

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: 04
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. Tortora, 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.	

Textbooks/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 5th 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.

Course content:03		14 h
Course Title: SEC-T1MBL701: Microbiological Techniques		
Total Contact Hours: 14 Hours	Duration of ESA:01Hrs.	
Formative Assessment Marks: 10	Summative Assessment Marks: 15	
Unit-1: <ul style="list-style-type: none">• 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		

<ul style="list-style-type: none"> • 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: 04
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									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
<p>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.</p> <p>Microbial Nutrition: Microbial nutrients, macro and micronutrients, classification of organisms based on nutritional requirements.</p> <p>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.</p>	
Unit – 4: Bioenergetics, Respiration and Photosynthesis	14h
<p>Bioenergetics: Free energy, enthalpy, entropy, laws of thermodynamics. High energy compounds: classification, structure and significance, oxidation reduction reactions, equilibrium constant, redox potential.</p> <p>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)</p> <p>Microbial Photosynthesis: Light reaction: Light harvesting pigments, Photophosphorylation, CO₂ fixation pathways: Calvin cycle, CODH pathway, Reductive TCA pathway.</p>	

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, New York
9. Lodish, H.T. Baltimore, A. Berck B.L. Zipursky, P. Mastsydaire and J. Darnell. 2004. Molecular Cell Biology, Scientific American Books, Inc. New York
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

Cummings.

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.
15. Pommerville, J.C. 2013. Alcamo's Fundamentals of Microbiology. Jones and Bartlett.
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.
19. Talaro, K.P. 2009. Foundations in Microbiology, 7th International edition McGraw Hill.
20. Tortora, 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

Assessment:

Weightage for assessments (in percentage)

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

Contents of Courses for B.Sc. Microbiology as Major**Mode III 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)							

ProgramName	BSc Microbiology		Semester	III Sem
CourseTitle	Microbial Diversity			
CourseNo.	MBL-103	DSC -3T	No. of Theory Credits	4
Contact hours	56hrs		Duration of ESA/Exam	2 Hours
Formative Assessment Marks	40		Summative Assessment Marks	60

Course Pre-requisite(s):.	
Course Outcomes(COs): At the end of the course the student should be able to:	
<ol style="list-style-type: none"> 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: <i>Thermus aquaticus</i> , Methanogens Bacteria: <i>Escherichia coli</i> , <i>Bacillus subtilis</i> , Cyanobacteria: <i>Microcystis</i> , <i>Spirulina</i> Actinomycetes: <i>Streptomyces</i> , <i>Nocardia</i> , <i>Frankia</i> Rickettsiae: <i>Rickettsia rickettsi</i> Chlamydiae: <i>Chlamydia trachomatis</i> Spirochaetes: <i>Trepanemapallidum</i> , Mycoplasma	16 Hrs

Unit-III	
Diversity of Eukaryotic Microorganism General characters; Classification- Economic importance Fungi: Ains worth classification-detailed study upto the level of classes, Salient features and reproduction. Type study: <i>Rhizopus, Saccharomyces, Aspergillus, Agaricus, Fusarium</i> Algae: Occurrence, distribution, and symbiotic association- Lichen; thallus organization and types. Type study: <i>Chlorella, Diatom, Gracilaria,</i> Protozoa: Classification up to the level of classes. Type study: <i>Euglena, Trichomonas, Plasmodium, Trypanosoma</i>	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. Capsidsymmetry - Icosahedral, helical,complex Animal: HIV,Corona,OrthoandParamyxovirus, Oncogenic virus Plants: TMV, Papaya virus Microbial: T4, lambda, Cyanophages and mycophages. Subviralparticles: Viroidsand Prions.	

CourseArticulationMatrix:Mappingof CourseOutcomes(COs)withProgramOutcomes(POs1-12)

CourseOutcomes(COs)/ProgramOutcomes(POs)	ProgramOutcomes (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 = 60Marks	
Formative Assessment Occasion/type	WeightageinMarks
Attendance	10
Seminar and Assignment	10
Debates and Quiz	10
Test	10
Total	60marks + 40marks= 100 marks

CourseTitle	MicrobialDiversity(Practical)		PracticalCredits	2
CourseNo.	MBL-103	DSC-4P	Contacthours	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 Cyano bacteria
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, Coronavirus

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, 5th 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 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, 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, 12th edition, Pearson Benjamin Cummings
- 9 G.J. Tortora, B.R. Funke, C.L. 2008. Microbiology-An Introduction, Case, 10th edition., Pearson Education, UK.

1 Stanier, 1987, Ingraham *et al.*, General Microbiology, 4th and 5th edition Macmillan education limited

- 1 Pelczar Jr. Chan, Krieg, Microbiology- Concepts and Applications, International edition, McGraw Hill
- 1
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

Program Name	BSc Microbiology		Semester	III 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:	
<ol style="list-style-type: none"> 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. Nutraceutical 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=60Marks	
Formative Assessment Occasion/type	Weightage in Marks
Attendance	10
Seminar	10
Debates and Quiz	10
Test	10
Total	60marks + 40marks= 100 marks

References

- 1 Srilakshmi,B.(2007).Dietetics.New Age Internationalpublishers.NewDelhi
- 2 Srilakshmi,B.(2002).NutritionScience.NewAgeInternationalpublishers. New Delhi
- 3 Swaminathan,M.(2002).AdvancedtextbookonfoodandNutrition.VolumeI.Bappco
- 4 Gopalan,.C.RamaSastry,B.V. and Balasubramanian, S.C (2009).Nutritive value of IndianFoods. NIN. ICMR. Hyderabad.
- 5 MudambiSRandRajagopalMV.2008.FundamentalsofFoods,Nutrition&diettherapybyNewAgeInternational Publishers, NewDelhi. 5th edition.

Date:

Subject Committee Chairperson

Program Name	BSc Microbiology		Semester	IV Sem
Course Title	Microbial Enzymology and Metabolism			
Course No.	MBL:104	DSC -4T	No. of Theory Credits	4
Contact hours	56hrs		Duration of ESA/Exam	2Hours
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:	
<ol style="list-style-type: none"> 1. Differentiating concepts of chemoheterotrophic metabolism and chemolithotrophic metabolism. 2. Describing the enzyme kinetics, enzyme activity and regulation. 3. Differentiating concepts of aerobic and an aerobic 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. An aerobic respiration with special reference to dissimilatory nitrate reduction and sulphate reduction.	
Unit-II	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 of purines and pyrimidines, recycling by salvage pathway 3. Amino acid degradation and biosynthesis: Deamination and decarboxylation- An overview of amino acids 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 hydroxylaspartate pathway Oxalate as carbon and energy source	

Unit-III	14 Hrs
<p>Basics of Enzymes Introduction to enzymes– Definition, enzyme unit, specific activity and turnover number, exo/endoenzymes, constitutive/ inducedenzymes, isozymes. Monomeric, Oligomeric and Multimericenzymes. 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: activesite, transition state complex and activation energy. Lock and key hypothesis and Induced Fithy pothesis. Multisubstrate reactions- Ordered, Random and Ping-pong.</p>	
Unit-IV	14 Hrs
<p>Enzyme Kinetics and Regulation Enzyme Kinetics: Kinetics of one substrate reactions. i.Equilibrium assumptionsi. Steadystate Assumptions iii. Lineweaver-Burk, Hanes-Woolf, Eadie-Hofstee equations and plots. Kinetics of enzymeinhibition. Competitive, non-competitive and uncompetitive inhibition. Effect of changes in pH and temperature on enzyme catalyzed reaction. Kinetics of two substrate reactions. Presteadystate 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 variousmechanisms. Regulation by proteolytic cleavage - blood coagulation cascade. Regulation of multi-enzyme complex- Pyruvate dehydrogenase. Feedback inhibition.</p>	

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	60marks + 40marks= 100 marks

CourseTitle	Microbial Enzymology and Metabolism(Practical)		Practical Credits	2
CourseNo.	MBL:104	DSC-4P	Contact hours	
Content				
<ol style="list-style-type: none"> 1. Estimation of total lipid 2. Identification of fatty acids and other lipids byTLC 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 absorptionco efficient(ϵ) ofl-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.pHc. substrate concentration d. Enzyme concentration 11. Determination of K_m and V_{max} of amylase (Line weaver-Burkeplot; Michaelis - Mentonequation) 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:

SubjectCommitteeChairperson

ProgramName	BSc Microbiology		Semester	IV Sem
CourseTitle	Human Microbiome			
CourseCode	MBL:304	OE-4T	No. of Theory Credits	3
Contacthours	Lecture		DurationofESA/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: <ol style="list-style-type: none"> 1. Articulate a deeper understanding on biological complexities of human microbiome. 2. Understand broader goals of biological anthropology. 3. Compare and contrast the micro biome of different human body sites and impact human health promotion 	
Content	42Hrs
Unit-I	14 Hrs
INTRODUCTION TO MICROBIOME Normal human microbiota and their role in health-gut microflora, skinmicroflora, 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 type2 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 microbiomegenome	
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=40marks theory paper, End semester Exam duration of exam 2hours	
Formative Assessment Occasion / type	Weightage in Marks
Assignment	10
Seminar	10
Case studies	10
Test	10
Total	40marks

References	
1	
2	
3	
4	
5	

Date:

Subject Committee Chairperson