2002. Microbiology-Principles and Explorations. John Wiley and Sons, Inc. New York
2	Brock, T.D. and Madigan, M. T. 1988. Biology of Microorganisms, V Edition. Prentice Hall. New Jersey
3	Dimmock, N. J., Easton, A.J., and Leppard, K. N.2001. Introduction to Modern Virology. 5th edn.Blackwell publishing, USA
4	Flint,S.J.,Enquist,L.W.,Drug,R.M.,Racaniello,V.R.andSkalka,A.M.2000.Principles of Virology- Molecular Biology, Pathogenesis and Control. ASM Press, Washington, DC
5	Prescott,Harley,Klein'sMicrobiology,J.M.Willey,L.M.Sherwood,C.J.Woolverton,7th International, edition 2008, McGraw Hill
6	Vashishta B. R, Sinha A. K and Singh V. P. Botany– Fungi 2005, S. Chand and Company Limited, New Delhi
7	KotpalR.LProtozoa5thEdition2008, Rastogi Publications, Meerut, New Delhi.
8	Brock Biology of Microorganisms, M.T. Madigan, J.M. Martinko, P. V. Dunlap, D. P. Clark- 12th edition, Pearson International edition 2009, Pearson Benjamin Cummings

References	
9	Microbiology – An Introduction, G. J. Tortora, B. R. Funke, C. L. Case, 10th ed. 2008, Pearson Education
10	General Microbiology, Stanier, Ingrahametal, 4th and 5th edition 1987, Macmillan education limited
11	Microbiology-Concepts and Applications, Pelczar Jr. Chan, Krieg, International ed, McGraw Hill
12	Alexopoulos, C. J., Mims, C. W., and Blackwell, M. 2002. Introductory Mycology. John Wiley and Sons (Asia) Pvt. Ltd. Singapore. 869 pp
13	Vashishta, B.R Sinha A.K and Singh V.P. Botany-Algae 2005 S. Chand and Company Limited, New Delhi
14	A Textbook of Microbiology, R. C. Dubey and D. K. Maheshwari, 1st edition, 1999, S. Chand & Company Ltd, New Delhi
15	Foundations in Microbiology, K. P.Talaro,7th International edition 2009 , McGraw Hill

Model Curriculum

Program Name	**B.Sc Microbiology**		Semester	**Fourth Semester**
Course Title	**Microbial Enzymology and Metabolism**			
Course No.	**MBL:104**	**DCS-4T**	No. of Theory Credits	**4**
Contact hours	**56hrs**		Duration of ESA/Exam	**2 Hours**
Formative Assessment Marks	**40**		Summative Assessment Marks	**60**

Course Pre-requisite(s):

Course Out comes (COs): At the end of the course the student should be able to:

1. Differentiating concepts of chemoheterotrophic metabolism and chemolithotrophic metabolism.
2. Describing the enzyme kinetics, enzyme activity and regulation.
3. Differentiating concepts of aerobic and anaerobic respiration and how these are manifested in the form of different metabolic pathways in microorganisms

Content	**56Hrs**
Unit–I	**14Hrs**
Basics of Enzymes **Definitions of terms** – Enzyme unit, specific activity and turnover number, exo/endoenzymes, constitutive/ induced enzymes, isozymes. Monomeric, Oligomeric and Multimeric enzymes. Multienzyme complex: pyruvate dehydrogenase; isozyme: Lactate dehydrogenase. Ribozymes, abzymes **Structure of enzyme**: Apoenzyme and cofactors, prosthetic group-TPP, coenzyme, NAD, metal cofactors. Classification of enzymes, Mechanism of action of enzymes: active site, transition state complex and activation energy. Lock and key hypothesis and Induced Fit hypothesis. **Microbial Enzymes: Sources**- Bacterial, Fungal, Yeast and their applications.	
Unit-II	**14Hrs**
Enzyme Kinetics and Regulation **Enzyme Kinetics**: Michaelis-menton equation, km value and its significance, line weaver-burk plot, Kinetics of enzyme inhibition-reversible and irreversible; Competitive, non-competitive and uncompetitive inhibition. Factors affecting enzyme catalyzed reaction: Effect of enzyme concentration, substrate concentration, pH and temperature. **Enzyme regulation**: Allosteric enzymes regulation and Feedback inhibition. Isozymes	
Unit –III **Metabolism of Carbohydrates** **Chemoheterotrophic Metabolism**- Sugar degradation pathways i.e. EMP, ED, Pentose phosphate pathway, Phosphoketolase pathway. TCA cycle. Utilization of Lactose, Cellulose and Pectin.	**14Hrs**

Fermentation – Fermentation balance, concept of linear and branched fermentation pathways. Alcohol fermentation and Pasteur effect; Butyric acid and Butanol-Acetone Fermentation. **Chemolithotrophic Metabolism**: Chemolithotrophy – Hydrogen oxidation, Sulphur oxidation, Iron oxidation, Nitrogen oxidation. Anaerobic respiration with special reference to assimilatory nitrate reduction and sulphate reduction.	
Unit–IV	**14Hrs**
Unit-IV Metabolism of amino acids, nucleotides and lipids **1. Nitrogen Metabolism** Introduction to biological nitrogen fixation (Symbiotic and non-symbiotic); Ammonia assimilation. Assimilatory nitrate reduction, dissimilatory nitrate reduction, denitrification **2. Biosynthesis of ribonucleotides and deoxyribonucleotides:** The de novo pathway. Regulation by feedback mechanisms. Recycling via the salvage pathway **3. Amino acid biosynthesis and degradation** **4. Lipid biosynthesis and degradation** **5. Metabolism of one carbon compounds:** Methylotrophs: i. Oxidation of methane, methanol, methylamines; ii. Carbon assimilation in methylotrophic bacteria and yeasts Methanogens: i. Methanogenesis from H_2, CO_2, CHOH, HCOOH, methylamines. **Metabolism of two-carbon compounds: Acetate**- Glyoxylate cycle. **Acetic acid bacteria**: Ethanol oxidation, sugar alcohol oxidation.	

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs1-12)

Course Outcomes (COs)/Program Outcomes (POs)	Program Outcomes (POs)											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Differentiating concepts of chemoheterotrophic metabolism and chemolithotrophic metabolism		✓						✓			✓	
Describing the enzyme kinetics, enzyme activity and regulation		✓						✓			✓	
Differentiating concepts of aerobic and anaerobic respiration and how these are manifested in the form of different metabolic pathways in microorganisms		✓						✓			✓	

Pedagogy: Lectures, Seminars, Industry Visits, Debates, Quiz and Assignments

Summative Assessment=60 Marks	
Formative Assessment Occasion/type	**Weightage in Marks**
Attendance	10
Seminar	10
Debates and Quiz	10
Test	10
Total	**60 marks+40 marks=100 marks**

Course Title	**Microbial Enzymology and Metabolism**		Practical Credits	**2**
Course No.	**MBL:104**	**DSC-4P**	Contact hours	

Content

1. Identification of fatty acids and other lipids by TLC
2. Sugar fermentation tests for bacteria
3. Separation of amino acids by paper chromatography
4. Screening of fungi for cellulose and pectin degradation
5. Screening of fungi for invertase
6. Enzyme immobilization by Alginate method
7. Biochemical tests- IMViC, Gelatin hydrolysis, Catalase test, Oxidase test and Citrate Utilization Test.
9. Microscopic observation of symbiotic nitrogen fixing bacteria.
10. Demonstration of Ammonifiaction
11. Demonstration of Nitrification – Nitrite and Nitrate
12. Demonstration of Denitrification
13. Demonstration of lipolytic activity
14. Demonstration of citric acid production
15. Effect of variables on enzyme activity (amylase): A. temperature B. pH C. substrate concentration D. enzyme concentration
16. Study of photographs/models: Metabolism of carbohydrates; Chemolithotrophy- Hydrogen oxidation, Sulphur oxidation, Iron oxidation, Nitrogen oxidation, biological Nitrogen fixation, ammonia assimilation, ribozymes, abzymes, lock and key hypothesis, Induced fit model; enzyme inhibition – reversible and irreversible; Competitive, non-competitive. Enzyme regulation- allosteric enzymes. Feedback inhibition. Metabolism of amino acids, nucleotides and lipids.

Practical assessment

Assessment			
Formative assessment		Summative Assessment	Total Marks
Assessment Occasion/ type	Weightage in Marks	Practical Exam	
Record	5	25	50
Test	10		
Attendance	5		
Performance	5		
Total	25	25	

References

1	Philipp. G. Manual of Methods for General Bacteriology.
2	David T. Plummer. An Introduction to Practical Biochemistry
3	Biochemistry-A Problem Approach, Wood W.B.WilsonJ.H.,BenbowR.M.andHoodL.E.2nd ed., 1981,The Benjamin/Cummings Pub.co
4	Biochemical calculations, SegelI.R.,2nd ed.,2004,John Wiley and Sons
5	Biochemical Calculations, Irwin H. Segel, 2nd Edition John Wiley & Sons

SCHEME OF PRACTICAL EXAMINATION
III SEMESTER (NEP)
PRACTICAL III: Microbial Diversity (DSC 3P)

Time: 3 Hours **Max. Marks: 25**

1. Demonstrate the experiment "A" by giving principle and procedure. Record the result. 08 marks

(Isolation of bacteria from air by exposure plate method/Isolation and enumeration of bacteria from soil or water by serial dilution method/Isolation of fungi from air by exposure plate method/Isolation and identification of fungi from soil by serial dilution method/Micrometry)

Demonstration–2M, Principle–2M, Procedure –2M, Result–2M

2. Prepare a temporary mount of the given material 'B' and identify the organism with labeled diagram and significance. (Leave the preparation for evaluation.

05marks

(Staining of fungi/algae)

Preparation– 1 M, Identification–1M, Diagram & significance– 3M

3. Write critical notes on C, D, E and F **2x4 =08 marks**

(Permanent slides or photographs of cyanobacteria -*Nostoc, Microcyctis, Spirulina*; Algae – *Chlorella, Cosmarium, Diatoms, Gracilaria*: Fungi –*Rhizopus, Aspergillus, Saccharomyces, Penicillium, Agaricus, Fusarium:* Protozoa – *Trichomonas,Trypanosoma and Entamoeba*; Viruses;- HIV, H1N1, TMV, Corona virus, FMDV T4 Phage and Sub viral particles (Viroids and Prions) Oncogenic viruses. Archaea-, methanogens; Eubacteria: *E. coli* and *Staphylococcus aureus*. Actinomycetes; *Streptomyces, Nocardia, Frankia, Rickettsiae- Rickettsia rickettsi-* Chlamydiae- *Chlamydia trachomatis* Spirochaetes-*Treponema pallidum)*

5. Viva-voce **04marks**

Scheme of Practical examination for IV SEM (NEP)
IV: Microbial Enzymology and Metabolism (DSC 4P)

Time: 3 Hours **Max. Marks: 25**

1. **Demonstrate the experiment 'A' giving principle and procedure. Record the result.** **08 Marks**

(Separation of amino acids by paper chromatography / Screening of fungi for invertase / Enzyme immobilization by Alginate method / Screening of fungi for cellulose and pectin Degradation / Microscopic observation of symbiotic nitrogen fixing bacteria/bacteriods/ Identification of fatty acids and other lipids by TLC)
(Demonstration–2M, Principle–2M, Procedure–2M, Result–2M)

2. **Conduct the given biochemical test B giving principle and procedure. Write the significance.** **05 Marks**

(Gelatin hydrolysis /Sugar fermentation tests/Demonstration of Ammonification/Nitrification/Denitrification/Lipolytic activity/Demonstration of citric acid production)
(Demonstration–2M, Principle and Procedure–2M, Significance–1M)

3. **Write critical notes on C, D, E and F** **2x4=08 Marks**

(Study of photographs/models: Metabolism of carbohydrates; Chemolithotrophy- Hydrogen oxidation, Sulphur oxidation, Iron oxidation, Nitrogen oxidation, biological Nitrogen fixation, ammonia assimilation, ribozymes, abzymes, lock and key hypothesis, Induced fit model; enzyme inhibition – reversible and irreversible; Competitive, non-competitive. Enzyme regulation- allosteric enzymes. Feedback inhibition. Metabolism of amino acids, nucleotides and lipids)

4. **Viva-voce** **04 Marks**

Date: BOS Chairperson

Model Curriculum

Program Name	**B.Sc. Microbiology**		Semester	**Third Semester**
Course Title	**Microbial Entrepreneurship**			
Course Code		**OE-3**	No. of Theory Credits	**3**
Contact hours	**Lecture**		Duration of ESA/Exam	**Hours**
	Practical			
Formative Assessment Marks	**40**		Summative Assessment Marks	**60**

Course Pre-requisite(s):	
Course Outcomes (COs): At the end of the course the student should be able to: 1. Demonstrate Entrepreneurial skills 2. Acquire knowledge industrial Entrepreneurship 3. Acquire knowledge about Healthcare Entrepreneurship	
CONTENT	**42HRS**
Unit–I	**14Hrs**
General Entrepreneurship Entrepreneurship and microbial entrepreneurship-Introduction and scope, Business development, product marketing, HRD, Bio-safety and Bioethics, IPR and patenting, Government organization/institutions/ schemes, Opportunities and challenges.	
UNIT-II	**14Hrs**
Industrial Entrepreneurship Microbiological industries – Types, processes and products, Dairy products, Fermented foods, Bakery and Confectionery, Alcoholic products and Beverages, Enzymes – Industrial production and applications. Biofertilizers and Biopesticides, SCP (Mushroom and *Spirulina*)etc.	
Unit-III	**14Hrs**
Healthcare Entrepreneurship Production and applications: Sanitizers, Antiseptic solutions, Polyphenols (Flavonoids), Alkaloids, Cosmetics, Biopigments and Bioplastics, vaccines, Diagnostic tools and kits.	

Pedagogy: Lectures, Seminars, Industry Visits, Debates, Quiz and Assignments

Summative Assessment = 60Marks	
Formative Assessment Occasion/type	**Weightage in Marks**
Attendance	10
Seminar	10
Debates and Quiz	10
Test	10
Total	**60 marks+40 marks=100 marks**

References	
1	Srilakshmi B, (2007), Dietetics. New Age International publishers. New Delhi
2	Srilakshmi B, (2002), Nutrition Science. New Age International publishers. New Delhi
3	Swaminathan M. (2002), Advanced textbook on food and Nutrition. VolumeI. Bappco
4	Gopalan. C., Rama Sastry B.V., and S.C. Balasubramanian (2009), Nutritive value of Indian Foods. NIN .ICMR. Hyderabad.
5	Mudambi S R and Rajagopal M V,(2008), Fundamentals of Foods, Nutrition & diet therapy by New Age International Publishers, New Delhi

Model Curriculum

Program Name	**B.Sc. Microbiology**		Semester	**Fourth Semester**
Course Title	**Human Microbiome**			
Course Code		**OE-4T**	No. of Theory Credits	**3**
Contact hours	**Lecture**		Duration of ESA/Exam	**Hours**
	Practical			
Formative Assessment Marks	**40**		Summative Assessment Marks	**60**

Course Pre-requisite(s):	
Course Outcomes (COs): At the end of the course the student should be able to: 1. Articulate a deeper understanding on biological complexities of human microbiome 2. Understand broader goals of biological anthropology. 3. Compare and contrast the micro biome of different human body sites and impact human health promotion	
Content	**42Hrs**
Unit–I	**14Hrs**
INTRODUCTIONTO MICROBIOME Evolution of microbial life on Earth, Symbiosis host-bacteria. Microbial association with plants and animals, Symbiotic and parasitic, Normal human microbiota and their role in health. Microbiomes other than digestive system.	
Unit-II	**14Hrs**
MICROBIOMES AND HUMANHEALTH Microbiome in early life, Nutritional modulation of the gut microbiome for metabolic health-role of gut microbiomes in human obesity, human type 2 diabetes and longevity. Probiotics-Criteria for probiotics, Development of Probiotics for animal and human use; Pre and synbiotics. Functional foods- health claims and benefits, Development of functional foods.	

Unit -III	14Hrs
CULTURING OF MICROBES FROM MICROBIOMES Culturing organisms of interest from the microbiome: bacterial, archaeal, fungal and yeast, viral. Extracting whole genomes from the microbiome to study microbiome diversity **Microbiomes and diseases:** Microbiome and disease risks: The gut microbiome and host immunity, bacteriocins and other antibacterials. Human microbiome research in nutrition	

Pedagogy

Summative assessment=40 marks theory paper, End semester Exam duration of exam 2hours	
Formative Assessment Occasion/type	**Weightage in Marks**
Assignment	10
Seminar	10
Case studies	10
Test	10
Total	**40 marks**

References	
1	Angela E Douglas, (2018), Fundamentals of Microbiome Science: How Microbes Shape Animal Biology. Princeton University Press.248pp.
2	Giulia Enders and Jill Enders,(2018), Gut: The Inside Story of Our Body's Most Underrated Organ (Revised Edition). Greystone Books, 304pp.
3	Emeran Mayer,(2018),The Mind-Gut Connection: How the Hidden Conversation within our bodies impacts our mood, our choices, and our overall Health .Harper Wave,336pp.
4	Edward Ishiguro, Natasha Haskey and Kristina Campbell, (2018), Gut Microbiota.1st edition.2008pp.
5	Natalia V Beloborodova (2021), Human Microbiome. Intech Open,166pp.