Resolution No.:

Bharatiya Vidya Bhavan's

M. M. College of Arts, N.M. Institute of Science, H.R.J. College of Commerce. (Bhavan's College) Autonomous

(Affiliated to University of Mumbai)

Syllabus for: S.Y.B. Sc Microbiology

Program: B.Sc.

Program Code: BH. BSc

Course Code: (BH. USMB)

Choice Based Credit System (CBCS)

with effect from academic year 2022-23

PROGRAM OUTCOMES

PO	PO Description A student completing Bachelor's Degree in Science program will be able to:
PO1	Nurturing Concepts and principles of science are the primary achievable learning outcomes.
PO2	Critical thinking with advancement in analytical analysis is the training imparted in practical sessions so that independent thinking, problem solving and finesse in scientific interpretation and documentation are endeavored.
PO3	The awareness and knowledge of Research can help to accomplish career in the field of Research and development since planning and execution of ideas is taught.
PO4	Through Self-study exercises students can explore the vast information available in public domain and broaden their knowledge.
PO5	Skill development will prepare them for jobs and higher studies
PO6	Understand environmental issues and perhaps sensitize the society towards saving the environment.

PROGRAM SPECIFIC OUTCOME

PSO	PSO Description A student completing Bachelor's Degree in BSc. Program with the subject of Microbiology will be able to:
PSO1	Having laid the foundation of Microbiology in the first year of the graduate course this course content will broaden their knowledge by studying some diverse fields of Microbiology.
PSO2	Core courses in Environmental & Applied Microbiology lays the foundation for a subsequent Master's program or occupations in those domains.
PSO3	Knowledge of different cellular molecules & some kinetic aspects will help understand physiological and metabolic outcomes.
PSO4	Identification and classification of bacteria is the need in clinical and non-clinical setups, study on taxonomy will help accomplish it.
PSO5	Knowledge of analytical techniques helps to relate to the use of the correct method when analyzing biological samples for their molecular content.
PSO6	Inclusion of Introduction to Research will enthuse students and lay the initial foundation for a career in Research & Development.

PROGRAM OUTLINE

YEAR	SEMESTER	COURSE CODE	COURSE TITLE	CREDITS
S.Y.B.Sc	III	BH. USMB301	Chemical foundations & Enzymology	02
S.Y.B.Sc	III	BH. USMB302	Environmental Microbiology	02
S.Y.B.Sc	III	BH. USMB303	Microbial symbiosis, host-pathogen interactions & laboratory safety	02
S.Y.B.Sc	III	BH. USMB304	Skill development in Laboratory safety, chemical foundations, enzymology, environmental microbiology & host-pathogen interactions.	01
S.Y.B.Sc	IV	BH. USMB401	Viruses, Taxonomy and Genetics	02
S.Y.B.Sc	IV	BH. USMB402	Applied Microbiology	02
S.Y.B.Sc	IV	BH. USMB403	Analytical techniques in Microbiology	02
S.Y.B.Sc	IV	BH. USMB404	Skill development in applied Microbiology, analytical techniques and taxonomy	01

DETAILED SYLLABUS
SEMESTER III & IV

PREAMBLE

Choice Based Credit System (CBCS) was introduced by the University of Mumbai on recommendations of the University Grants Commission (UGC) from the academic year 2016-2017. Its main objective was to provide flexibility in designing curriculum and assigning credits based on the course contents and number of hours of teaching.

The standing committee constituted by the UGC conferred Autonomous status to Bhavan's College, Andheri (affiliated to the University of Mumbai) for a period of 10 years with effect from the academic year 2019-20.

In light of this, the F.Y.B.Sc curriculum was updated and has been implemented from the academic year 2021-22. Subsequently, the process of restructuring the S.Y.B.Sc syllabus according to the CBCS pattern was initiated for its implementation from academic year 2022-23.

To achieve this, the Board of Studies comprising of the core faculty, senior faculty from various academic institutions was instituted to critically examine the drawbacks of the existing syllabus. After intensive discussions, numerous suggestions and feedbacks were received from the members of the Board and the syllabus has been suitably finalized.

The proposed S.Y.B.Sc curriculum is designed with the view to upgrade the existing syllabus and make it more relevant, industry friendly and suitable to cater all types of students.

DETAILED SYLLABUS

<table>
<tr><td colspan="5">Programme: B. Sc.</td><td>Semester: III</td></tr>
<tr><td colspan="4">Teaching Scheme</td><td colspan="2">Evaluation Scheme (Theory)</td></tr>
<tr><td>Lecture (Periods per week)</td><td>Practical (Periods per week per batch)</td><td>Tutorial (Periods per week per batch)</td><td>Credits (Theory + Practical)</td><td>Continuous Internal Assessment (CIA-I & II) (Marks - 40)</td><td>End Semester Examination (ESE) (Marks: 60)</td></tr>
<tr><td>9</td><td>9</td><td>--</td><td>9+1</td><td>40</td><td>60</td></tr>
<tr><td colspan="6">Any other information: Batch size for practical as prescribed by the University of Mumbai.</td></tr>
<tr><td colspan="6">Pre-requisites & eligibility: As prescribed by the University of Mumbai.</td></tr>
<tr><td>Course</td><td colspan="3">CHEMICAL FOUNDATIONS & ENZYMOLOGY</td><td colspan="2">Course Code: BH. USMB 301</td></tr>
<tr><td colspan="6">COURSE OBJECTIVES:
1.The study of chemical foundations & biomolecules brings to light the secrets of life and life processes.
2.The vital molecules namely enzymes that catalyse myriad reactions in a cell will be studied for its kinetics and applications.
3. Study of proteins and amino acids is fundamental to all fields of applied science like immunology, molecular biology, cell biology etc. This knowledge would help students make a successful head start in all fields of biological science.</td></tr>
</table>

COURSE OUTCOMES:

1. Make successful endeavours in all fields of biological science.
2. Build strong foundations for higher studies and Research.

Self-study exercises are a practical attempt to understand the applications of the units being studied.

Detailed Syllabus: (per session plan)

Unit No.	Description	Periods/credits
1	**Chemical foundations**	**15/01**
	1.1 Cellular foundations a. Cells as structural & functional units b. Cellular dimension limited by oxygen diffusibility c. 3 domains of life and their types d. Escherichia coli the most studied organism e. Organelles of eukaryotes and their fractionation f. Dynamic cytoskeleton g. Structural hierarchy in molecular organization	**04**
	1.2 Chemical foundations a. Compounds of carbon with variety of functional groups b. Universal set of molecules in cells c. Macromolecular composition of cells d. Configuration & conformation interactions within biomolecules.	**03**
	1.3 Physical foundations a. Dynamic steady state of living organisms b. Transformation of energy & matter by cells c. Electron flow d. Maintenance of order e. Energy coupling reactions in biology f. Importance of equilibrium constant & standard free energy change g. Central role and structure of ATP h. High energy rich compounds	**03**
	1.4 Genetic foundations a. DNA structure that allows replication & repair with fidelity b. Genetic continuity and outcome of linear DNA sequence.	**01**

	1.5 Evolutionary foundations a. Heredity changes allow evolution b. Biomolecules & evolution c. Chemical evolution stimulated in laboratory d. Biological evolution and landmarks in evolution	**03**
	Self-study and class presentation: Evolution of world of chemical molecules (E.g evolution of RNA)	**01**
2	**Enzyme kinetics**	**15/01**
	2.1 Introduction of Enzymes a. General characteristics and properties of enzymes b. Classification and naming of enzymes c. Concept of metalloenzymes d. Inducible, constitutive, repressible, intracellular & extracellular enzyme e. Acceleration of reaction by enzyme f. Mechanism of action of enzymes g. Rate law for a simple enzyme catalyzed reaction h. Michaelis-Menten equation and its derivation i. Significance of Km and Vmax j. Enzyme unit & Units used for expressing enzyme (IU and Katal) **k.** Lineweaver Burk plot & its significance	**07**
	2.2 Enzyme Kinetics a. Saturation kinetics b. Effect of temperature & pH c. Effect of Inhibitors d. Irreversible inhibition and reversible inhibition (competitive, noncompetitive & uncompetitive inhibition) e. Multisubstrate enzyme catalyzed reactions f. Use of enzymes in industries (Food, Textile industries) g. Turnover number of enzymes. h. Specific activity (Introduction)	**07**
	Self-study and class presentation: Numerical based on Km, Vmax and Michaelis Menten kinetics of some common enzyme.	**01**
3	**Amino acids, peptides & proteins**	**15/01**

	3.1 Amino Acids a. Properties of zwitterions b. Isoelectric Point c. General Structural features d. Stereoisomers e. Amino acid classification by R group **f.** Uncommon amino acids & their functions	**04**
	3.2 Peptides & proteins a. Peptides Can Be Distinguished by Their Ionization Behavior b. Biologically Active Peptides and Polypeptides c. Characteristics of polypeptide chains **d.** Planarity of peptide bond & Ramachandran plot	**03**
	3.4 Protein structure a. Primary structure b. Secondary structures c. Tertiary structure d. Quaternary structure e. Weak interactions f. Protein conformation and stabilization **g.** Protein denaturation	**04**
	3.5 Different types of proteins a. Fibrous & globular proteins **b.** Biological significance of proteins	**03**
	Self-study and class presentation Ribbon model of any one fibrous & one globular protein with its description and labelling.	**01**
	Total	**45/03**

Reference Books:

1. G. Zubay, W.W. Parson, D.E. Vance. Principles of Biochemistry 1995 Wm. C. Brown Publishers
2. Nelson D. L. and Cox M. M. (2005). Lehninger's Principles of Biochemistry, Fourth Edition
3. Palmer Trevor (2001) Enzymes: Biochemistry, Biotechnology, and Clinical chemistry, Horwood Pub. Co. Chinchester, England.

4. Veer Bala Rastogi & K.R. Aneja. Zubay's Principles of Biochemistry. (2015).5th edition. MEDTECH, a division of Scientific International Pvt.. Ltd.
5. Segel Irvin H. (1997) Biochemical Calculations 2nd Edition, John Wiley and Sons, New York.
6. David L. Nelson, M.M. Cox. Principles of Biochemistry (2017) Lehninger 7th edition. H. Freeman and company.

PRACTICALS (Section 1): Skill development in Cellular foundations & Enzymology
BH. USMBP03

Unit No.	Description 01 credit
1	1. Preparation of acetate buffer and checking.
	2. Problem solving in peptides & and proteins. (I. Segel page No. 98-109)
2	1. Isolation of amylase, protease, lipase producers.
	2. Detect the success of blanching by detecting peroxidases/polyphenol oxidase.
	3. Production of invertase from yeast.
	4. Effect of pH, Temperature and substrate concentration on activity of invertase.
	5. Determination of Km and Vmax of invertase enzyme.
3	Separation and identification of amino acids by paper chromatography

Program: B.Sc.		**SEMESTER III**
Course	**ENVIRONMENTAL MICROBIOLOGY**	**Course code: BH. USMB302**

COURSE OBJECTIVES:

1. To teach students about the normal microflora in the environment
2. Methods of sampling of air microflora, air sanitation and quality standards
3. To teach about sewage and wastewater microbiology including the methods of assessment of microflora and the treatment methods involved.
4. Exploring various biogeochemical cycles, their significance in the environment

COURSE OUTCOMES:

After the successful completion of this course, students will:

1. Have a broader understanding of AeroMicrobiology

2. Learn the need and importance of sewage treatment.
3. Better understanding of the biogeochemical cycles and their importance with respect to current climatic change scenarios.
4. Knowledge of methods used for water treatment

Unit No.	Description	Periods/credits
1	**Air Microbiology**	**15/01**
	1.1 Aeromicrobiology (7 periods) a. Important airborne pathogens and toxins. b. Aerosols, nature of bioaerosols, aeromicrobiological pathway c. Microbial survival in the air d. Extramural aeromicrobiology **e.** Intramural aeromicrobiology	**07**
	1.2 Sampling Devices for the Collection of Air Samples, Detection of microorganisms on fomites	**02**
	1.3 Air Sanitation	**02**
	1.4 Air quality standards in pharma, ATC and Dairy laboratories	**03**
	Self-study module and class presentation: Discuss the different kinds of air flora found in different environments, including microbiological laboratories and industrial laboratories**.**	**01**
2	**Freshwater and Waste water Microbiology**	**15/01**
	A. Freshwater Microbiology	
	2.1 Freshwater environments and microorganisms found in Springs, rivers and streams, Lakes	**02**
	2.2 Potable water a. Definition & types of bottled water b. Water purification c. Water quality standards d. Pathogens transmitted through water	**02**
	2.3 Microbiological analysis of water samples a. Sampling strategies and analysis methods for safe water b. Processing of water samples for virus analysis	**04**

	c. Processing of water samples for detection of protozoan parasites d. Routine analysis of water for bacteria [presumptive, completed and confirmed test] as per ISI/APHA standards	
	B. Waste Water Microbiology	
	2.4 Composition of waste water, BOD [Carbonaceous and Nitrogenous] and Chemical Oxygen Demand	**02**
	2.5 Primary and Secondary Waste water treatment	**02**
	2.6 Advanced Waste water treatment	**02**
	Self-study module and class presentation: Modern and efficient methods for sewage treatment.	**01**
3	**Soil and Geo Microbiology**	**15/01**
	3.1 Terrestrial environment a. Soil- Definition b. Composition i. Function ii. Textural triangle c. Types of soil microorganisms and their activities	**02**
	3.2 Methods of studying soil microorganisms: a. Sampling b. Cultural methods c. Physiological methods (only tabulate name and principle of different methods) d. Immunological methods (only tabulate name and principle of different methods) e. Nucleic acid-based methods (only tabulate name and principle of different methods) f. Radioisotope techniques (only tabulate name and principle of different methods) g. Metagenomics : Introduction and Principle h. VBNC	**06**
	3.3 Role of Microorganisms in Biogeochemical cycles: a. Sulphur cycle b. Phosphorus Cycle	**04**

	c. Iron transformation / sequestering	
	3.4 Soil Bioremediation [Common methods, Environmental factors affecting bioremediation]	**02**
	Self-study module and presentation**:** Flip classroom Carbon and Nitrogen Cycle in soil	**01**
	Total	**45/03**

References:

1. Michael T. Madigan, Kelley Bender, Daniel Buckley, W. M. Sattley, David Stahl, Brock- Biology of Microorganisms 15th Edition, 2019.Pearson Education Limited.
2. Gabriel Bitton, Waste water Microbiology, 3rd Edition, Wiley Series Editor
3. Raina M. Maier, Ian L. Pepper, Charles P.Gerba. Environmental Microbiology, 2nd Edition; 2010 Academic Press
4. A.J. Salle. Fundamental Principles of Bacteriology, 7th Edition; Tata Mc Graw Hill Publishing Company
5. Air Quality Standards- NAAQS Manual, Volume I
6. Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton Prescott's Microbiology, 8th Edition; 2011, Mc Graw Hill International Edition
7. Frobisher, Hinsdill, Crabtree, Goodheart. Fundamentals of Microbiology, 9th Edition, 1974, Saunders College Publishing
8. Barbara Kolwzan, Waldemar Adamiak. Introduction to Environmental Microbiology – (E Book)
9. N.S Subba Rao. Soil Microbiology-4th Edition, ,2000, Oxford and IBH Publishing Co. Pvt ltd.
10. Waste water Microbiology: Gabriel Bitton, 2005 3rd ed. A. John Wiley & sons, Inc., Publication
11. Modern Soil Microbiology – 3rd Edition, 2019, Edited by Jan Dirk van Elsas, Jack T. Trevors, Alexandre Soares Rosado, and Paolo Nannipieri, CRC Press Taylor & Francis Group

PRACTICALS (Section 1): Skill development in Environmental Microbiology
BH. USMBP03

1	1. Study of air microflora & determination of sedimentation rate.
	2. Enumeration of microorganisms in air and study its load after fumigation
2	1. Routine analysis of water: a. Standard Plate Count b. Detection of Coliforms in water: Presumptive Test, Confirmed Test and Completed Test c. Rapid Detection of E. coli by MUG Technique (Demonstration)
	2. Waste water analysis: a. Study of microbial flora in raw and treated sewage b. Determination of BOD and COD of wastewater

3	1. Total viable count of soil microflora [bacteria and fungi]
	2. Enrichment and isolation of Sulphate reducers and Phosphate solubilizers and cellulose degraders from soil
	3. Isolation of actinomycetes from soil.
	4. Winogradsky's column
	5. Visit to a sewage treatment plant or water purification plan

Program: B.Sc.		**SEMESTER III**
Course	**Microbial Symbiosis, Host-pathogen Interactions & Laboratory Safety**	**Course code: BH. USMB 303**

COURSE OBJECTIVES:

1. To teach students about different types of symbiotic interactions and different symbiotic habitats associated with microbes.
2. To teach the concepts of microbial pathogenesis, immune system and its components.
3. Introduce the students to principles of epidemiology, a broader perspective of laboratory safety and infection control.

COURSE OUTCOMES:

After the successful completion of this course, students will:

1. Will have a better understanding towards the symbiotic interactions of microbes with various organisms including plants and animals
2. Understand the symbiotic relationship in terms of habitat interactions with different organisms.
3. Understand the concepts of epidemiology and immune systems, the coordination between different systems to protect and fight against pathogenic diseases.
4. Have a better understanding towards laboratory safety, risk assessment and infection control.

Unit No.	**Description**	**Periods/credits**
1	**Microbial Symbiosis, Host-pathogen Interactions & Laboratory Safety**	**15/01**
	1.1 **Basics of Symbiosis** a. Types of symbiosis b. Functions of symbiosis c. Establishment of symbiosis Evolution of symbiosis	**02**
	1.2 **Plants as microbial habitats** a. Legume-root nodule symbiosis b. Agrobacterium and crown gall disease	**05**

	c. Signalling in plant disease resistance & symbiosis	
	1.3 Invertebrates as microbial habitats a. Hawaiian Bobtail squid b. Marine invertebrates at hydrothermal vents c. Entomopathogenic nematodes d. Reef building corals	**04**
	1.4 Mammalian gut system as microbial habitats a. Alternative mammalian gut system b. Rumen and ruminant animals i. Rumen anatomy, activity ii. Microbial fermentation in rumen iii. Changes in rumen microbial community c. Rumen protists and fungi	**03**
	Self-study module and class presentation**:** Diagrammatic representation on different human microbiomes [skin/oral/intestine etc].	**01**
2	**Microbial pathogenesis & host response**	**15/01**
	2.1 Understanding microbial pathogenesis a. Concepts of virulence and attenuation b. Genetics of virulence and compromised host c. Enzymes as virulence factors d. Toxins as virulence factors:- 1. AB type Exotoxins [diphtheria toxin, botulinum & tetanus toxin, cholera toxin] 2. Cytolytic and superantigen toxins 3. Endotoxin – Structure and biology	**07**
	2.2 Players of Immune System a. Cells of the immune system b. Organs of the immune system **Complement System** a. Classical, alternate and lectin pathway **Introduction to antigen & antibody** a. Different classes of antibodies b. Antigens and haptens c. Consequences of antigen-antibody binding in vivo and in vitro	**07**

	Self-study and class presentation**:** Different tests for detection of microbial toxins	**01**
3	**Epidemiology & laboratory safety**	**15/01**
	3.1 Principles of Epidemiology a. Basic terminologies [epidemic, endemic, pandemic, Hyperendemic, sporadic, morbidity, mortality, prevalence, DALY, Basic reproduction number R_0] b. Measuring frequency [morbidity and mortality rate] c. Classifying disease based on severity, duration & host involvement d. Patterns of disease – predisposing factors and development of disease e. Spread of infection – reservoirs and transmission of disease	**04**
	3.2 Basics of Laboratory Safety & Infection Control	
	A. Understanding Lab Safety a. General principles & microbial risk assessment b. Good laboratory techniques, contingency plans and emergency procedures [Overview] **c.** Safety, organization & training [biosafety officer, biosafety committee, training programmes]	**03**
	B. Infection Control **a.** Control of public health and infectious diseases 1. Controls against reservoirs and vehicles 2. Immunization 3. Isolation, Quarantine and Surveillance 4. Pathogen eradication **b.** Controlling infections in community/healthcare lab **(5periods)** 1. Infection Prevention and Control Team 2. Isolation and Cohort Nursing 3. Hand hygiene 4. Personal protective equipment 5. Safe handling and Disposal of Sharps 6. Cleaning **7.** Education and training	**02**

	Self-study module and presentation: Survey on different companies manufacturing biosafety cabinets and safety equipment required in microbiological laboratory.	**01**
	Total	**45/03**

Skill development in Microbial Symbiosis, Host-pathogen Interactions & Laboratory Safety

1. Understanding the principles of laboratory safety, Types of laboratories [basic, containment & maximum containment laboratories]
2. Laboratory equipment – biosafety cabinets & safety equipment
3. Transport of infectious substances [triple packaging system and spill clean-up procedure]
4. Study of various enzymes as virulence factors -
    a. Coagulase
    b. Lecithinase
5. Identification of various WBC's in a blood smear by Field's staining method.
6. Evaluation of efficiency of hand washing by swab rinse method as per regulatory standards.
7. Evaluation of antiseptics/disinfectants by filter paper disc method as per regulatory standards.
8. Case study [Epidemiology]

Reference Books:

1. Michael T. Madigan, Kelley Bender, Daniel Buckley, W. M. Sattley, David Stahl, Brock Biology of Microorganisms 15th Edition, Pearson Education Limited, 2019 .
2. Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton. Prescott's Microbiology, 8th Edition; 2009, McGraw Hill International Edition.
3. Betty Forbes, Daniel Sahm, Alice Weissfeld. Bailey & Scott's Diagnostic Microbiology 12th Edition, International Edition, 2007 Mosby Inc.
4. R. Y. Stainier, J. Ingraham, M. Wheelis and P.R. Painter. General Microbiology. (2007) 5th Edition,. Prentice Hall. New Jersey.
5. Tortora Gerard, Berdell Funke and Christine Case, Microbiology and Introduction, 10th Edition, Pearson Education Inc, 2010.
6. Kuby Immunology – 6th Edition
7. Debbie Weston, Fundamentals of Infection Prevention and Control [Theory and Practice], 2nd Edition, Wiley Blackwell. 2013.
8. Laboratory Biosafety Manual, 3rd Edition, World Health Organization, Geneva 2004.

Additional Reading:

1. Swanson John and Annette Jeanes (2016), Infection control in the community: a pragmatic approach, British Journal of Community Nursing, Vol 16, No 6, Pg 282-288.
2. Songzi Zhao and Xiaoquan Qi (2008). Signalling in plant disease resistance and symbiosis, Journal of Integrative Plant Biology, Vol 50, No 7; Pg no 799-807

Programme: B. Sc.					**Semester: IV**
Teaching Scheme				**Evaluation Scheme (Theory)**	
Lecture (Periods per week)	**Practical (Periods per week per batch)**	**Tutorial (Periods per week per batch)**	**Credits (Theory + Practical)**	**Continuous Internal Assessment (CIA-I & II) (Marks - 40)**	**End Semester Examination (ESE) (Marks: 60)**
9	9	--	9+1	40	60
Any other information: Batch size for practical as prescribed by the University of Mumbai.					
Pre-requisites & eligibility: As prescribed by the University of Mumbai.					
Course	**Viruses, Taxonomy and Genetics**				**Course code: BH.USMB 401**

COURSE OBJECTIVES:

1. To understand the norms of taxonomy and classification.
2. To study important and advanced techniques of analysis used in classification of organisms.
3. To understand different concepts of bacterial viruses, their methods of quantification and life cycle.
4. Nucleic acids chemistry will help understand all processes that are central to life.

COURSE OUTCOMES:

After the successful completion of this course, students will:

1. Acquire understanding of the principles and science of microbial taxonomy & systematics. Understand latest technologies used for identification.
2. Basis of Virology is strengthened.

Detailed Syllabus: (per session plan)

Unit No.	Description	Periods
1	**Bacterial viruses**	**15/01**
	1.1 Overview of bacterial viruses	**01**
	1.2 Classification of bacteriophages Criteria used for classification a. ICTV b. Baltimore classification	**03**
	1.3 Reproduction of Double-Stranded DNA T4 Phages a. The Lytic Cycle b. Adsorption to the Host Cell and Penetration. c. Synthesis of Phage Nucleic Acids and Proteins. d. The Assembly of Phage Particles	**04**
	1.4 Temperate Bacteriophages and Lysogeny	**03**
	1.5 The virus host	**01**
	1.6 Quantification of bacterial viruses	**01**
	1.7 Viral diversity	**01**
	Self-study module and presentation**:** Flip classroom on topics related to bacterial viruses (refer https://viralzone.expasy.org/4557)	**01**
2	**Microbial taxonomy**	**15/01**
	2.1 Introduction to Microbial Taxonomy a. Systems of classification (Cavalier Smith 6 kingdom) b. Bergey's manual c. The three domain concept is based on: a. Phylogeny b. Nomenclature c. Taxonomic ranks d. Numerical Taxonomy d. Phylum proteobacteria a. The six taxonomic classes of proteobacteria. b. Commonalities in the taxonomic classes	**4**

	2.2 Methods of analysis used in classification (Identification in Medical and Environmental domain) a. Phenotypic analysis based on: a. Morphological characteristics b. Physiological and metabolic characteristics c. Biochemical characteristics b. Commercial Identification procedures (significance) a. Using VITEK b. API Identification kits	**4**
	2.3 Genetic methods a. DNA-DNA hybridization b. Multilocus sequence analysis c. G+C ratio i. Numericals for G+C ratio ii. Applications for determining closely related species d. Genetic fingerprinting e. Whole genome sequence analysis	**4**
	2.4 Amino acid sequencing a. Introduction to sequencing of amino acid Proteases used for degradation of amino acids -Types of proteases and their specific site of action b. Edman degradation c. Modern technique for amino acid sequencing using (circular dichroism in brief)	**2**
	Self-study module and presentation**:** Refer to recent research papers related to taxonomy and understand the procedures used for identification of culture	**1**
3	**Nucleic acid structure and chemistry**	**15/01**
	3.1 Nucleic Acid Structure and function a. DNA stores genetic information b. DNA molecules have distinctive base composition c. DNA is a double helix d. DNA can occur in different 3D forms e. DNA sequences adopt unusual structures f. Many RNAs have complex 3D structures g. Methods for detection of DNA structure	**6**

	3.2 Nucleic acid chemistry a. Denaturation of double helical DNA and RNA b. Nucleic acid from different species can form hybrids c. Nucleotides and nucleic acids undergo non enzymatic transformations d. DNA methylation e. Different types of RNA molecules (mRNA, tRNA, rRNA hn RNA, sc RNA, miRNA, siRNA) f. Unusual nucleotides, types and structures.	**5**
	3.3 Other Functions of nucleotides	**1**
	3.4 Structures of chromosomes of eukaryotic cell a. Structure of chromosomes and their types. b. Banding patterns in chromosomes c. Study of Ideograms and Karyotype (With reference to Chromosomal abnormalities)	**2**
	Self-study module and presentation: Diagrams of different structures of DNA and RNA molecules found in eukaryotic systems.	**1**
	Total	**45/03**

Reference Books:

1. Breed and Buchanan (1982). Bergey's Manual of Determinative Bacteriology. 9th edition**.**
2. Breed and Buchanan (2001 – 2003). Bergey's Manual of Systematic Bacteriology. 2nd Edition, (Volumes.1 – 5).
3. Catherine Lozupone and Rob Knight. (2008). Species Divergence and the measurement of microbial diversity. FEMS Microbiol. Rev. 32 (557-578)
4. Woese C. (1987). Bacterial Evolution. Microbiological Reviews, 221-271.
5. Jacquelyn G. Black (2015). Microbiology: Principles and Explorations, 9th edition, John Wiley & Sons, Inc.
6. Prescott, Harley and Klein's Microbiology, Willey, Sherwood, Woolverton (2008) 7th edition, McGraw-Hill International edition
7. Brock Biology of Microorganisms, Madigan, Martinko, Dunlap and Clark (2009) 13th edition, Pearson Education
8. Principles of Biochemistry 2017 Lehninger 7th edition W.H. Freeman & Co
9. Peter J. Russell, "iGenetics - A molecular approach", 3rd edition, 2010, Benjamin Cummings.
10. Madigan, Martinko, Dunlap and Clark, Brock Biology of Microorganisms, 12th edition, 2009, Pearson Education

11. D. Nelson & M. Cox, Lehninger's Principles of Biochemistry, 4th Edition, 2005, (W.H. Freeman & Co.), (LPE)	
PRACTICALS (Section 1): Skill development in Viruses, Taxonomy and Genetics BH. USMBP04	
1	1. Detection of phage host interaction by spot test
	2. Enumeration of coliphages by phage assay
2	Isolation and detection of DNA by DPA method from onion/ *Escherichia coli*
3	1. Study biochemical tests important for identification of bacteria.
	2. Identification of bacteria (Genera of any 4 bacteria including Gram positive and negative)

Programme: B.Sc.	**Semester: IV**
Course: APPLIED MICROBIOLOGY	**Course Code: BH. USMB 402**

COURSE OBJECTIVES

1. To teach students the basic concepts of Industrial Microbiology
2. To inculcate the methods of screening of organisms, and different methods of fermentation
3. To teach the various factors involved in spoilage of food, sources of contamination and general principles of food spoilage.

COURSE OUTCOMES

After the successful completion of this course, students will:

1. Have a better understanding of the processes involved in different methods of fermentation, their significance and applications.
2. Have a better understanding of the methods for screening of organisms for industrial fermentation scale.
3. Understand the principles of food spoilage and the various factors involved in the process of food spoilage.

Unit No.	**Description**	**Periods**
1	**Industrial Microbiology**	**15/01**
	1.1 Introduction a. An introduction to fermentation processes : historical overview, Economics & scale of microbial product fermentation, applications of industrial microbiology.	**02**

	a. The Component parts of a fermentation process	
	1.2 Primary & secondary screening of industrially important microorganisms	**04**
	1.3 Types of fermentations : definition & example a. Aerobic fermentation b. Anaerobic fermentation c. Batch fermentation d. Continuous fermentation e. Fed-batch fermentation f. Surface fermentation g. Submerged fermentation h. Solid-state fermentation	**05**
	1.4 Production of Alcoholic beverages: Beer & Wine	**03**
	Self-study module and presentation**:** Strain improvement with respect to one fermentation	**01**
2	**Food Microbiology**	**15/01**
	2.1 Food as a substrate for microorganisms a. Hydrogen-Ion Concentration (pH) b. Moisture Requirement: The Concept of Water Activity c. Oxidation-Reduction Potential d. Nutrient Content e. Accessory Food Substances, or Vitamins f. Inhibitory Substances and Biological Structure g. Combined Effects of Factors Affecting Growth	2
	2.2 Sources of contamination of foods a. From Green Plants and Fruits b. From Animals c. From Sewage d. From Soil e. From Water f. From Air g. During Handling and Processing	1
	2.3 General principles of food spoilage a. Causes of Spoilage	4

	b. Classification of Foods by Ease of Spoilage c. Spoilage of different kinds of foods i. Sugar and sugar products ii. Meat and meat products iii. Milk and milk products iv Heated canned foods	
	2.4 Food Preservation [Principle with examples] a. Thermal methods of preservation [high temperature, low temperature, drying] b. Non-thermal methods of preservation [modified atmosphere] c. Chemical methods of preservation [salt, sugar, benzoate and Parabens] d. Preservation by Irradiation [UV, X ray, Beta ray, Gamma ray]	4
	2.5 Advanced methods for detection of microbes in food Principle, Significance & Applications of:- a. Culture based methods – conventional SPC, swab rinse method, contact plate method. b. Immunological methods [Fluorescent antibody, RIA, ELISA] c. Molecular methods [DNA probes] d. Chemical methods [Thermostable nuclease, ATP measurement]	3
	Self-study module: Study on any one pathogen responsible for food borne infection/intoxication	1
3	**Dairy Microbiology**	**15/01**
	3.1 Raw and fluid milk products Pasteurization & Ultra-Pasteurization, Efficiency of pasteurization	**02**
	3.2 Concentrated and dry milk, whey	**02**
	3.3 Microbiology of butter	**01**
	3.4 Fermented milk: Yogurt, cultured buttermilk and fermented milk in India	**03**
	3.5 Cheese a. Cheddar cheese b. Cottage cheese c. Processed Cheese d. Cheese Defects	**03**

	e. Enlist other cheese and associated microorganisms	
	3.6 Microbiological Quality of Milk & Milk Products a. SPC b. Coliform count c. LPC d. Thermophilic **e.** Psychrophilic counts and RPT (RRT, MBRT, DMC)	**03**
	Self-study module: Quality standards followed by industries in processing of milk and milk products.	**01**
	Total	**45/03**

Reference Books:

1. Casida L. E., "Industrial Microbiology" (2009) Reprint, New Age International (P) Ltd, Publishers, New Delhi.
2. Stanbury P. F., Whitaker A. & Hall S. J., (1997), "Principles of Fermentation Technology", 2nd edition, Aditya Books Pvt. Ltd, New Delhi
3. H. A. Modi, (2009). ''Fermentation Technology'' Vol. 1 & 2, Pointer Publications, India.
4. A.H. Patel, Industrial Microbiology, 2nd edition, MacMillan Publication, 2016
5. Sibi G.: Industrial Microbiology and Biotechnology (2018) , First edition , Himalaya Publishing house.
6. W.C. Frazier, Dennis Westhoff, Food Microbiology, 5th edition, McGraw Hill Education [India], Pvt Ltd. 2014.
7. James Jay, Martin Loessener, David Golden, Modern Food Microbiology, 7th edition, Springer Inc, 2005
8. Prescott's Microbiology, 8th Edition; Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton, 2009, McGraw Hill International Edition.
9. FSSAI specifications for milk and milk products
10. Applied Dairy Microbiology by Martha & Steele .

Skill development in Applied Microbiology	
1	1. Primary screening for antibiotic producers using Wilkins agar overlay method. **2.** Demonstration of Wine fermentation
2	1. Isolation of spoilage causing bacteria from foods (bread, any one fruit/vegetable, fish) 2. Determination of TDT and TDP 3. Determination of Salt and Sugar tolerance 4. Determination of MIC of sodium benzoate against food spoilage organisms

	5. Enrichment, isolation and detection of coagulase positive *Staphylococcus aureus* and *Escherichia coli* from food samples as per FSSAI methods. Visit report of an industrial visit to food industry
3	1. RPT of Milk– RRT, MBRT 2. Microbiological Quality Control of Milk as per FSSAI 3. Analysis of Cheese, Butter, as per FSSAI methods. Alkaline phosphatase test for determining efficiency of pasteurization.

Course	**Analytical Techniques in Microbiology**	**Course code: BH. USMB403**

COURSE OBJECTIVES:

1. Enable students to understand the cell fractionation and separation process.
2. Further they will learn about methods of lysis of cells, and the analytical methods such as chromatography, centrifugation and electrophoresis.
3. Involve study of techniques used for separation and purification of macromolecules.
4. Understand and learn the working principle of instruments used in estimation and analysis.

COURSE OUTCOMES:

After the successful completion of this course, students will:

1. Understand the different cell disintegration methods and know the working principles of different centrifugation, electrophoresis & chromatographic techniques used in analysis.
2. Know the separation & purification techniques for proteins & techniques to estimate biomolecules.

Unit No.	**Description**	**Periods**
1	**Analytical techniques**	**15/01**
	1.1 Designing experiments a. Definitions, SI units of mass, constants of acids & bases b. Aims of laboratory experiments c. Outline of Scientific method d. Experimental design e. Analytical considerations and experimental error.	**03**
	1.2 Analytical techniques a. Centrifugation techniques: i. Types of centrifuges and their use: preparative & analytical, ultracentrifuges ii. Density Gradient & isopycnic centrifugation iii. Applications & calculation of rcf b. Colorimeter & spectrophotometer (Principle, instrument and applications), Beer-Lamberts law. c. Chromatographic Techniques	**11**

	i. General principles ii. Types and applications- Partition, adsorption, ion exchange, affinity and size exclusion iii. Modes- Paper, TLC, GC. Applications and significance d. Electrophoretic techniques: i. General Principles ii. Support media- Agarose gels and Polyacrylamide iii. SDS PAGE significance and process iv. Applications	
	Self study: Problem will be provided to the students in the area of designing experiments using analytical techniques.	**01**
2	**Quantitative estimation of biomolecules**	**15/01**
	2.1 Macromolecular composition of a microbial cell	**01**
	2.2 Preparation of bacterial cells for analysis	**01**
	2.3 Methods of elemental analysis a. Carbon by Slyke‟s method b. Nitrogen by Micro Kjeldahl method	**03**
	2.4 Estimation of Phosphorus by Fiske-Subbarow method	**01**
	2.5 Estimation of Proteins a. Proteins by Biuret method i. (Direct and indirect)	**02**
	2.6 Amino acids by Ninhydrin method	**01**
	2.7 Estimation of Carbohydrates : Total carbohydrates by Anthrone method	**01**
	2.8 Reducing Sugars by DNSA method.	**01**
	2.9 Extraction of Lipids by Soxhlet method.	**01**
	2.10 Isolation and Estimation of Nucleic acids by spectrophotometric method	**02**
	Self-study module: Study the efficiency and accuracy of estimation methods.	**01`**
3	**Introduction to scientific research and biostatistics**	**15/01**
	3.1 Understanding Scientific Research: a. Perception of Research b. Meaning of research c. P M Cook's definition of Research d. General characteristics of research e. Functions of research f. Specific characteristics of research	**03**

	g. Objectives of research h. Classification of research i. Steps of action research j. Characteristics of an investigator	
	3.2 Introduction to Research Methodology a. Difference between action research & fundamental research b. Research design – Experimental & Non-experimental design c. Field research d. Survey research	**03**
	3.3 Methods of data collection a. Secondary data collection methods b. Qualitative methods of data collection c. Survey methods of data collection	**03**
	3.4 Basics of Biostatistics a. Introduction to Biostatistics Sample and Population Data presentation b. Dot diagram c. Bar diagram d. Stem and leaf plot e. Histogram f. Frequency curve g. Central Tendency: h. Mean i. Median j. Mode Summation	**05**
	Self-study module: Correlate practical experimental results with biostatistics methods.	**01**
	TOTAL	**45/03**

Reference:

1. I.H. Segel , Biochemical calculations , 2 nd Edition 2004, Wiley India
2. Norris & Ribbon ,Methods In Microbiology,Vol.5B, Edition,1971, Academic Press
3. J. Jayaraman , Laboratory Manual in Biochemistry, 2003, New Age International Publishers
4. Current Research, Technology & Education Topics in Applied Microbiology & Microbial Biotechnology. A Mendez Vilas Edition
5. Research Methodology, Yogesh Kumar Singh, New age International Publisher
6. Biostatistics. P.N. Arora, P.K. Malhan. Himalaya Publishing House.
7. Methods in biostatistics for medical & research workers. 6th edition. B.K.

Mahajan. Jaypee brothers, Medical Publishers (P) ltd.
8. Textbook of Biotechnology by R C Dubey. 4th edition
Principles and techniques of Biochemistry and Molecular Biology 7th edition by Keith Wilson and John Walker, 2010, Cambridge university press

	Skill development in Analytical Techniques in Microbiology
1	1. Demonstration density gradient centrifugation: Sizing of Yeast cells 2. Demonstration of agarose gel electrophoresis 3. Separation of sugars using TLC
2	1. Determination of Dry and wet Weight of microbial biomass. 2. Estimation of Proteins by Biuret method (Direct and Indirect method) 3. Estimation of Reducing Sugars by DNSA method 4. Estimation of Nucleic acid by spectrophotometric method 5. Extraction of lipids by Soxhlet method (Demo) **All graphs to be made in excel and not on graph paper**
3	1. Assignment on report writing 2. Writing a review from 3-5 research papers [demo] 3. PowerPoint presentation of one research paper [group exercise]

MODALITY OF ASSESSMENT

Theory Examination Pattern:

A) Internal Assessment- 40%- 40 Marks

Sr. No.	Evaluation type	Marks
1	Internal Class Test with Objective type questions and Short Notes (CIA-I)	20
2	One Assignment (CIA-II)	20
	TOTAL	40

Assignment types can include:

1. Research Paper Reviews
2. Case studies
3. Power Point Presentation
4. Survey and report submission
5. Small project & report submission
6. Societal Subject related venture (Kitchen waste composting, safe water drinking, hygiene of orphan homes, old-age homes etc)

B) External Examination- 60%- 60 Marks Semester End Theory Examination: 60 marks (for offline Mode)

Duration - The examinations shall be of **2 hours** duration.
Paper Pattern:

1. There shall be **04** questions of 15 marks each.
2. The first question will be a mixed bag and remaining three questions will be unitized.
3. All questions shall be compulsory with internal choice within questions.
4. The unitized questions would have subjective and objective type of questions.

Overall Examination & Marks Distribution Pattern

Semester I & II

Course BH. USMB	101 & 102			201 & 202			Grand total
	Internal	**External**	**Total**	**Internal**	**External**	**Total**	
Theory	80	120	200	80	120	200	400
Practical	-	100	100	-	100	100	200
Total							600

Rubrics of evaluation for ESE

Unit	Knowledge	Understanding	Analysis & critical thinking	Total marks/unit
From all units	05	05	5	15
1	05	05	5	15
2	05	05	5	15
3	05	05	5	15
Total	**20**	**20**	**24**	**60**
% Weightage	**33.33**	**33.33**	**33.34**	**100**

Rubrics of evaluation for CIA-2 Assignment: <u>Presentation/debate</u>

Parameters	**Max Marks**	**80 – 100% Excellent**	**60 -80% Good**	**40 – 60% Satisfactory**	**20 – 40% Poor**	**0-20% very poor**
CONTENT	10					
Knowledge	02					
Development	03					
Conclusion	03					
Bibliography	02					
Effective communication skill	10					
Language, Style and Structure	05					
Teaching aids	05					
Total	**20**					