Telephone No. 2419677/2419361
Fax: 0821-2419363/2419301

e-mail : registrar@uni-mysore.ac.in
www.uni-mysore.ac.in

UNIVERSITY OF MYSORE

Estd. 1916

VishwavidyanilayaKaryasoudha
Crawford Hall, Mysuru- 570 005

No.AC2(S)/151/2020-21 Dated:10.10.2022

Notification

Sub:- Syllabus and Examination Pattern of Microbiology (UG) (III & IV Semester) with effective from the Academic year 2022-23 as per NEP-2020.

Ref:-
1. Decision of Board of Studies in of Microbiology (UG) Meeting held on 22-08-2022.
2. Decision of the Faculty of Science & Technology Meeting held on 15-09-2022.
3. Decision of the Academic Council meeting held on 23-09-2022.

*****

The Board of Studies in Microbiology (UG) which met on 22-08-2022 has recommended & approved the syllabus and pattern of Examination of Microbiology Course (III & IV Semester) with effective from the Academic year 2022-23 as per NEP -2020.

The Faculty of Science & Technology and Academic Council at their meetings held on 15-09-2022 and 23-09-2022 respectively has also approved the above said syllabus and hence it is hereby notified.

The syllabus and Examination pattern is annexed herewith and the contents may be downloaded from the University Website i.e., www.uni-mysore.ac.in.

Draft Approved by the Registrar

DeputyRegistrar(Academic)

Deputy Registrar (Academic)
University of Mysore
Mysore-570 005

To:-

1. All the Principal of affiliated Colleges of University of Mysore, Mysore.
2. The Registrar (Evaluation), University of Mysore, Mysuru.
3. The Chairman, BOS/DOS, in Microbiology, Manasagangothri, Mysore.
4. The Dean, Faculty of Science & Technology, DoS in Earth Science, MGM.
5. The Director, Distance Education Programme, Moulya Bhavan, Manasagangotri, Mysuru.
6. The Director, PMEB, Manasagangothri, Mysore.
7. Director, College Development Council , Manasagangothri, Mysore.
8. The Deputy Registrar/Assistant Registrar/Superintendent, Administrative Branch and Examination Branch, University of Mysore, Mysuru.
9. The PA to Vice-Chancellor/ Registrar/ Registrar (Evaluation), University of Mysore, Mysuru.
10. Office Copy.

Annexure 1

EXISTING SYLLABUS	CHANGES INCORPORATED
Semester 3: MBL-103, DCS-3T Microbial Diversity	
Unit 4	**Unit 4** Structure, Replication and Significance of the following: **Human &Animal viruses:** HIV, Corona, Ortho and paramyxovirus, Oncogenic virus, H1N1 **Microbial viruses:** Sub viral particles; Viroids, Virusoids, satellite and Prions.
Practicals:MBL-103, DSC-4P Microbial Diversity	11. Study of Fungi – *Rhizopus, Aspergillus, Saccharomyces, Agaricus* 13. Study of HIV, TMV, Corona virusT4Phage 14. Study of Paramyxovirus Oncogenic viruses
Semester 4: MBL:104, DCS- 4T Microbial Enzymology and Metabolism	
~~**Unit 3:**~~ **Basics of enzyme** **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.-Multi substrate reactions– ~~Ordered, Random, Ping-pong.~~ **Enzyme catalysis:** ~~Catalytic mechanisms with~~ types & examples, catalytic mechanisms and testing – ~~Serine proteases and~~ Lysozyme	**Unit 1: Basics of enzyme**

~~Unit 4:~~ **Enzyme Kinetics and Regulation** Enzyme Kinetics: Kinetics of one substrate reactions. i. Equilibrium assumptions ii. Steady state assumptions iii. Lineweaver-Burk, ~~Hanes-Woolf, Eadie-Hofstee equations and plots.~~ Kinetics of enzyme inhibition. Competitive, non-competitive and uncompetitive inhibition. Effect of changes in pH and temperature on enzyme catalysed reaction. ~~Kinetics of two substrate reactions. Pre steady state kinetics.~~ Kinetics of immobilizedenzymes Enzyme regulation:Allosteric enzyme - general properties, Hill equation, KoshlandNemethy ~~and Filmer model, Monod Wyman and Changeux model.~~ Covalent modification by various mechanisms. ~~Regulation by proteolytic cleavage - blood coagulation cascade.~~	**Unit 2** **Enzyme Kinetics and Regulation** **Microbial Enzymes: sources-** Bacterial, Fungal, Yeast and their applications
Metabolism of Carbohydrates ~~**Unit 1 :**~~	**Metabolism of Carbohydrates** **Unit 3 :** Utilization of Lactose, Maltose, Galactose, Cellulose and Pectin.
Practicals: MBL 104, DSC-4P **Microbial Enzymology and Metabolism** 1. ~~Handling of micropipettes and checking theiraccuracy~~ 2. ~~Isolation of cholesterol and lecithin from eggyolk~~ 3. ~~Identification of fatty acids and other lipids byTLC/GC~~	1. Separation of amino acids by paper chromatography 2. Screening of fungi for cellulose and pectin degradation 3. Screening of fungi for invertase 4. Enzyme immobilization by Alginate method

~~4. Determination of degree of unsaturation of fats andoils~~ ~~5. Isolation of lactose from bovinemilk~~ ~~6. Estimation of total sugars by the phenol-sulphuric acidmethod~~ ~~7. Estimation of DNA - DPA method & UV absorbancemethod~~ ~~8. Estimation of RNA (Orcinolmethod)~~ ~~9. Isolation of glutamic acid from gluten~~ ~~10. Determination of molar absorption coefficient (ε) of l-tyrosine~~ ~~11. Determination of the isoelectric point of the givenprotein~~ ~~12. Estimation of polyphenols/ tannins by Folin- Denismethod~~ ~~13. Chemotaxis of *Pseudomonas*~~ ~~14. Demonstration of alcoholicfermentation~~ 15. Effect of variables on enzyme activity (amylase): a. Temperature b. pH c. substrate concentration d. Enzyme concentration ~~e. Determination of Km of amylase (Lineweaver-Burke plot; Michaelis-Menton graph)~~	5. Gelatin hydrolysis 6. Microscopic examination of Root nodules 7. Demonstration of Ammonification 8. Demonstration of Nitrification – Nitrite and Nitrate 9. Demonstration of Dentification 10. Demonstration of lipolytic activity 11. Demonstration of citric acid production 12. Effect of variables on enzyme activity (amylase): a. Temperature b. pH c. substrate concentration d. Enzyme concentration 13. Study of photographs/models: Chemolithotrophy-hydrogen oxidation, sulphur oxidation, iron oxidation, nitrogen oxidation, biological nitrogen fixation, ammonia assimilation, ribozymes, abzymes, lock and key hopothesis, enzyme inhibition – competitive, non competitive and un competitive. Enzyme regulation – allosteric enzymes. Feedback inhibition.

Curriculum Framework for Four-Year Undergraduate Multidisciplinary Programme (Honours) & Master Programme in Colleges and Universities of Karnataka State Under NEP2020.

3rd and 4th Semester Model Syllabus for
UG Program in Microbiology
University of Mysore
Mysuru

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 substantial 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-employment or 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 has been 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 microorganism's 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.

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	**56hrs**		Duration of ESA/Exam	**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 Pro-eukaryotic and Eukaryotic microbes.
3. Knowledge about viruses and their diversity

Content	**56Hrs**
Unit–I	**14 Hrs**
Biodiversity and Microbial Diversity Concept, definition, and levels of biodiversity; Biosystematics – Major classification systems- Numerical and Chemotaxonomy. Study and measures of microbial diversity; Conservation and Economic values of microbial diversity.	
Unit -II	**14 Hrs**
Diversity of Prokaryotic Microorganisms General characters; Classification; Economic importance; Distribution and factors regulating distribution. **Bacteria and Archaea-** An overview of Bergey's Manual of Systematic Bacteriology. **Bacteria-** *Escherichia coli, Bacillus subtilis, Staphylococcus aureus* **Cyanobacteria**- *Nostoc, Microcystis, Spirulina* **Archea**-*Thermus aquaticus*, Methanogens **Actinomycetes:** *Streptomyces, Nocordia, Frankia* **Rickettsiae-** *Rickettsia rickettsi* **Chlamydiae –** *Chlamydia trachomatis* **Spirochaetes**- *Trepanema pallidum*	
Unit -III	**14 Hrs**
Diversity of Eukaryotic Microorganisms **Diversity of Eukaryotic Microorganisms**: General characters; Classification- Economic importance **Fungi:** Ainsworth classification- detailed study up to the level of classes, Salient features and Reproduction -Type study: *Rhizopus, Aspergillus, Agaricus, Fusarium, Saccharomyces.*	

Algae: Occurrence, distribution, and symbiotic association- Lichen; thallus organization and types. Type study: *Chlorella, Cosmarium,* Diatoms,*Gracilaraia,* **Protozoa:** Classification up to the level of classes. Type study: *Amoeba, Euglena, Trichomonas, Paramoecium, Trypanosoma*	
Unit -IV	**14 Hrs**
Diversity of Virus General properties and structure, Isolation and purification and assay of virus. 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, Ortho and paramyxovirus, Oncogenic virus, H1N1 **Plants viruses:** TMV, Ring spot virus **Microbial viruses:** T4/T7/lambda/cyano/mycophages. Sub viral particles, Viroids, Virusoids, satellite virus and Prions.	

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs 1-12)

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 Pro-eukaryotic 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	**60 marks + 40 marks = 100 marks**

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

Content

1. Study of morphology of bacteria
2. Isolation of bacteria from soil
3. Isolation of bacteria from air and water
4. Isolation of fungi from soil
5. Isolation of fungi from air
6. Cultivation of cyanobacteria
7. Cultivation of Actinomycetes
8. Measurement of microbial cell size by Micrometry
9. Study of cyanobacteria -*Nostoc,Microcyctis, Spirulina*
10. Study of Algae –*Chlorella, Diatoms, Gracilaria*
11. Study of Fungi – *Rhizopus, Aspergillus, Saccharomyces, Agaricus*
12. Study of Protozoa – *Amoeba, Paramoecium, Euglena*
13. Study of HIV, TMV, Corona virus, T4Phage
14. Study of Paramyxovirus, Oncogenic viruses

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. 5thedn. Blackwell publishing, USA
4	Flint, S.J., Enquist, L.W., Drug, R.M., Racaniello, V.R. and Skalka, A.M. 2000. Principles of Virology- Molecular Biology, Pathogenesis and Control. ASM Press, Washington,D.C
5	Prescott, Harley, Klein's Microbiology, J.M. Willey, L.M. Sherwood, C.J. Woolverton, 7th International, edition 2008, McGraw Hill
6	VashishtaB.R, Sinha A.K and Singh V. P. Botany – Fungi 2005, S. Chand and Company Limited, NewDelhi
7	Kotpal R.L Protozoa 5th Edition 2008, 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, Ingraham et al, 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. 869pp
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	**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	**42 HRS**
Unit–I	**14 Hrs**
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	**14 Hrs**
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 -	**14 Hrs**
Healthcare Entrepreneurship Production and applications: Sanitizers, Antiseptic solutions, Polyhenols (Flavonoids), Alkaloids, Cosmetics, Biopigments and Bioplastics, vaccines, Diagnostic tools and kits.	

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**

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 text book on food and Nutrition. Volume I. Bappco
4	Gopalan.C.,RamaSastry 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	**Microbial Enzymology and Metabolism**			
Course No.	**MBL:104**	**DCS -4T**	No. of Theory Credits	**4**
Contact hours	**56 hrs**		Duration of ESA/Exam	**2 ½ Hours**
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. Differentiating concepts of chemo heterotrophic metabolism and chemo lithotrophic 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	**56 Hrs**
Unit–I	**14 Hrs**
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. Multi substrate reactions. **Enzyme catalysis:** Types & examples, catalytic mechanisms and testing Lysozyme	

Unit -II	14 Hrs
Enzyme Kinetics and Regulation Enzyme Kinetics: Kinetics of one substrate reactions. i. Equilibrium assumptions ii. Steady state assumptions iii. Lineweaver-Burk plot, Kinetics of enzyme inhibition. Competitive, non-competitive and uncompetitive inhibition. Effect of changes in pH and temperature on enzyme catalyzed reaction. Kinetics of two substrate reactions. Kinetics of immobilized enzymes Enzyme regulation: Allosteric enzyme - general properties, Hill equation, Koshland-Nemethy-Filmer model Covalent modification by various mechanisms. Regulation of multi- enzyme complex- Pyruvate dehydrogenase. Feedback inhibition. HIV enzyme inhibitors and drug design. **Microbial Enzymes: sources-** Bacterial, Fungal, Yeast and their applications.	
Unit -III	**14 Hrs**
Metabolism of Carbohydrates Chemoheterotrophic Metabolism- Sugar degradation pathways i.e. EMP, ED, Pentose phosphate pathway, Phosphoketolase pathway. TCA cycle. Utilization of Lactose, Maltose, Galactose, Cellulose and Pectin. Fermentation – Fermentation balance, concept of linear and branched fermentation pathways. Alcohol fermentation and Pasteur effect;-Butyric acid and Butanol- Acetone Fermentation, Mixed acid and 2,3-butanediol fermentation, Propionic acid Fermentation (Succinate pathway and Acrylate pathway), acetate 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	14 Hrs
Metabolism of aminoacids, nucleotides and lipids **1.NitrogenMetabolism** Introduction to biological nitrogen fixation Ammonia assimilation. Assimilatory nitrate reduction, dissimilatory nitrate reduction, denitrification **2. Biosynthesis of ribonucleotides anddeoxyribonucleotides** The de novo pathway. Regulation by feedback mechanisms. Recycling via the salvage pathway **3. Amino acid degradation andbiosynthesis** **4. Lipid degradation andbiosynthesis** **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; ii. Energy coupling and biosynthesis in methanogenicbacteria,Acetogens - Autotrophic pathway of acetate synthesis. **Metabolism of two-carbon compounds:Acetate-** Glyoxylate cycle. **Acetic acid bacteria**: Ethanol oxidation, sugar alcohol oxidation. **Glyoxylate and glycolate metabolism** – i. Dicarboxylic acid cycle, ii. Glycerate pathway iii. Beta hydroxyaspartatepathway, **Oxalate** as carbon and energy source	

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs 1-12)

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. Chemotaxis of *Pseudomonas*
3. Effect of variables on enzyme activity (amylase): a. Temperature b. pH c. substrate concentration d. Enzyme concentration
4. Sugar fermentation tests for bacteria
5. Separation of amino acids by paper chromatography
6. Screening of fungi for cellulose and pectin degradation
7. Screening of fungi for invertase
8. Enzyme immobilization by Alginate method
9. Gelatin hydrolysis
10. Microscopic examination of root nodules
11. Demonstration of Ammonifiaction
12. Demonstration of Nitrification – Nitrite and Nitrate
13. Demonstration of Denitrification
14. Demonstration of lipolytic activity
15. Demonstration of citric acid production
16. Effect of variables on enzyme activity (amylase): A. temperature B. pH C. substrate concentration D. enzyme concentration
17. Study of photographs/models: Chemolithotrophy- Hydrogen oxidation, Sulphur oxidation, Iron oxidation, Nitrogen oxidation, biological Nitrogen fixation, ammonia assimilation, ribozymes, abzymes, lock and key hopothesis, enzyme inhibition – competitive, non competitive and un competitive. Enzyme regulation- allosteric enzymes. Feedback inhibition.

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. Mannual of Methods for General Bacteriology.
2	David T. Plummer. An Introduction to Practical Biochemistry
3	Biochemistry- A Problem Approach, Wood W. B. Wilson J.H., Benbow R.M. and Hood L.E.2nd ed., 1981, The Benjamin/ Cummings Pub.co
4	Biochemical calculations, Segel I.R., 2nd ed., 2004, John Wiley and Sons
5	Biochemical Calculations, Irwin H. Segel, 2nd Edition John Wiley & Sons

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 microbiome of different human body sites and impact human health promotion	
Content	**42 Hrs**
Unit–I	**14 Hrs**
INTRODUCTION TO 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	**14 Hrs**
MICROBIOMES AND HUMAN HEALTH Microbiome in early life, Nutritonal modulation of the gut microbiome for metabolic health- role of gut mocrobiomes 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 unctional foods.	

Unit -III	14 Hrs
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 2 hours	
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. IntechOpen, 166pp.

Date: BOS Chairperson

SCHEME OF PRACTICAL EXAMINATION
II SEM (NEP)

Practical – II: Microbial Biochemistry and Physiology (DSC-2P)

Duration: 3 hours **Max. Marks: 25**

I. Demonstrate the given experiment 'A'. Write the principle and procedure. Record and interpret the result 08 marks

(Effect of temperature/ Effect of pH/ Effect of salt concentration/ Determination of bacterial growth by spectrophotometric method& calculation of generation time)

Demo – 2M, Principle – 2M, Procedure – 2M, Result & interpretation – 2M

II. Perform the given experiment 'B'. Write the principle, procedure and record the result.
Leave the preparation for evaluation. 05 marks

(Qualitative determination of carbohydrates/ proteins/ amino acids/ fatty acids. Quantitative estimation of reducing sugar/protein/Determination of lipid saponification values)

Preparation – 1M, Principle – 1M, Procedure – 2M, Result – 1M)

III. Comment on C, D, E & F 2x4=08 marks

pH meter, Chlorophyll, Haemoglobin, Cytochrome, Haemocytometer,Membrane filter, Spectrophotometer, Nephelometer, anaerobic respiration, Buffer solutions. Calculation of Normal or Molar solutions.

IV. Viva Voce 04 marks

SCHEME OF PRACTICAL EXAMINATION

III SEM (NEP)

PRACTICAL III: Microbial Diversity (DSC 3P)

Time: 3 hrs **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 of bacteria from soil or water by serial dilution method/Isolation of fungi from air by exposure plate method/Isolation of fungi from soil or water 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
05 marks

(Staining of fungi/ algae/ cyanobacteria)

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 *Amoeba, Paramecium,Euglena,*TMV,Corona,T4 phage, Paramyxovirus, Oncogenic virus, Actinomycetes,Aspergillus,*Rhizopus, Sachharomyces, Agaricus, Chlorella, Diatoms, Gracilaria, Nostoc, Microcystis, Spirulina*)

5. Viva-voce **04 marks**

SCHEME FOR PRACTICAL EXAMINATION

IV SEM (NEP)

PRACTICAL IV: Microbial Enzymology and Metabolism (DSC 4P)

Time: 3 hrs. **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 examination of root nodules / 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: Chemolithotrophy-hydrogen oxidation, sulphur oxidation, iron oxidation, nitrogen oxidation, biological nitrogen fixation, ammonia assimilation, ribozymes, abzymes, lock and key hypothesis, enzyme inhibition- competitive, non-competitive and un competitive. Enzyme regulation-allosteric enzymes. Feedback inhibition, Chemotaxis of *Pseudomonas*)

4. **Viva-voce** **04 marks**