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ನಗರ ವಿಶ್ವವಿದ್ಯಾಲಯ
BENGALURU
CITY UNIVERSITY
ಆಗು ಏ ಅಪೇಕ್ಷಾ
BE BOUNDLESS

Syllabus for B.Sc. Microbiology (UG)

CHOICE BASED CREDIT SYSTEM (CBCS)

I & II Semester Microbiology Papers

Under-Graduate (UG) Program
Framed According to the National Education Policy (NEP 2020)

From the academic year 2021-22

MODEL 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 for securing B.Sc. (Basic) or B.Sc. (Hons)

Introduction:

The NEP-2020 offers an opportunity to effect paradigm shift from a teacher-centric to student-centric higher education system in India. It caters skill based education where the graduate attributes are first kept in mind to reverse-design the programs, courses and supplementary activities to attain the graduate attributes and learning attributes. The learning outcomes-based curriculum framework for a degree in **B.Sc. (Honours) Microbiology** is intended to provide a comprehensive foundation to the subject and to help students develop the ability to successfully continue with further studies and research in the subject while they are equipped with required skills at various stages. Effort has been made to integrate use of recent technology and use of MOOCs to assist teaching-learning process among students. The framework is designed to equip students with valuable cognitive abilities and skills so that they are successful in meeting diverse needs of professional careers in a developing and knowledge-based society. The curriculum framework takes into account the need to maintain globally competitive standards of achievement in terms of knowledge and skills in **Microbiology** and allied courses, as well develop scientific orientation, spirit of enquiry, problem solving skills, human and professional values which foster rational and critical thinking in the students. This course serves a plethora of opportunities in different fields right from classical to applied aspects in **Microbiology**.

GRADUATE ATTRIBUTES IN B.Sc. (Hons.) Microbiology

Some of the characteristic attributes a graduate in **Microbiology** should possess are:

• Disciplinary knowledge and skills
• Skilled communication
• Critical thinking and problem solving capacity
• Logical thinking and reasoning
• Team Spirit & Leadership Quality
• Digital efficiency
• Ethical awareness / reasoning
• National and international perspective
• Lifelong learning

Flexibility:

- The programmes are flexible enough to allow liberty to students in designing them according to their requirements. Students may choose a single Major, one Major with a Minor, and one Major with two Minors. Teacher Education or Vocational courses

may be chosen in place of Minor/s below listed are the various options students may choose from.

- One Major subject/discipline, Two Languages, Generic Electives, Ability Enhancement, Skill Development and Vocational courses including Extracurricular Activities.

- One Major and one Minor subject/discipline along with Languages, Generic Electives, Ability Enhancement, Skill Development and Vocational courses including Extracurricular Activities

- Two Major subject/disciplines along with Languages, Generic Electives, Ability Enhancement, Skill Development and Vocational courses, including Extracurricular Activities.

- One Major subject/discipline and one Vocational course along with Languages, Generic Electives, Ability Enhancement and Skill Development and courses including Extracurricular Activities.

- One Major Discipline and One Education Discipline along with Languages, Generic Electives, Ability Enhancement and Skill Development Courses including Extracurricular Activities.

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

- Acquire knowledge and gain understanding of concepts in microbiology and its applications in **pharma, food, agriculture, beverages, and nutraceutical industries**.

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

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

- Learning, practicing professional skills in handling microbes and contaminants in laboratories and production sectors.
- Exploring the microbial world and analyzing the specific benefits and challenges.

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

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

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

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

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

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

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

Assessment: Weightage for assessments

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

*In lieu of the research Project, two additional elective papers/ Internship may be offered in 8th semester.

Progressive Certificate, Diploma, Bachelor's Degree or Bachelor's Degree with Honours provided at the end of each year of exit of the Four-years Undergraduate Programme.

	EXIT OPTIONS	Credits Required
1.	**Certificate** upon the successful completion of the First Year (Two Semesters) of the multidisciplinary Four-years Undergraduate Programme/Five-years Integrated Master's Degree Programme.	44-48
2.	**Diploma** upon the successful completion of the Second Year (Four Semesters) of the multidisciplinary Four-years Undergraduate Programme/Five-years Integrated Master's	88-96

	Degree Programme.	
3.	**Basic Bachelor's Degree** at the Successful Completion of the Third Year (Six Semesters) of the multidisciplinary Four-years Undergraduate Programme/Five-years Integrated Master's Degree Programme.	132-144
4.	**Bachelor's Degree with Honours** in a Discipline at the Successful Completion of the Fourth Year (Eight Semesters) of the multidisciplinary Four-years Undergraduate Programme/Five-years Integrated Master's Degree Programme	176-192

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

1. Acquire and understand the concepts of microbiology and its application in **pharma, food, agriculture, beverages, and nutraceutical 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. Gain knowledge for conserving the environment and resolve the environmental related issues.
4. Apply the knowledge acquired to undertake studies and identify specific remedial measures for the challenges in health, agriculture and food sectors.
5. Understand and apply good laboratory and good manufacturing practices in microbial quality control.
6. Understand biochemical and physiological aspects of microbes and develop broader perspectives to identify innovative solutions for present and future challenges posed by microbes.
7. Understand the application of microbes in forensic and working knowledge about clinical microbiology.
8. Demonstrate the ability to identify ethical issues related to recombinant DNA technology, GMOs, intellectual property rights, biosafety and biohazards.
9. Demonstrate the ability to identify key questions in microbiological research, optimize research methods, and analyze outcomes by adopting scientific methods, thereby improving the employability.
10. Enhance and demonstrate analytical skills and apply basic computational and statistical techniques in the field of Microbiology.

IIA. Model Program Structures for the Under-Graduate Programs in Bengaluru City University and its affiliated Colleges.
Subject: Microbiology

Semester	Discipline Core (DSC)(Credits) (L+T+P)	Discipline Elective(DSE) / Open Elective (OE) (Credits) (L+T+P)	Ability Enhancement Compulsory Courses (AECC),Languages (Credits) (L+T+P)		Skill Enhancement Courses (SEC)		Total Credits
					Skill based (Credits) (L+T+P)	Value based (Credits) (L+T+P)	
I	DSC-T1 MBL 101 A1- General Microbiology (04) DSC-P1 MBL 101 General Microbiology (02)	OE-T1, MBL-301 Microorganisms for Human Welfare (03)	L1-1(3), L2-1(3) (4 hrs. each)	----------	SEC-T1, MBL-701, Microbiological Techniques (1+0+2)	Physical Education for Health &Wellness fitness(1)(0+0+2)(1)(0+0+2)	**25**
II	DSC-T2 MBL 102 A2-Microbial Biochemistry and Physiology (04) DSC-P2 MBL 102 Microbial Biochemistry and Physiology (02)	OE-T2, MBL 302, Environmental Microbiology and Human Health (3)	L1-2(3), L2-2(3) (4 hrs. each)	Environmental Studies (2)	----------	Physical Education - NCC/NSS/R&R(S&	**25**
Exit option with Certificate in Microbiology (50 Credits)							

B.Sc. Microbiology (Basic / Hons.), First Semester

Course Title: DSC-T1MBL101, General Microbiology (A1)	
Course Code: **DSC-T1 MBL101**	L-T-P per week: 4-0-0
Total Contact Hours: **56**	Course Credits: 0**4**
Formative Assessment Marks: **40**	Duration of ESA/Exam: **3 h**
Model Syllabus Authors: **Curriculum Committee**	Summative Assessment Marks: **60**

Course Prerequisite (s): PUC or +2 (Life Sciences as one of the core disciplines)

Course Outcomes (COs): At the end of the course the students will 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)

Sl. No	Course Outcomes (COs) / Program Outcomes (POs)	T1	1	2	3	4	5	6	7	8	9	10	11
I	Core competency	X											
II	Critical thinking	X											
III	Analytical reasoning	X											
IV	Research skills	X											
V	Team work	X											

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.

B.Sc. Microbiology (Basic / Hons.), First Semester

Content of Course 01: Theory: DSC-T1 MBL101: General Microbiology	**56 h**
Unit – 1: Historical development and origin of microorganisms	**14 h**
Historical development of Microbiology – Theory of spontaneous generation, Biogenesis and Abiogenesis. Contributions of Antony van Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Edward Jenner, Alexander Fleming, Martinus Beijerinck, Sergei Winogradsky and Elie Metchnikoff. Contribution of Indian scientists in the field of Microbiology. Fossil evidences of microorganisms. Origin of life, primitive cells and evolution of microorganisms. Microscopy- working principle, construction and operation of simple and compound microscopes.	
Unit – 2: Staining, sterilization and preservation techniques	**14 h**
Staining: Nature of stains, principles, mechanism, methods and types of staining- simple, Differential-Gram staining, acid fast staining, capsule staining, endospore, inclusion bodies. Sterilization: Principles, types and techniques - physical and chemical. Preservation of microorganisms: Methods of preservation, slant culture, stab culture, soil culture, mineral oil overlaying, glycerol preservation, Lyophilization.	
Unit – 3: Prokaryotic microorganisms	**14 h**
Overview of prokaryotic cell structure: Size, shape, arrangement. Ultra structure of prokaryotic cell: bacterial and archaeal - cell wall and cell membrane. Components external to cell wall - capsule, slime, s-layer, pili, fimbriae, flagella; structure, motility, chemotaxis. Cytoplasmic matrix - Cytoskeleton, ribosome, inclusion granules: Composition and function. Nuclear Material – bacterial structure (its differences with the Eukaryotic chromosome); Extra Chromosomal material. Bacterial Endospore - Examples of spore forming organisms, habitats, function, formation and germination. Reproduction in bacteria.	
Unit – 4: Eukaryotic microorganisms	**14 h**
Overview of eukaryotic cell: Types of cells; Structure and function of organelles- cell wall, cell membrane, cytoplasmic matrix, cytoskeleton, endoplasmic reticulum, Golgi complex, peroxisomes, lysosomes, vesicles, ribosomes, mitochondria, chloroplast and nucleus. Structure and functions of flagella. Reproduction in fungi-Vegetative, asexual and sexual	

Pedagogy: Lectures, Presentations, videos, Assignments and Weekly Formative Assessment Tests.

Formative Assessment	
Assessment Occasion	**Weightage in marks**
Assignment/ Field Report/ Project	15 Marks
Test	20 Marks
Participation in class	05 marks
Total	**40 Marks**

General Microbiology Laboratory Content:
Course 01: Practicals: DSC-P1MBL101: General Microbiology

Course Title: **General Microbiology**	Course Credits: **02**
Course Code: **DSC-P1MBL101**	L-T-P per week: 0-0-4
Total Contact Hours: **28**	Duration of ESA/Exam: 4 h
Formative Assessment Marks: **25**	Summative Assessment Marks: **25**

1. Microbiological laboratory standards and safety protocols.
2. Operation and working principles of light and compound microscope.
3. Working principle and operations of basic equipments of microbiological laboratory (Autoclave, oven, incubator, LAF, pH meter, spectrophotometer, colorimeter, vortex, magnetic stirrer etc.).
4. Isolation and identification of microorganisms from natural sources (Algae, Yeast, filamentous fungi and protozoa).
5. Bacterial motility by hanging drop method.
6. Simple staining – Negative staining.
7. Differential staining – Gram staining.
8. Acid fast staining.
9. Structural staining – Flagella and capsule.
10. Bacterial endospore staining.
11. Staining of reserved food materials (granular).
12. Staining of fungi by lactophenol cotton blue.

Text Books/References

1. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. 2002. Introductory Mycology. John Wiley and Sons (Asia) Pvt. Ltd. Singapore.869 pp.
2. Atlas, R.M. 1984. Basic and practical microbiology. Mac Millan Publishers, USA.987pp.
3. Black, J.G. 2008. Microbiology principles and explorations. 7th edition. John Wiley and Sons Inc., New Jersey. 846pp.
4. Dubey, R.C. and Maheshwari, D.K. 1999. A Textbook of Microbiology, 1st edition, S. Chand & Company Ltd.
5. Madigan, M.T., Martinko, J.M., Dunlap, P.V. and Clark, D.P. 2009. Brock Biology of Microorganisms, - 12th edition, Pearson International edition, Pearson Benjamin Cummings.
6. Michael Pelczar, Jr., Chan E.C.S., Noel Krieg 1993. Microbiology - Concepts and Applications, International ed, McGraw Hill.
7. Pommerville, J.C. 2013. Alcamo's Fundamentals of Microbiology. Jones and Bartlett.
8. Schlegel, H.G. 1995. General Microbiology. Cambridge University Press, Cambridge, 655 pp.

9. Stanier, Ingraham et al. 1987. General Microbiology, 4th and 5th edition Macmillan education limited. International, edition 2008, McGraw Hill.
10. Talaro, K.P. 2009. Foundations in Microbiology, 7th International edition, McGraw Hill.
11. Toratora, G.J., Funke, B.R. and Case, C.L. 2007. Microbiology 9th ed. Pearson Education Pvt. Ltd., San Francisco.958 pp.
12. Tortora, G.J., Funke, B.R., Case C.L. 2008. Microbiology an Introduction, 10th ed. Pearson Education.
13. Willey, J. M., Sherwood, L., Woolverton, C. J., & Prescott, L. M. (2008). Prescott, Harley, and Klein's microbiology. New York: McGraw-Hill Higher Education.

Pedagogy: Lectures, Presentations, videos, Assignments and Weekly Formative Assessment Tests.

Formative Assessment	
Assessment Occasion	**Weightage in Marks**
Assignment/Monograph	10
Test	10
Participation in class	05
Total	**25**

Course 02: Theory: OE-T1MBL301: Microorganisms for Human Welfare

Course Title: **Microorganisms for Human Welfare**	Course Credits: **03**
Course Code: **OE-T1MBL301**	L-T-P per week: 0-0-3
Total Contact Hours: **42h**	Duration of ESA/Exam: 4h
Formative Assessment Marks: **30**	Summative Assessment Marks: **45**

Unit – 1: Food and Fermentation	**14 h**
Fermented Foods – Types, nutritional values and health benefits.Probiotics, prebiotics, synbiotics and nutraceuticals. Fermented Products – Alcoholic and non-alcoholic beverages, dairy products.	
Unit – 2: Agriculture	**14 h**
Bio-fertilizers and bio-pesticides - types and applications, beneficial microorganisms in agriculture, AM fungi, Mushroom cultivation, Biogas production.	
Unit – 3: Pharmaceutical Industry	**14 h**
Drugs – types, development and applications. Antibiotics – types, functions and antibiotic therapy. Vaccines – types, properties, functions and schedules.	

Texbooks/References

1. Ananthnarayanan, R and Jeyaram Panicker, C. K. 2010.Textbooks of Microbiology, Orient Longman.
2. Dubey, R.C. and Maheshwari, D.K. 2013. A Textbook of Microbiology –2nd edition (S chand & Co. N. Delhi).
3. Michael, J. Pelczar, Jr. E.C.S., Chan, Noel R. 1998. Krieg Microbiology Tata McGraw- Hill Publisher.
4. Pelczar, M.J., Chan E.C.S. and Kreig, N.R. 1993. Microbiology 5th edition (Tata McGraw-Hill, New Delhi)
5. Prescott, L.M., Harley, J.P. and Klein, D.A., 2007. Microbiology –7th edition (Wm. C. Brown Publishers, USA) Elementary Microbiology – Modi, HA (vol. I), 1st edition (Ekta Pakashan, Nadiad).
6. Prescott, M.J., Harly, J.P. and Klein 2002. Microbiology 5ft Edition, WCB McGraw Hill, New York.
7. Sateesh, M.K. 2010. Bioethics and Biosafety. IK International Pvt Ltd. 2. Dubey, RC A Textbook of Biotechnology. S Chand Publications.
8. Singh, B.D. 2013. Expanding Horizons in Biotechnology. Kalyani Publication.
9. Sree Krishna, V. 2007. Bioethics and Biosafety in Biotechnology, New age international publishers
10. Willey, J.M., Sherwood L.M and Woolverton C.J., Prescott, Harley and Klein's. 2013. Microbiology. McGraw Hill Higher education. 9th Edition.

Pedagogy: Chalk and Talk, PPT, Group discussion, Seminars, Field visit

Formative Assessment	
Assessment Occasion	Weightage in Marks
House Examination/Test	15
Written Assignment/Presentation/Project / Term Papers/Seminar	10
Class performance/Participation	05
Total	30

Skill Enhancement Course in Microbiology

Course 03: Theory: SEC-T1MBL701, Microbiological 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, Level3.

- 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.

- Principles which underlies sterilization of culture media, glassware and plastic ware to be used for microbiological work.

- 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.

- 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 to a variety of modifications in the microscopes for specialized viewing.

<table>
<tr><td colspan="2">Course content:03
Course Title: SEC-T1MBL701: Microbiological Techniques</td><td rowspan="3">14 h</td></tr>
<tr><td>Total Contact Hours: 14 Hours</td><td>Duration of ESA:01Hrs.</td></tr>
<tr><td>Formative Assessment Marks: 10</td><td>Summative Assessment Marks: 15</td></tr>
<tr><td colspan="2">Unit-1:
• 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, inoculation of samples, incubation and observations of microbial colonies. Morphological characterization of microorganisms -Colony characteristics, Microscopic characters, biochemical / physiological tests or properties and identification. Sub culturing 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 Microscopes, Scanning Probe Microscopy</td><td></td></tr>
</table>

• **Centrifugation, Chromatography and spectroscopy:** principles, types, instrumentation, operation and applications.	

Lab content of Skill Enhancement Course in Microbiology

Course - 03: Practicals: SEC-P1MBL701, Microbiological Techniques

Course content:03 Course Title: SEC-P1MBL701: Microbiological Techniques	
Total Contact Hours: 28 Hours	Duration of ESA:02Hrs.
Formative Assessment Marks: 25	Summative Assessment Marks: 25

1. Methods and practices in Microbiology lab: MSDS (Material Safety and Data Sheet), Good Clinical Practices (GCP), Standard Operating Procedure (SOP), Good Laboratory Practices (GLP), Good Manufacturing Practices (GMP).
2. Usage and maintenance of basic equipments of microbiology lab: Principles, calibrations, and SOPs of balances, pH meter, autoclave, incubators, laminar air flow (LAF) and biosafety cabinets, microscopes, homogenizers, stirrers.
3. Preparation of different types of bacterial culture media.
4. Preparation of different types of fungal culture media.
5. Preparation of different types of algal culture media.
6. Isolation and cultivation of bacteria, actinobacteria, fungi and algae.
7. Identification and characterization of bacteria, actinobacteria, fungi and algae.
8. Biochemical and physiological tests for identification of bacteria.
9. Separation of biomolecules by paper/thin layer chromatography.
10. Demonstration of column chromatography.
11. Preparation of permanent slides (bacteria, fungi and algae).
12. Procedures for documentation, lab maintenance, repair reporting.

Pedagogy: Lectures, Presentations, videos, Assignments and Weekly Formative Assessment Tests.

Formative Assessment	
Assessment Occasion	**Weightage in Marks**
Assignment/Monograph	10
Test	10
Participation in class	05
Total	**25**

B.Sc. Microbiology (Basic / Hons.), Second Semester

Course Title: DSC-T2 MBL102, Microbial Biochemistry and Physiology (A2)	
Course Code: **DSC-T2 MBL102**	L-T-P per week: 4-0-0
Total Contact Hours: **56**	Course Credits: 0**4**
Formative Assessment Marks: **40**	Duration of ESA/Exam: **3 h**
Model Syllabus Authors: **Curriculum Committee**	Summative Assessment Marks: **60**

Course Outcomes (COs): At the end of the course the students will be able to:

1. Acquire thorough knowledge and understanding of concepts of Microbiology.
2. Learn and practice professional skills in handling microbes.
3. Gain thorough knowledge and apply good laboratory and good manufacturing practices in microbial quality control.

Course Articulation Matrix: Mapping of Course Outcomes (Cos) with Program Outcomes (Pos 1-12)

Sl. No	Course Outcomes (COs) / Program Outcomes (POs)	T1	1	2	3	4	5	6	7	8	9	10	11
I	Core competency	X											
II	Critical thinking	X											
III	Analytical reasoning	X											
IV	Research skills	X											
V	Team work	X											

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.

B.Sc. Microbiology (Basic / Hons.), Second Semester

Content of Course 1: Theory: DSC-T2MBL102: Microbial Biochemistry and Physiology	**56h**
Unit – 1: Biochemical concepts	**14h**
Basic Biochemical Concepts: Major elements of life and their primary characteristics, atomic and chemical bonds – covalent, non-covalent, ionic, hydrogen and Vander Waal's Forces. **Biological Solvents:** Structure and properties of water molecule, water as an universal solvent, polarity, hydrophilic and hydrophobic interactions, acids, bases, electrolytes, pH and buffers, Henderson–Hasselbalch equation.	
Unit – 2: Macromolecules	**14h**
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; fatty acids: types and classification.	

Porphyrins and Vitamins: Definition, structure, properties and importance of chlorophyll, cytochromes and hemoglobin.	
Unit – 3: Microbial growth and nutrition	**14h**
Microbial Growth: Definition, growth curve, phases of growth, growth kinetics, generation time. Synchronous culture, continuous culture (chemostat and turbidostat), coulter cultures, diauxic growth. Measurement of growth: Direct microscopic count - Haemocytometer; viable count, membrane filtration; electronic Counting; Measurement of cell mass; Turbidity measurements - Nephelometer and spectrophotometer based techniques; Measurement of cell constituents. Growth yield. Influence of environmental factors on growth. **Microbial Nutrition:** Microbial nutrients, macro and micronutrients, classification of organisms based on nutritional requirements. **Membrane Transport:** Structure and organization of biological membranes, Types of cellular transport - passive, facilitated, active, group translocation, membrane bound protein transport system, carrier models, liposomes, ion channels, Na^+K^+-ATPase.	
Unit – 4: Bioenergetics, Respiration and Photosynthesis	**14h**
Bioenergetics: Free energy, enthalpy, entropy, laws of thermodynamics. High energy compounds: classification, structure and significance, oxidation reduction reactions, equilibrium constant, redox potential. **Microbial Respiration:** Electron transport chain, protein translocation, and substrate level phosphorylation, oxidative phosphorylation, inhibitors of ETC and mechanism, structure and function of ATP synthase and ATP synthesis. Fermentation reactions (homo and hetero lactic fermentation) **Microbial Photosynthesis:** Light reaction: Light harvesting pigments, Photophosphorylation, CO_2 fixation pathways: Calvin cycle, CODH pathway, Reductive TCA pathway.	

Text Books/References

1. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. 2002. Introductory Mycology. John Wiley and Sons (Asia) Pvt. Ltd. Singapore. 869 pp.
2. Atlas, R.M. 1984. Basic and practical Microbiology. Mac Millan Publishers, USA. 987 pp.
3. Black, J.G. 2008. Microbiology principles and explorations. 7th edition. John Wiley and Sons Inc., New Jersey 846 pp.
4. Boyer, R. 2002, Concepts in Biochemistry 2nd Edition, Brook/Cole, Australia.
5. Caldwell, D.R. 1995 – Microbial Physiology and Metabolism. Brown Publishers
6. Dubey R.C. and Maheshwari D.K. 1999. A Textbook of Microbiology, 1st edition, S. Chand & Company Ltd.
7. Felix Franks, 1993. Protein Biotechnology, Humana Press, New Jersey.
8. Harper, 1999. Biochemistry, McGraw Hill, NewYork
9. Lodish, H.T. Baltimore, A. Berck B.L. Zipursky, P. Mastsydaire and J. Darnell. 2004. Molecular Cell Biology, Scientific American Books, Inc. Newyork
10. Madigan, M.T., Martinko J.M., Dunlap P.V., Clark D.P. 2009. Brock Biology of Microorganisms, 12th edition, Pearson International edition Pearson Benjamin

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11. Michael Pelczar, Jr., Chan E.C.S., Noel Krieg 1993. Microbiology - Concepts and Applications, International ed, McGraw Hill.
12. Moat, A. G., Foster, J.W. Spector. 2004. Microbial Physiology 4th Edition Panama Book Distributors.
13. Nelson, and Cox, 2000. Lehninger Principles of Biochemistry, Elsevier Publ.
14. Palmer, T. 2001. Biochemistry, Biotechnology and Clinical Chemistry, Harwood Publication, Chichester.
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16. Schlegel, H.G. 1995. General Microbiology. Cambridge University Press Cambridge, 655 pp.
17. Stanier, Ingraham et al. 1987. General Microbiology, 4th and 5th edition Macmillan education limited. International, edition 2008, McGraw Hill.
18. Stryer, L, 1995. Biochemistry, Freeman and Company, New York.
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20. Toratora, G.J., Funke, B.R. and Case, C.L. 2007. Microbiology 9th edition. Pearson Education Pvt. Ltd., San Francisco. 958pp.
21. Tortora, G.J., Funke, B.R., Case, C.L. 2008. Microbiology-An Introduction, 10th ed. Pearson Education.
22. Voet and Voet, 1995; Biochemistry, John Wiley and Sons, New York.
23. Willey, J. M., Sherwood, L., Woolverton, C. J., and Prescott, L. M. (2008). Prescott, Harley, and Klein's microbiology. New York: McGraw-Hill Higher Education.

Formative Assessment	
Assessment Occasion	**Weightage in marks**
Assignment/ Field Report/ Project	15 Marks
Test	20 Marks
Participation in class	05 marks
Total	**40 Marks**

Microbial Biochemistry and Physiology Laboratory Content
Course 01: Practicals: DSC-P2, MBL102: Microbial Biochemistry and Physiology

Course Title: **Microbial Biochemistry and Physiology**	Course Credits: **02**
Course Code: **DSC-P1 MBL102**	L-T-P per week: 0-0-4
Total Contact Hours: **28**	Duration of ESA/Exam: 03 h
Formative Assessment Marks: **25**	Summative Assessment Marks: **25**

1. Preparation of normal and molar solutions.
2. Calibration of pH meter and determination of pH of natural samples.
3. Preparation of buffer solutions (any 4).
4. Qualitative analysis of carbohydrates.
5. Qualitative analysis of amino acids and proteins.
6. Qualitative analysis of lipids.
7. Estimation of reducing sugar by DNS method.
8. Estimation of protein by Lowry's method.
9. Determination of saponification values and iodine number of lipids/fatty acids.
10. Determination of bacterial growth by turbidometric method & calculation of generation time.
11. Effect of pH, temperature and salt concentration on bacterial growth.
12. Demonstration of aerobic and anaerobic respiration in microbes.

Pedagogy: Lectures, Presentations, videos, Assignments and Weekly Formative Assessment Tests.

Formative Assessment	
Assessment Occasion	**Weightage in Marks**
Assignment/Monograph	10
Test	10
Participation in class	05
Total	**25**

Course 02: Theory: OE-T2, MBL302: Environmental Microbiology and Human Health

Course Title: Environmental Microbiology and Human Health	**Course Credits: 03**
Course Code: OE-T2MBL302	**L-T-P per week: 0-0-3**
Total Contact Hours: 42h	**Duration of ESA/Exam: 3h**
Formative Assessment Marks: 30	**Summative Assessment Marks: 45**

Unit – 1: Soil and Air Microbiology	**14 h**
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 h**
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: Microbial Diseases and Control	**14 h**
Public health hygiene and communicable diseases. Survey and surveillance of microbial infections. Air borne microbial diseases, water borne microbial diseases, Food borne microbial infections. Epidemiology of microbial infections, their detection and control.	

Text Books/References

1. Alexopoulos, C.J., Mims, C.W., and Blackwell, M. 2002. Introductory Mycology. John Wiley and Sons (Asia) Pvt. Ltd. Singapore. 869 pp.
2. Atlas, R.M. 1984. Basic and practical Microbiology. Mac Millan Publishers, USA. 987 pp.
3. Black, J.G. 2008. Microbiology principles and explorations. 7th edn. John Wiley and Sons Inc., New Jersey 846 pp.
4. Dubey R.C. and Maheshwari D.K. 1999. A Textbook of Microbiology, 1st edition, S. Chand & Company Ltd.
5. Madigan, M.T., Martinko, J.M., Dunlap, P.V. and Clark, D.P. 2009. Brock Biology of Microorganisms, - 12th edition, Pearson International edition, Pearson Benjamin Cummings.
6. Michael Pelczar, Jr., Chan E.C.S., Noel Krieg 1993. Microbiology - Concepts and Applications, International ed, McGraw Hill.
7. Pommerville, J.C. 2013. Alcamo's Fundamentals of Microbiology. Jones and Bartlett.
8. Schlegel, H.G. 1995.General Microbiology. Cambridge University Press, Cambridge, 655 pp.
9. Stanier, Ingraham et al. 1987. General Microbiology, 4th and 5th edition Macmillan education limited. International, edition 2008, McGraw Hill.
10. Talaro, K.P. 2009. Foundations in Microbiology, 7th International edition, McGraw Hill.
11. Toratora, G.J., Funke, B.R. and Case, C.L. 2007. Microbiology 9th ed. Pearson Education Pvt. Ltd., San Francisco.958 pp.
12. Tortora, G.J., Funke, B.R., Case C.L. 2008. Microbiology an Introduction, 10th ed. Pearson Education.

13. Willey, J. M., Sherwood, L., Woolverton, C. J., and Prescott, L. M. (2008). Prescott, Harley, and Klein's microbiology. New York: McGraw-Hill Higher Education.

Pedagogy: Chalk and Talk, PPT, Group discussion, Seminars, Field visit

Formative Assessment	
Assessment Occasion	Weightage in Marks
House Examination/Test	15
Written Assignment/Presentation/Project / Term Papers/Seminar	10
Class performance/Participation	05
Total	30

Structure of
B.Sc. Honours
in
MICROBIOLOGY
(Model II A)

Government of Karnataka

Model Curriculum

Program Name	**B.Sc. Discipline**	Total Credits for the Program	**Credits**
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, 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 analysing 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 analyse 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.		DSC- 7	Theory	3	Microbial Diversity	60	40
			Practical	2	Microbial Diversity	25	25
		OE- 3	Theory	3	Microbial Entrepreneurship	60	40
4.		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
	Exit Option with Diploma in Microbiology (100 Credits)						

Government of Karnataka

Model Curriculum

Program Name	**BSc Microbiology**		Semester	**Third Sem**
Course Title	**Microbial Diversity**			
Course No.	**MBL-103**	**DSC -3T**	No. of Theory Credits	**4**
Contact hours	**56 hrs**		Duration of ESA/Exam	**2 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. Acquire knowledge about microbes and their diversity
2. Study the characteristics, classification and economic importance of Prokaryotic and Eukaryotic microorganisms.
3. Gain knowledge about viruses and their diversity

Content	**Hrs**
Unit–I	**08 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	
Diversity of Prokaryotic Microorganisms Distribution, factors regulating distribution. An overview of Bergey's Manual of Systematic Bacteriology. General characteristics; Classification; Economic importance of: **Archaea:** *Thermus aquaticus,* Methanogens **Bacteria:** *Escherichia coli, Bacillus subtilis,* Cyanobacteria*: Microcystis, Spirulina* Actinomycetes: *Streptomyces, Nocardia, Frankia* Rickettsiae: *Rickettsia rickettsi* Chlamydiae: *Chlamydia trachomatis*	**16 Hrs**
Spirochaetes**:** *Trepanema pallidum,* Mycoplasma	

Unit -III	
Diversity of Eukaryotic Microorganism General characters; Classification- Economicimportance **Fungi:** Ainsworth classification- detailed study up to the level of classes, Salient features and reproduction. Type study: *Rhizopus, Saccharomyces, Aspergillus, Agaricus, Fusarium* **Algae:** Occurrence, distribution, and symbiotic association- Lichen; thallus organization and types. Type study: *Chlorella, Diatom, Gracilaria,* **Protozoa:** Classification up to the level of classes. Type study: *Euglena, Trichomonas, Plasmodium, Trypanosoma*	**16 Hrs**
Unit -IV	**16 Hrs**
Diversity of Viruses General structure, Isolation, purification and culturing of viruses. Principles of Viral Taxonomy- Baltimore and ICTV and the recent trends. Capsid symmetry- Icosahedral, helical, complex **Animal:** HIV, Corona, Ortho and Paramyxovirus, Oncogenic virus **Plants:** TMV, Papaya virus **Microbial:** T4, lambda, cyano and myco phages. Sub viral particles.Viroids 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 and Assignment	10
Debates and Quiz	10
Test	10
Total	**60 marks + 40 marks = 100 marks**

Course Title	**Microbial Diversity (Practical)**		Practical Credits	**2**
Course No.	**MBL-103**	**DSC-4P**	Contact hours	**26 Hrs**

Content

1. Isolation and identification of bacteria from soil, air and water
2. Isolation, and identification of fungi from soil, air and water
3. Isolation, and identification of Cyanobacteria
4. Isolation, and identification of Actinomycetes
5. Study of morphology of bacteria - cocci, bacilli, vibrio and spiral
6. Measurement of microbial cell size by Micrometry,
7. Spore count by haemocytometer
8. Type study: Cyanobacteria *Nostoc, Microcystis Spirulina*
9. Type study: Algae; *Chlorella, Diatoms, Gracilaria*
10. Type study: Fungi; *Rhizopus, Saccharomyces, Agaricus*
11. Type study: Protozoa: *Euglena,Plasmodium, Trypanosoma*
12. Study of micrographs /models - HIV, TMV, Corona virus

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 edition.Blackwell Publishing, USA

4 Flint, S.J., Enquist, L.W., Drug, R.M., Racaniello, V.R. and Skalka, A.M. 2000. Principles ofVirology-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, 2008. 7th International, edition ,McGraw Hill

6 Vashishta, B.R, Sinha A.K and Singh V. P. 2005. Botany – Fungi, S. Chand and Company Limited, New Delhi

7 Kotpal, R.L Protozoa 5th Edition 2008. Rastogi Publications, Meerut, New Delhi.

8 Madigan, M.T. Martinko, J.M, Dunlap, P. V. Clark, D. P. 2009. Brock Biology of Microorganisms, 12thedition, Pearson Benjamin Cummings

9 G. J. Tortora, B. R. Funke, C. L. 2008. Microbiology – An Introduction, Case, 10th edition., Pearson Education, UK.

10 Stanier, 1987,Ingraham *et al*, General Microbiology, 4th and 5th edition Macmillan education limited
11 Pelczar Jr. Chan, Krieg, Microbiology- Concepts and Applications, International edition, 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, 4th edition.

13 Vashishta, B.R Sinha A.K and Singh V. P. 2005. Botany - Algae S. Chand and Company Limited, New Delhi

14 Dubey R. C., and Maheshwari, D. K. 1999. A Textbook of Microbiology, 1st edition, S. Chand & Company Ltd, New Delhi

15 K. P. Talaro, 2009. Foundations in Microbiology, 7th International edition, McGraw Hill

Date: Subject Committee Chairperson

Government of Karnataka

Model Curriculum

Program Name	**BSc Microbiology**		Semester	**Third Sem**
Course Title	**Microbial Entrepreneurship**			
Course Code	**MBL:303**	**OE-3**	No. of Theory Credits	**3**
Contact hours	**Lecture**		Duration of ESA/Exam	**2 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 on Industrial entrepreneurship 3. Acquire knowledge on Healthcare Entrepreneurship	
Content	**42 Hrs**
Unit–I	**14 Hrs**
General Entrepreneurship Entrepreneurship and microbial entrepreneurship - Introduction and scope, Business development, product marketing, HRD, Biosafety 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 and SCO. Neutraceutical products.	
Unit -III	**14 Hrs**
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 = 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 Balasubramanian, S.C (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. 5th edition.

Date: Subject Committee Chairperson

Government of Karnataka

Model Curriculum

Program Name	**BSc Microbiology**		Semester	**Fourth Sem**
Course Title	**Microbial Enzymology and Metabolism**			
Course No.	**MBL:104**	**DSC -4T**	No. of Theory Credits	**4**
Contact hours	**56 hrs**		Duration of ESA/Exam	**2 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 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	**56 Hrs**
Unit–I	**14 Hrs**
Metabolism of Carbohydrates Concept of aerobic respiration, anaerobic respiration and fermentation. Sugar degradation pathways i.e. EMP, ED, Pentose phosphate pathway, Phosphoketolase pathway. TCA cycle. Fermentation - Fermentation balance, concept of linear and branched fermentation pathways. Fermentation pathways: Alcohol fermentation and Pasteur effect; Butyric acid and Butanol-Acetone Fermentation, Mixed acid and 2,3-butanediol fermentation, Propionic acid Fermentation, acetate fermentation. Chemolithotrophic metabolism: Chemolithotrophy -Oxidation of Hydrogen, Sulphur, Iron and Nitrogen. Anaerobic respiration with special reference to dissimilatory nitrate reduction and sulphate reduction.	
Unit -II	**14 Hrs**
Metabolism of aminoacids, 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 of purines and pyrimidines, recycling by salvage pathway **3. Amino acid degradation and biosynthesis: Deamination and decarboxylation-** An overview of aminoacids biosynthesis **4. Lipid degradation and biosynthesis**: β-oxidation of palmitic acid; Biosynthesis of palmitic acid. **5. Metabolism of one carbon compounds:** Acetogens: Autotrophic pathway of acetate synthesis	

6. Metabolism of two-carbon compounds: Acetate: **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	
Unit -III	**14 Hrs**
Basics of Enzymes Introduction to enzymes–Definition, 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. Multisubstrate reactions -Ordered, Random and Ping-pong.	
Unit -IV	**14 Hrs**
Enzyme Kinetics and Regulation Enzyme Kinetics: Kinetics of one substrate reactions. i. Equilibrium assumptions ii. Steady state assumptions iii. Line weaver-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 catalyzed reaction. Kinetics of two substrate reactions. Pre steady state kinetics. Kinetics of immobilized enzymes Enzyme regulation: Allosteric enzyme - general properties, Hill equation, Koshland Nemethy and Filmer model, Monod Wyman and Changeux model. Covalent modification by various mechanisms. Regulation by proteolytic cleavage - blood coagulation cascade. Regulation of multi-enzyme complex- Pyruvate dehydrogenase. Feedback inhibition.	

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 and Assignment	10
Debates and Quiz	10

Test	10
Total	**60 marks + 40 marks = 100 marks**

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

Content

1. Estimation of total lipid
2. Identification of fatty acids and other lipids by TLC
3. Isolation of lactose from bovine milk
4. Estimation of total sugars by the phenol-sulphuric acid method
5. Estimation of DNA - DPA method & UV absorbance method
6. Estimation of RNA (Orcinol method)
7. Determination of molar absorption coefficient (ε) of l-tyrosine
8. Estimation of polyphenols/ tannins by Folin- Denis method
9. Demonstration of alcoholic fermentation
10. Effect of variables on enzyme activity (amylase): a. Temperature b. pH c. substrate concentration d. Enzyme concentration
11. Determination of Km and Vmax of amylase (Lineweaver-Burke plot; Michaelis-Menton equation)
12. Identification of metabolic pathways through charts (Any 3)

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 Wood W. B. Wilson J.H., Benbow R.M. and Hood L.E. 1981. Biochemistry- A Problem Approach, 2nd edition. The Benjamin/ Cummings Pub.co

4 Segel I.R., 2nd edition., 2004, Biochemical calculations, John Wiley and Sons

5 Irwin H. Segel, 2nd Edition, Biochemical Calculations, John Wiley & Sons

Date: Subject Committee Chairperson

Government of Karnataka

Model Curriculum

Program Name	**BSc Microbiology**		Semester	**Fourth Sem**
Course Title	**Human Microbiome**			
Course Code	**MBL:304**	**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 micro biome.
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	**42 Hrs**
Unit–I	**14 Hrs**
INTRODUCTION TO MICROBIOME Normal human microbiota and their role in health-gut microflora, skin microflora, microflora of reproductive and excretory system. Symbiotic and parasitic association.	
Unit -II	**14 Hrs**
MICROBIOMES AND HUMAN HEALTH Pre and post-natal Microbiome, Nutritional modulation of the gut microbiome for metabolic health -role of gut microbiomes in human obesity, human type 2 diabetes. Influence of microbiome in aging. 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	**14 Hrs**
CULTURING OF MICROBES FROM MICROBIOMES Culturing of organisms of interest from the microbiome: bacterial, fungal, and yeast. Study of the microbiome genome	
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	
2	
3	
4	
5	

Date: Subject Committee Chairperson