JSS COLLEGE OF ARTS, COMMERCE AND SCIENCE
(An autonomous College of University of Mysuru)
Re-accredited by NAAC with 'A' grade
Ooty road, Mysuru-570 025, Karnataka

ESTD-1964

DEPARTMENT OF MICROBIOLOGY

SYLLABUS

NATIONAL EDUCATION POLICY
FOR
B.Sc. PROGRAMME

Microbiology & Biotechnology

Microbiology & Biochemistry

(W. E. F. 2022 – 2023)

JSS COLLEGE OF ARTS, COMMERCE AND SCIENCE, OOTY ROAD, MYSURU-25
DEPARTMENT OF MICROBIOLOGY
PROFORMA OF INSTRUCTIONS AND EXAMINATION FOR B.Sc. PROGRAMME IN MICROBIOLOGY (NEP)
DURATION OF THE COURSE: 4YEARS (8SEMESTER)
PROGRAMME: BSc Mb & Bt, (2022-23)
PROGRAMME CODE: BScMbBt41
BSc Microbiology (Basic / Hons.)

Year	Semester	Core course	Title of the paper	Lecture + Practicals hours per week	No. of credits			Total credits	Total hours		Maximum Marks in exam/Assessment			
					L	T	P		Th	Pr		IA(Theory)		Total
												C-1	C-2	
I B.Sc	I	DSC-I :Theory FSA500	General Microbiology	04	4: 0 : 0			06	56		60	20	20	100
		DSC-I: Pract-I	General Microbiology	04	0: 0: 2					60	25	10	10+5(record)	50
		OE-I	Microbial Technology for human welfare	03	3: 0: 0			03	42	-	-	20	20	100
		SEC-1	Microbiological methods and Analytical Techniques	01	1 : 0: 0			01	14					
	II	DSC-II: Theory FSB500	Microbial biochemistry and physiology	04	4: 0 : 0			06	56		60	20	20	100
		DSC-II: Pract-II	Microbial biochemistry and physiology	04	0: 0: 2					60	25	10	10+5(record)	50
		OE-II	Environmental and sanitary Microbiology	03	3: 0: 0			03	42			20	20	100
II B.Sc	III	DSC-III :Theory FSC500	Microbial Diversity	04	4: 0 : 0			06	56		60	20	20	100
		DSC-III: Pract-III	Microbial Diversity	04	0: 0: 2					60	25	10	10+5(record)	50
		OE-III	Microbial Entrepreneurship	03	3: 0: 0			03	42	-	-	20	20	100
	IV	DSC-IV: Theory FSD500	Microbial Enzymology andMetabolism	04	4: 0 : 0			06	56		60	20	20	100
		DSC-IV: Pract-IV	Microbial Enzymology andMetabolism	04	0: 0: 2					60	25	10	10+5(record)	50
		OE-IV	Human Microbiome	03	3: 0: 0			03	42			20	20	100

JSS COLLEGE OF ARTS, COMMERCE AND SCIENCE, OOTY ROAD, MYSURU-25
DEPARTMENT OF MICROBIOLOGY
PROFORMA OF INSTRUCTIONS AND EXAMINATION FOR B.Sc. PROGRAMME IN MICROBIOLOGY (NEP)
DURATION OF THE COURSE: 4YEARS (8 SEMESTER)
PROGRAMME:BSc MB &BC
PROGRAMME CODE:BScMbBc42
BSc Microbiology (Basic / Hons.)

Year	Semester	Core course	Title of the paper	Lecture + Practicals hours per week	No. of credits			Total credits	Total hours		Maximum Marks in exam/Assessment			
					L	T	P		Th	Pr		IA(Theory)		Total
												C-1	C-2	
I B.Sc	I	DSC-I :Theory FSA500	General Microbiology	04	4: 0 : 0			06	56		60	20	20	100
		DSC-I: Pract-I	General Microbiology	04	0: 0: 2					60	25	10	10+5(record)	50
		OE-I	Microbial Technology for human welfare	03	3: 0: 0			03	42	-	-	20	20	100
		SEC-1	Microbiological methods and Analytical Techniques	01	1 : 0: 0			01	14					
	II	DSC-II: Theory FSB500	Microbial biochemistry and physiology	04	4: 0 : 0			06	56		60	20	20	100
		DSC-II: Pract-II	Microbial biochemistry and physiology	04	0: 0: 2					60	25	10	10+5(record)	50
		OE-II	Environmental and sanitary Microbiology	03	3: 0: 0			03	42			20	20	100
II B.Sc	III	DSC-III :Theory FSC500	Microbial Diversity	04	4: 0 : 0			06	56		60	20	20	100
		DSC-III: Pract-III	Microbial Diversity	04	0: 0: 2					60	25	10	10+5(record)	50
		OE-III	Microbial Entrepreneurship	03	3: 0: 0			03	42	-	-	20	20	100
	IV	DSC-IV: Theory FSD500	Microbial Enzymology andMetabolism	04	4: 0 : 0			06	56		60	20	20	100
		DSC-IV: Pract-IV	Microbial Enzymology andMetabolism	04	0: 0: 2					60	25	10	10+5(record)	50
		OE-IV	Human Microbiome	03	3: 0: 0			03	42			20	20	100

DEPARTMENT OF MICROBIOLOGY
PROGRAMME: BSc MBt (NEP)
PROGRAMME OUTCOMES: B.Sc., Mb-Bt & Mb-Bc

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:

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

PROGRAMME SPECIFIC OUTCOME

After completing the graduation in the Bachelor of Science the students are able to:

PSO 1	Demonstrate effectively the applications of biochemical and biological sciences
PSO2	Inculcating proficiency in all experimental techniques and methods of analysis
PSO3	Acquire, articulate, retain and demonstrate laboratory safety skills applicable to microbiological research or clinical methods, including accurately reporting observations and analysis
PSO4	Communicate scientific information effectively, especially relating to microbes and their role in ecosystem and health related issues
PSO5	Be knowledgeable in proper procedures and regulations in handling and disposal of chemicals
PSO6	Gain and understanding of biochemical and molecular processes that occur in and between cells to expand understanding of biology

Assessment:
Weight age for assessments (in percentage)

Type of Course	Formative Assessment / IA	Summative Assessment
Theory	**40%**	**60%**
Practical	**50%**	**50%**
Projects	**40%**	**60%**
Experiential Learning (Internships/MOO C/ Swayam etc.)	**40%**	**60%**

Formative Assessment : 40%	
Assessment Occasion/ type	**Weightage in Marks**
C1 = IA -1 + Assignments / Visits	10% + 10% = 20% : 20 Marks
C2 = IA -2 + Seminars / Group Discussion	10% + 10 = 20% : 20 Marks
Total	40% : 40 Marks

Total Marks for each course = 100%
Formative Assesment (C1+C2) = 40%
Semester end examination (C3) = 60%

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.

BSc Microbiology (Basic / Hons.)
Semester 1

Course Title: DSC-1T, General Microbiology	
Course code:FSA500	
Total Contact Hours: **56**	Course Credits: **4+2**
Formative Assessment Marks: **40%**	Duration of ESA/Exam: **3 Hrs**
Model Syllabus Authors: **Curriculum Committee**	Summative Assessment Marks: **60%**

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

1. **Thorough 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.**

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

Course Outcomes (COs) / Program Outcomes (POs)	1	2	3	4	5	6	7	8	9	10	11	12
1. Thorough 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.		✔		✔			✔					

Course Articulation Matrix relates course outcomes of course with the corresponding program outcomes whose attainment is attempted in this course. Mark ‘X’ in the intersection cell if a course outcome addresses a particular program outcome.

BSc Microbiology (Basic / Hons.)

Semester 1

Title of the Courses:

Course 1 : DSC-1T: General Microbiology
Course 2 : OE 1T: Microbial Technology for Human Welfare
Course 3 : SEC 1T: Microbiological Methods and Analytical Techniques

Course 1 : DSC-1T General Microbiology		**Course 2 : OE 1T Microbial Technology for Human Welfare**		**Course 3 : SEC 1T Microbiological Methods and Analytical Techniques**	
Number of Theory Credits	Number of lecture hours/semester	Number of Theory Credits	Number of lecture hours/semester	Number of Theory Credits	Number of lecture hours/semester
4	**56**	**3**	**42**	**1**	**14**

Content of Course 1: Theory: DSC-1T, MBL 101, General Microbiology	**56 Hrs**
Unit – 1: Historical development, major contributions, origin of microorganisms and microscopy	**14Hrs**
Historical development of microbiology -Theory of spontaneous generation, Biogenesis and Abiogenesis. Contributions of Anton Von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister and Edward Jenner, Alexander Fleming, Martinus Beijirinic, Segei Winogrodsky, Elei Metechnikoff. Contributions of Indian scientists in the field of Microbiology. Fossil evidences of microorganisms. Origin of life, primitive cells and evolution of microorganisms. Microcopy- working principle, construction and operation of simple and compound microscopes.	
Unit – 2: Staining, sterilization and preservation of microorganisms	**14Hrs**
Staining: Nature of strains, principles, mechanism, methods and types of staining- Simple, Differential-Gram staining, Acid fast staining, staining of capsule, cell wall, endospore, inclusion bodies. Sterilization: Principles, types and techniques, Physical and chemical methods. Culture media – Types, Cultivation of aerobic and anaerobic bacteria. Pure culture techniques and Cultural characteristics. Preservation of microorganisms: Methods of preservation of microorganisms; slant culture, stab culture, soil culture, mineral oil overlaying, glycerol preservation.	
Unit – 3: Types, structure, organisation and reproduction of prokaryotic microorganism	**14Hrs**
Overview of Prokaryotic Cell Structure: Size, shape, arrangement. Diagram of Prokaryotic cell organisation, cell wall structure of Gram positive and negative bacteria, cell membrane; Bacterial and Archaeal, Cytoplasmic matrix- Cytoskeleton, ribosome, inclusion granules: Composition and function. Nuclear Materials – Bacterial chromosomes structure (its differences with the Eukaryotic chromosome); Extra Chromosomal materials. Components external to cell wall- capsule, slime, s- layer, pilli, fimbriae, flagella; structure, motility, chemotaxis. Bacterial Endospore - Examples of spore forming organisms, habitats, function, formation and germination.Reproduction in bacteria and bacterial cell cycle.	

Unit – 4: Types, structure, organisation and reproduction of eukaryotic microorganisms	14Hrs
Over view of eukaryotic cell structure: General structure and types of cells; External cell coverings and cell membrane. Structure and function of Cytoplasmic matrix- cytoskeleton: Structure and function; single Membrane organelles- Endoplasmic reticulum, Golgi complex, Lysosomes, Vesicles and Ribosomes; Double Membrane organelles- Nucleus, Mitochondrion and Chloroplast: Structure and Functions; Peroxisomes; Organelles of motility- Structure and movement of flagella and cilia.	

Course 1: Practical: DSC-1P : General Microbiology

1. Microbiological laboratory standards and safetyprotocols
2. Standard aseptic conditions of Microbiological laboratory.
3. Operation and working principles of Light/ Compound microscope.
4. A. Working principles and operations of basic equipments of microbiological laboratory (Autoclave, Oven, Incubator, pH meter, Spectrophotometer, Colorimeter, Vortex, Magnetic stirrer).
5. Applications of basic microbiological tools (Pipettes, Micropipette, Bunsen burner, Inoculation loop, Spreader).
6. Demonstration and observations of microorganisms from natural sources under light microscope (Algae, Yeast and Protozoa).
7. Demonstration of bacterial motility by hanging drop method.
8. Simple staining & Negative staining
9. Differential staining - Gram staining
10. Acid fast staining
11. Structural staining - Flagella and Capsule
12. Bacterial endospore staining
13. Staining of fungi by Lactophenol cotton blue.
14. Staining of reserved food materials.
15. A.Preparation of Physiological saline and Serial dilution
    B. Method of obtaining pure cultures of Microorganisms

Text Books / References

1. General Microbiology 1st Edition, 2020 , Linda Bruslind, Oregon State University
2. Prescott, Harley, Klein's Microbiology, J.M. Willey, L.M. Sherwood, C.J. Woolverton, 7th International, edition 2008, McGraw Hill.
3. Foundations in Microbiology, K. P. Talaro, 7th International edition 2009, McGraw Hill.
4. A Textbook of Microbiology, R. C. Dubey and D. K. Maheshwari, 1st edition, 1999, S. Chand & Company Ltd.
5. 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.
6. Microbiology – An Introduction, G. J.Tortora, B. R.Funke, C. L. Case, 10th ed. 2008,Pearson Education.
7. General Microbiology, Stanier, Ingraham et al, 4th and 5th edition 1987, Macmillan education limited.
8. Microbiology- Concepts and Applications, Pelczar Jr,Chan, Krieg, International ed, McGraw Hill.
9. Alexopoulos, C.J., Mims, C.W., and Blackwell, M. 2002. Introductory Mycology. John Wiley and Sons (Asia) Pvt. Ltd. Singapore. 869 pp.
10. Atlas, R.M. 1984. Basic and practical microbiology. Mac Millan Publishers, USA. 987pp.
11. Black, J.G. 2008. Microbiology principles and explorations. 7edn. John Wiley and Sons Inc., New Jersey 846 pp.
12. Pommerville, J.C. Alcamo's Fundamentals of Microbiology. Jones and Bartlett Pub..Sudburry, 835 pp.
13. Schlegel, H.G. 1995.General Microbiology. Cambridge University Press, Cambridge, 655 pp.
14. Toratora, G.J., Funke, B.R. and Case, C.L. 2007. Microbiology 9th ed. Pearson Education Pte. Ltd., San Francisco. 958pp.

Course 2 : Theory: OE 1T: Microbial Technology for Human Welfare

Course 2 : OE 1T: Microbial Technology for Human Welfare	**42Hrs**
Unit – 1: Food and Fermentation Microbial Technology	14Hrs
Fermented Foods – Types, Nutritional Values, Advantages and Health Benefits Prebiotics, Probiotics, Synbiotics and Nutraceutical Foods Fermented Products – Alcoholic and nonalcoholic beverages, fermented dairy products, Fruit fermented drinks,	
Unit – 2: Agricultural Microbial Technology	14Hrs
Microbial Fertilizers, Microbial Pesticides, Mushroom Cultivation, Biogas Production	
Unit – 3: Pharmaceutical Microbial Technology	14Hrs
Microbial Drugs – Types and Development of Drug resistance Antibiotics – Types, Functions and Antibiotic Therapy Vaccines – Types, Properties, Functions and Schedules	

Course 3 : Therory: SEC 1T

Title: Microbiological Methods and Analytical Techniques

LEARNING OUTCOMES

- Demonstrate skills as per National Occupational Standards (NOS) of "Lab Technician/ Assistant" Qualification Pack issued by Life Sciences Sector Skill Development Council - LFS/Q0509, Level 3.
- Perform microbiology and analytical techniques. Knowledge about environment, health, and safety (EHS), good laboratory practices (GLP), good manufacturing practices (GMP) and standard operating procedures (SOP)
- Demonstrate professional skills at work, such as decision making, planning, and organizing, Problem solving, analytical thinking, critical thinking, and documentation.

1. Principles which underlies sterilization of culture media, glassware and plastic ware to be used for microbiological work.
2. Principles of a number of analytical instruments which the students have to use during the study and also later as microbiologists for performing various laboratory manipulations.
3. Handling and use of microscopes for the study of microorganisms which are among the basic skills expected from a practicing microbiologist. They also get introduced a variety of modifications in the microscopes for specialized viewing.
4. Several separation techniques which may be required to be handled later as microbiologists.

Course 3 :Theory: SEC 1T

SEC 1T : Microbiological Methods and Analytical Techniques	**14Hrs**

DIGITAL SKILLS:

The components of digital skills provided by KSHEC, will be followed accordingly.

Microbiological Skills

Microbiological culture media: Types, Composition, Preparation, Application and storage**;** Ingredients of media, natural and synthetic media, chemically defined media, complex media, selective, differential, indicator, enriched and enrichment media.

Isolation and cultivation of microorganisms: Collection of samples, processing of samples, serial dilution, technique, inoculation of samples, incubation and observations of microbial colonies. Morphological characterization of microorganisms - Colony characteristics, Microscopic characters, biochemical/physiological tests or properties and identification. Subculturing of microorganisms and pure culture techniques. Preservation of microorganisms.

Advanced Microscopic Skills: Different types of microscopes - Phase contrast, Bright Field, Dark Field, Fluorescent, Confocal, Scanning and Transmission Electron Microscopy.

Analytical Skills

Centrifugation, Chromatography and Spectroscopy: Principles, Types, Instrumentation, Operation and applications.

Course 3 : Practicals: SEC 1P: Microbiological Methods and Analytical Techniques

1. Preparation of different microbiological culture media
2. Isolation and cultivation of bacteria, actinobacteria, fungi and algae
3. Characterization and identification of bacteria, actinobacteria, fungi and algae – colony characters and microscopic characters
4. Biochemical and physiological tests for identification of bacteria
5. Methods and practices in microbiology lab: MSDS (Material Safety Data Sheet), Good clinical Practices (GCP), Standard Operating Procedure (SOP), Good Laboratory Practices (GLP), Good Manufacturing Practices**.**
6. Usage and maintenance of basic equipment of microbiology lab: Principles, calibrations, and SOPs of balances (Types), pH meter (Types), Autoclaves (Types), Laminar flows and biosafety cabinets, basic Microscopes, homogenizers, stirrers.
7. Procedures for documentation, lab maintenance, repair reporting
8. Separation of mixtures of biomolecules by paper / thin layer chromatography.
9. Demonstration of column packing in column chromatography.

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, Experiential documentation and Innovative methods.

Active learning as per LSSSDC (NSDC) LFS/Q0509 guidelines, at skill training Level 3. Case studies about application of microbial biomolecules in various industries. Seminar on topics of microbial biochemistry

Formative Assessment : 40%	
Assessment Occasion/ type	**Weightage in Marks**
C1 = IA -1 + Assignments / Visits	10% + 10% = 20% : 20 Marks
C2 = IA -2 + Seminars / Group Discussion	10% + 10 = 20% : 20 Marks
Total	40% : 40 Marks

BSc Microbiology (Basic / Hons.)
Semester II

Title of the Courses:

Course 1: DSC-2T: Microbial Biochemistry and Physiology Course 2 : OE- 2T: Environmental and Sanitary Microbiology

Course code:FSB500

Course 1: DSC-2T, MBL 102, Microbial Biochemistry and Physiology		**Course 2: OE- 2T, MBL 302, Environmental and Sanitary Microbiology**	
Number of Theory Credits	Number of lecture hours/semester	Number of Theory Credits	Number of lecture hours/semester
4	**56**	**3**	**42**

Content of Course: DSC-2T: Microbial Biochemistry and Physiology	**56 Hrs**
Unit – 1 Biochemical Concepts	**14Hrs**
Basic Biochemical Concepts: Major elements of life and their primary characteristics, atomic bonds and molecules – bonding properties of carbon, chemical bonds- covalent and non covalent, Hydrogen bonds and Vander Waal Forces. Biological Solvents: Structure and properties of water molecule, Water as an universal solvent, polarity, hydrophilic and hydrophobic interactions, properties of water, Acids, bases, electrolytes, hydrogen ion concentration, pH, buffers and physiological buffer system, Handerson – Hasselbatch equation.	
Unit – 2 Macromolecules – Types, Structure and Properties	**14Hrs**
Carbohydrates: Definition, classification, structure and properties. Amino acids and proteins: Definition, structure, classification and properties of amino acids, Structure and classification of proteins. Lipids and Fats: Definition, classification, structure, properties and importance of lipids. Porphyrins and Vitamins: Definition, structure, properties and importance of chlorophyll, cytochrome and hemoglobin.	
Unit – 3 Microbial Physiology	**14Hrs**
Microbial Growth: Definition of growth, Mathematical expression, Growth curve, phases of growth, calculation of generation time and specific growth rate. Synchronous growth, Continuous growth (chemostat and turbidostat), Diauxic growth. Measurement of Growth: Direct Microscopic count – Haemocytometer; Viable count, Membrane filtration; Electronic Counting; Measurement of cell mass; Turbidity measurements-Nephelometer and spectrophotometer techniques;Measurements of cell constituents. Growth Yield (definition of terms). Influence of environmental factors on growth. Microbial growth in natural environments. Viable non-culturable organisms. Quorum sensing. **Microbial Nutrition**: Microbial nutrients, Classification of organisms based on carbon source, energy source and electron source, Macro and micronutrients. **Membrane Transport**: Structure and organization of biological membranes, Types of Cellular transport, Passive, Facilitated, Active, Group Translocation, Membrane bound and binding protein transport system, Carrier models, Liposomes, Ion transduction Na K^+, ATPase.	
Unit – 4: Microbial Physiology- Bioenergetics, Microbial Respiration, Microbial Photosynthesis	**14Hrs**

Bioenergetics: Free energy, Enthalpy, Entropy, Classification of high energy compounds, Oxidation reduction reactions, equilibrium constant, Redox potential, Law of thermodynamics. Microbial Respiration:Respiratory electron transport chain in bacteria, oxidation – reduction reactions, protein translocation, oxidative and substrate level phosphorylation – inhibitors and mechanism, chemiosmotic coupling. Fermentation reactions (homo and hetero) Microbial Photosynthesis: Light reaction:Light harvesting pigments Photophosphorylation, CO2 fixation pathways: Calvin cycle, CODH pathway, Reductive TCA pathway.	

Course 1: Practicals: DSC-2P: Microbial Biochemistry and Physiology

1. Preparation of Solution: Normal and Molar solutions
2. Calibration of pH meter and determination of pH of natural samples
3. Preparation of Buffer Solutions
4. Qualitative determination and identification of Carbohydrates
5. Qualitative determination and identification of Proteins & Amino Acids
6. Qualitative determination and identification of Fatty Acids
7. Quantitative estimation of Reducing Sugar by DNS method
8. Quantitative estimation of Proteins by Biuret and Lowry's method
9. Determination of lipid saponification values of fats and iodine number of fatty acids
10. Determination of bacterial growth by spectrophotometric method & calculation of generation time
11. Measurement of cell number by Haemocytometer
12. Effect of pH on bacterial growth
13. Effect of Salt concentration on bacterial growth
14. Effect of Temperature on bacterial growth
15. Demonstration of aerobic and anaerobic respiration in microbes

Text Books / References

1. Cohen, Georges N, 2014, Microbial Biochemistry, Springer Netherlands.
2. Felix Franks, 1993; Protein Biotechnology, Humana Press, New Jersey.
3. Stryer L, 1995; Biochemistry, Freeman and Company, New York.
4. Voet & Voet, 1995; Biochemistry, John Wiley and Sons, New York.
5. Nelson and Cox, 2000; Lehninger Principles of Biochemistry, Elsevier Publ.
6. Harper, 1999; Biochemistry, McGraw Hill, New York.
7. Palmer T. (2001), Biochemistry, Biotechnology and Clinical Chemistry, Harwood Publication, Chichester.
8. Boyer R. (2002), Concepts in Biochemistry 2nd Edition, Brook/ Cole, Australia.
9. Moat A. G., Foster J.W. Spector. (2004), Microbial Physiology 4th Edition Panama Book Distributors.
10. Caldwell, D. R. (1995) – Microbial Physiology and Metabolism. Brown Publishers.
11. Lodish H, T. Baltimore, A. Berck B.L. Zipursky, P. Mastsydaire and J. Darnell. (2004) – Molecular Cell Biology, Scientific American Books, Inc. Newyork.

Course 2 :Theory: OE- 2T: Environmental and Sanitary Microbiology

Course 2 :Theory: OE- 2T:Environmental and Sanitary Microbiology	**42 Hrs**
Unit – 1: Soil and Air Microbiology	**14 Hrs**
Soil and Air as a major component of environment. Types, properties and uses of soil and air. Distribution of microorganisms in soil and air. Major types of beneficial microorganisms in soil. Major types of harmful microorganisms in soil	
Unit – 2: Water Microbiology	**14 Hrs**
Water as a major component of environment. Types, properties and uses of water. Microorganisms of different water bodies. Standard qualities of drinking water	
Unit – 3: Sanitary Microbiology	**14 Hrs**
Public health hygiene and communicable diseases. Survey and surveillance of microbial infections. Airborne microbial infections, waterborne microbial infections, Food borne microbial infections. Epidemiology of microbial infections, their detection and control.	

Text Books / References

1. Diana Marco, 2019, Microbial Ecology: Current advances from Genomics, Metagenomics and other omics, Caister Academic Press.
2. Prescott, Harley, Klein's Microbiology, J.M. Willey, L.M. Sherwood, C.J. Woolverton, 7th International, edition 2008, McGraw Hill.
3. Foundations in Microbiology, K. P. Talaro, 7th International edition 2009, McGraw Hill.
4. A Textbook of Microbiology, R. C. Dubey and D. K. Maheshwari, 1st edition, 1999, S. Chand & Company Ltd.
5. 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.
6. Microbiology – An Introduction, G. J.Tortora, B. R.Funke, C. L. Case, 10th ed. 2008,Pearson Education.
7. General Microbiology, Stanier, Ingraham et al, 4th and 5th edition 1987, Macmillan education limited.
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9. Alexopoulos, C.J., Mims, C.W., and Blackwell, M. 2002. Introductory Mycology. John Wiley and Sons (Asia) Pvt. Ltd. Singapore. 869 pp.
10. Atlas, R.M. 1984. Basic and practical microbiology. Mac Millan Publishers, USA. 987pp.
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12. Pommerville, J.C. Alcamo's Fundamentals of Microbiology. Jones and Bartlett Pub..Sudburry, 835 pp.
13. Schlegel, H.G. 1995.General Microbiology. Cambridge University Press, Cambridge, 655 pp.
14. Toratora, G.J., Funke, B.R. and Case, C.L. 2007. Microbiology 9th ed. Pearson Education Pte. Ltd., San Francisco. 958pp.

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, Experiential

documentation and Innovative methods.

Formative Assessment : 40%	
Assessment Occasion/ type	**Weightage in Marks**
C1 = IA -1 + Assignments / Visits	10% + 10% = 20% : 20 Marks
C2 = IA -2 + Seminars / Group Discussion	10% + 10 = 20% : 20 Marks
Total	40% : 40 Marks

BSc Microbiology (Basic / Hons.)

Semester III

Title of the Courses:

Course 1 : DSC-1T: Microbial Diversity
Course 2 : OE 1T: Microbial Entrepreneurship

Program Name	**B. Sc Microbiology**		Semester	**Third Semester**
Course Title	**Microbial Diversity**			
C**ourse code**	**FSC500**			
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 : 40%	**Weightage in Marks**
C1 = IA -1 + Assignments / Visits	10% + 10% = 20% : 20 Marks
C2 = IA -2 + Assignments / Group Discussion	10% + 10 = 20% : 20 Marks
Total	40% : 40 Marks
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**	
C1- **Assessment**	10		
C2- Test+Record	10+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
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

Course 2 : Theory: OE 1T: Microbial Entrepreneurship

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**

Summative Assessment = 60 Marks	
Formative Assessment Occasion / type	**Weightage in Marks**
C-1 Test + Assignment	20
C-2 Test + Assignment	20
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

BSc Microbiology (Basic / Hons.) Semester IV

Title of the Courses:

Course 1: DSC-2T: Microbial Enzymology and Metabolism
2 : OE- 2T: Human Microbiome

Program Name	**B. Sc Microbiology**		Semester	**Fourth Semester**
Course Title	**Microbial Enzymology and Metabolism**			
Course code	**FSD500**			
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, metalcofactors. Classification of enzymes, Mechanism of action of enzymes: active site, transition state complexand 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 amino acids, nucleotides and lipids **1. Nitrogen Metabolism** Introduction to biological nitrogen fixation 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	

Metabolism of aminoacids, nucleotides and lipids **3.Nitrogen Metabolism** Introduction to biological nitrogen fixation Ammonia assimilation. Assimilatory nitrate reduction, dissimilatory nitrate reduction, denitrification **4. Biosynthesis of ribonucleotides and deoxyribonucleotides** The de novo pathway. Regulation by feedback mechanisms. Recycling via the salvage pathway **5. Amino acid degradation and biosynthesis** **6. Lipid degradation and biosynthesis** **7.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 hydroxyaspartate pathway, **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**
C-1 Test + Assignment	20
C-2 Test + Assignment	20
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**	
C1- **Assessment**	10	**25**	50
C2- Test+Record	10+5		
Total	**25**		
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

Course 2 : Theory: OE 1T: Human Microbiome

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.

GENERAL PATTERN OF THEORY EXAMINATION

B.Sc MICROBIOLOGY(I –IV Semester)

Duration:2 Hours **Maximum: 60 Marks**

Note: *All questions are compulsory*
Draw neat labeled diagrams wherever necessary

QNo. I Answer any EIGHT of the following: **2X8=16**

1.
2.
3.
4.
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10.

QNo. II Answer any SIX of the following: **4X6=24**

11.
12.
13.
14.
15.
16.
17.
18.

QNo. III Answer any TWO of the following : **10X2=20**

19.
20.
21.
22.

PATTERN OF PRACTICAL EXAMINATION

Practical examination – B. Sc MICROBIOLOGY

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

Q. 1	Major question	08 Marks
Q. 2	Minor question	05 Marks
Q. 3	Identify and comment	2X4 = 08Marks
Q. 4	Viva-voce	04 Marks

PATTERN OF FORMATIVE ASSESMENT - PRACTICALS

Max. Marks: 25

1	IA 1(Assesment)	10 Marks
2	IA 2(Test +Record)	15 Marks