Kavayitri Bahinabai Chaudhari
North Maharashtra University, Jalgaon

Structure of Syllabus for

Program: B. Sc. (Microbiology)

S. Y. B. Sc.

Choice Based Credit System (CBCS)

2019-2020

S. Y. B. Sc. Microbiology (CBCS Structure) Semester III and IV

Preface

Bachelor of Science (Choice Based Credit System) with Microbiology as one of the core subjects is designed to cultivate a scientific challenge and help the students to become critical, curious in their outlook. The courses are designed to introduce the essential basics in Biochemistry, Chemistry, and Microbiology at the initial level of graduation. The basic courses are integrated with current application in modern life sciences to develop proficiency in the theory as well as practical experiments, common equipment, laboratory, along with the collection and interpretation and presentation of scientific data in proper manner. Beside this, the students will be equipped with knowledge in the newer areas of Microbiology and its application in medical science, agriculture, industry, proteomics, genomics, metabolomics, bioinformatics, etc. This will create zeal and zest about Microbiology which will pave a newer path for the development of society. At the end of the course, the students are expected to have good working knowledge in the field of Microbiology. Students will surely have an urge to continue higher studies in Microbiology and contribute significantly in the development.

The syllabus in microbiology is restructured anticipating the future needs of Microbiology in research, industry sector with more emphasis on imparting hands-on skills. The core thrust is laid on making syllabus compatible with developments in Education, Research and Industrial sectors. The Theory and Practical course in new restructured course will lead to impart skill-set essentials to further microbiology.

Hence, Board of Studies in Life Sciences in its meeting held on 23/06/2018 resolved to accept the revised syllabus for S. Y. B. Sc. (Microbiology) based on Choice Based Credit System (CBCS) of UGC guidelines.

Scheme for B.Sc. Program (Faculty of Science and Technology)

		First Year				Second Year				Third Year				Total Credit value
		Semester I		Semester II		Semester III		Semester IV		Semester V		Semester VI		
1	Core courses(16)	Credits each	Courses	Credits each	Courses	Credits each	Courses	Credits each	Courses	Credits each	Courses	Credits each	Courses	
	(i)Theory	4	4	4	4	4	3	4	3					4X14=56
	(ii)Practical	2	4	2	4	2	3	2	3					2X14=28
2	Ability enhancement compulsory course (AECC)(2)	2	1	2	1	2	1	2	1					2 x 2 x 2 x 2 = 08
3	Skill Enhancement Course (SEC) (4)					2	1	2	1	2	1	2	1	2X4=16
4	Discipline Specific Elective DSE(6)													
	(i)Theory									4	3	4	3	4X6=24
	(ii)Practical									2	3	2	3	2X6=12
	Total Credit value (Credit x No .of Courses)	26		26		22		22		20		20		136

Course Structure:

Duration: The duration of B.Sc. (Microbiology) degree program shall consists of three years.

Medium of instruction: The medium of instruction for the course shall be English.

The present syllabus has been prepared to (i) accommodate the advanced topic on the Microbiology discipline, (ii) build the basic science knowledge at the level of first year of Microbiology and (iii) reflect the changing needs of the students. The detailed syllabus for each paper is appended with a list of suggested readings.

At second year under-graduation, students will be introduced to different areas necessary to form the basis of microbiology like genetics, immunology, enzymology, and bioprocess biotechnology. The relevant practicals are included to enrich their knowledge.

Structure for S. Y. B. Sc. (Microbiology)

Semester	Core Course				Ability Enhancement Compulsory Course			Skill Enhancement Courses		
III (Total Credits = 22)	DSC	Paper	Credits	Lectures	AECC	Credits	Lectures	SEC	Credits	Lectures
	DSC-1C:Core Course I: Microbiology	Paper I	2	30	AECC I: English/Hindi/MIL Communication III (Advance)	2	30	SEC I: Microbiological Analysis of Air, Water and Soil	2	30
		Paper II	2	30	AECC II: General knowledge paper	Non-credit				
		Practical Paper	2	60						
	DSC-2C: Core Course II	Paper I	2	30						
		Paper II	2	30						
		Practical Paper	2	60						
	DSC-3C: Core Course III	Paper I	2	30						
		Paper II	2	30						
		Practical Paper	2	60						
IV (Total Credits = 22)	DSC-1D:Core Course I: Microbiology	Paper I	2	30	AECC I: English/Hindi/MIL Communication III (Advance)	2	30	SEC II: Biofertilizers and Biopesticides	2	30
		Paper II	2	30	AECC II: General knowledge paper	Non-credit				
		Practical Paper	2	60						
	DSC-2D: Core Course II	Paper I	2	30						
		Paper II	2	30						
		Practical Paper	2	60						
	DSC-3D: Core Course III	Paper I	2	30						
		Paper II	2	30						
		Practical Paper	2	60						

Student has choice to study two subsidiary subjects from DSC 2, DSC 3 among Chemistry/ Botany/ Zoology /Geography during III and IV semester; subject to availability of course at respective college.

- **Duration of Lecture:** 30 Lectures of 60 minutes or 36 Lectures of 50 min. Each theory and practical course has to be completed in 30 and 60 lectures, respectively of 60 min duration
- Each theory and practical course will be of 100 marks comprising of 40 marks internal and 60 marks external examination.
- Theory examination (60 marks) will be of three hours duration for each theory course. There shall be 5 questions each carrying equal marks (12 marks each). The pattern of question papers shall be:
- **Question 1 (12 marks):** 9 sub-questions, each of 2 marks; answerable in 2 -3 line and based on entire syllabus, attempt any 6 out of 9 questions.
- **Question 2, 3 and 4 (12 marks each):** based from Unit I, II, and III, respectively, each question has 3 sub-questions of 6 marks each and answer only 2 sub-questions from each Q2, Q3, and Q4 in brief.

- **Question 5 (12 marks):** answer only 3 out of 5 in brief, based from all 3 units, Each 4 marks.
- **Internal examination (40 marks each semester):** Internal assessment of the student by respective teacher will be comprehensive and continuous, based on written test. The written test shall comprise of both objective and subjective type questions.
- **Practical Examination:** Practical examination shall be conducted by the respective college at the end of the semester. Practical examination will be of minimum 5 – 6 hours duration and shall be conducted as per schedule (10 am to 5 pm on schedule date or can be scheduled 10 am -1pm/ 2 – 5 pm for 2 consecutive days) in case of microbiology practicals where incubation condition, allied aspect are essential. There shall be 5 marks for laboratory log book and well written journal, 10 marks for viva-voce and minimum three experiments (major and minor). Certified journal is compulsory to appear for practical examination. There shall be one expert and two examiners (external and internal) per batch for the practical examination.

Equivalence for S.Y. B.Sc. (Microbiology) is furnished in the following table:

Old Syllabus (June 2016) (Semester pattern 60:40)	**New Syllabus (June 2019) CBCS pattern (Semester pattern 60:40)**
MB 231: Fundamental Biochemistry	MB 301: Basic Microbial Enzyme and Metabolism
MB 232: Microscopy and Microbial Ecology	MB 302: Microscopy and Microbial Ecology
MB 233: Practical Course in Microbiology- I	MB 303: Practical Paper III
MB 241: Genetics and Immunology	MB 401: Genetics and Immunology
MB 242: Basic Microbial Biotechnology	MB 402: Basic Industrial Microbiology
MB 243: Practical Course in Microbiology II	MB 403: Practical Paper IV

S. Y. B. Sc. (Microbiology) Semester – III and IV

Semester	CC-A and B	Paper code	Paper-I	Paper Code	Paper-II	Practical Paper Code	Practical Paper	Skill Enhancement Courses (SEC)	Ability Enhancement Compulsory Courses (AECC)
III	CC A III	MB 301	Basic Microbial Enzyme and Metabolism	MB 302	Microscopy and Microbial Ecology	MB 303	Practical Paper III	SEC I: Microbiological Analysis of Air, Water and Soil	AECC I: English/Hindi/MIL Communication III (Advance): Credit 2; AECC II: General knowledge paper (Noncredit)
IV	CC A IV	MB 401	Genetics and Immunology	MB 402	Basic Industrial Microbiology	MB 403	Practical Paper IV	SEC II: Biofertilizers and Biopesticides	AECC I: English/Hindi/MIL Communication III (Advance): Credit 2; AECC II: General knowledge paper (Noncredit)

MB - 301: Basic Microbial Enzyme and Metabolism

Total Hours: 30 **Credits: 2**

Unit	Topics	Lectures
Course objective	To acquaint students with basic concepts of enzymology and microbial metabolism.	
Learning outcomes	After successful completion of this course, students are expected to: • understand the basic of microbial enzymology, nature of enzyme, their nomenclature, working mechanism, classification based on their action etc. • know how about different parameters affecting the activity of enzyme. • learn about nutrient uptake by microbes, various mechanism used to transport ions and molecules in microbial cells. • aware about concept of metabolism and its basic types. • cognizant about various pathways used by microbes to break down molecule and generate ATP as a source of energy. • aware about the regulations and energetics of various pathways. • understand aerobic, anaerobic respiration and fermentation.	
UNIT-1:	**Microbial Enzymes**	**10**
	• Introduction to enzymes and its nature (Protein and non-protein)	
	• General properties of enzymes, Units of enzyme activity, Isoenzyme, oligomeric enzymes, Multiple enzyme complex	
	• Cofactors, prosthetic groups, apoenzyme, holoenzyme, active site	
	• Enzyme nomenclature and classification (IUBMB), Significance of numbering system	
	• Features of enzymes catalysis:	
	➢ Collision theory, activation energy, transition state theory, catalysis	
	➢ Lowering of activation energy	
	➢ Fischer's Lock and key hypothesis	
	➢ Koshland's Induced fit hypothesis	
	➢ Thermodynamics of enzymatic reaction	
	• Enzyme kinetics	
	➢ Effect of Substrate concentration, temperature, pH, activators and inhibitor on the enzyme activity	
	➢ Relationship between initial velocity and substrate concentration	
	➢ Steady state and equilibrium theory	

	➢ Michaelis-Menten equation, *Km, Vmax,* and *Kcat* concept	
	• Applications of various microbial enzymes in different fields	
UNIT-2:	**Nutrient uptake and Transport**	**10**
	• Nutritional categories of microbes	
	• Bacterial cellular membrane structure and functions	
	• Bacterial cell transport	
	➢ Passive diffusion: water, gases, Glucose transporter, porins	
	➢ Facilitated diffusion: Glycerol transport	
	• Primary active transport: P-, V- and F- type ATPase ➢ Sodium potassium pump, Calcium pump and Proton pump	
	• Secondary active transporters: Lactose permease, Na^+ glucose symport	
	• Concept of uniport, symport and antiport	
	• Group translocation: PEP, ABC family transporters (MDR, CFTR)	
	• Ionophores, Bacteriorhodopsin, ion channels, iron uptake	
UNIT-3:	**Microbial metabolism**	**10**
	• Cellular metabolism: Anabolic and Catabolic reactions	
	• Aerobic respiration, Anaerobic respiration, and Fermentation	
	• Bacterial metabolic pathways: reaction sequence, energetics and regulation: ➢ Carbohydrate catabolism: Glycolytic pathways (EMP, ED, PP), PDH complex, TCA cycle and reverse TCA cycle, Glyoxylate cycle ➢ Carbon dioxide fixation: Carl-Bensen's and Hatch-Slack pathway ➢ Lactate and alcohol fermentation ➢ Methane formation (Methanogenesis)	
Suggested Readings	1. Lehninger, A I. (2013) Principles of Biochemistry, 6th edn., Nelson, D L and Cox, M. M. (eds.) WH Freeman and Co., New York. 2. Moat, A. and Foster, J. (2002) Microbial Physiology, 4th edn., Wiley Interscience Publications, New York. 3. Gottschalk, G. (1986) Bacterial Metabolism, 2nd edn., Springer- Verlag 4. Stryer, L. (2001) Biochemistry, 5th edn., WH Freeman and Co., New York. 5. Stanier RY, Ingraham JL, Wheelis ML, Painter PR (1995) General Microbiology, 5th Edition, MacMillan Press Ltd., London. 6. Prescott, L. M., Hartley, J. P. and Klein, D. A. (1993) Microbiology, 2nd Ed., W. M. C. Brown Publ., England 7. Tortora, G. J., Funke, B. R. and Case, C. L. (2004) Microbiology, 8th Edn., Person Education, New Delhi 8. Nicholas, C.P. and Lewis, S. (1999) Fundamentals of Enzymology, 3rd edn., oxford University Press Inc. New York 9. Caldwell, D.R. (1995) Microbial Physiology and Metabolism, Brown Publishers, London 10. Wiley, J.M., Sherwood, L.M. and Woolverton, C.J. (2013) Prescott's Microbiology, 9th edn., MacGraw Hill Higher Education	

MB - 302: Microscopy and Microbial Ecology

Total Hours: 30 **Credits: 2**

Unit	Topics	Lectures
Course objective	To complement the students with the basic knowledge about microscopy and microbial ecology.	
Learning outcomes	After successful completion of this course, the students are expected to: • demonstrate theory in microscopy and acquaint with advanced microscopy. • know the basic concepts of microbial ecology such as biotic and abiotic factors, microbial interactions etc. • learn the establishment of symbiosis, some positive and negative interactions. • comprehend the various symbiotic interactions of microbes with plants, animals and other microbes. • understand the microbial interactions in extreme habitats. • know the detail concept of biotopes.	
UNIT-1:	**Microscopy**	**10**
	• Principle, image formation, working, ray diagram and applications: ➢ PCM ➢ Fluorescence Microscope, FISH, FRET ➢ TEM, SEM and Scanning Tunneling Microscopy (STM)	
	• Specimen preparation, Freeze Etching, Shadow casting technique	
UNIT-2:	**Microbial Ecology**	**10**
	• Concept of microbial ecology and biotic and abiotic factors	
	• Types of microbial interactions	
	➢ Positive: Mutualism, Commensalism, Syntropy, Neutral association, Symbiosis	
	➢ Negative: Prey, Amensalism, Antibiosis, Competition, Parasitism, Predation	
	• Establishment of symbiosis: Direct and Reinfection with examples	
	• Microbial Interactions (Rhizosphere, phyllo-sphere) • Interactions with plants ➢ Legume-Rhizobium Root and Stem, Leaf nodulation ➢ Mycorrhiza: Ecto, Endo, VAM, Orchid ➢ Lichen ➢ PGPR • Interactions in Animals ➢ Ruminant symbiosis • Interactions of Bacteria ➢ Bacterial Bioluminescence. ➢ Microbial Kappa particles	
UNIT-3:	**Microbial interactions in extreme habitats**	**10**
	• Extremophiles: Archaebacteria and their characteristic features and types Acidophiles, Psychrophiles, Thermophiles, Barophiles, Alkalophiles, Halophiles, Methanogens (Acetotrophic, Hydrogenotrophic, Methylotrophic) with examples	
	• Biotopes	
	• Adaptation strategies and their physiology	
	• Evolutionary significance and applications of extremophiles	

Suggested Readings	1. Kathy Talaro and Barry Chess (2012) Foundations in Microbiology, The McGraw-Hill Companies, Inc., New York. 2. Tortora, Funke and Case (2010) Microbiology, Brenjamin Cummings Inc., California 3. Stanier, R.Y., Ingraham, J.L., Wheelis M.L., Painter R.K. (1995) General Microbiology, MacMillan Press Ltd. London. 4. Frobisher M. (1974) Fundamentals of Microbiology, Hinsdill, Crabtree and Goodheart Ed., WB Saunder's Co. USA. 5. Pelczar MJ, Chan ECS, Krieg NR (1998) Microbiology Tata McGraw Hill Publishing Co. Ltd. New Delhi. 6. Ulhas Patil, JS Kulkarni, AB Chaudhari and SB Chincholkar (2011) Foundations in Microbiology Nirali Prakashan, Pune. 7. Modi H. A. (1995) Elementary Microbiology 1 and 2, Ekta Prakashan, Ahmedabad 8. Stolp, H. (1988) Microbial Ecology; Organism's habitat activities, Cambridge University Press, Cambridge 9. Barton, L.L. and Northrup, D.E. (2011) Microbial Ecology, 1st edn., Wilet Blackwell, USA 10. Atlas, R.M. and Bartha, R. (2000) Microbial Ecology: Fundamental's and Application, 4th edn., Benjamin/Cummings Science Publ., USA 11. Campbell R.E. (1983) Microbial Ecology, Blackwell Scientific Publ., Oxford 12. Adam Schikora (2018) Plant-Microbe Interactions in the Rhizosphere, Caister Academic Press, Germany, ISBN: 978-1-912530-00-7 13. Anitori, R.P. (2012) Extremophiles: Microbiology and Biotechnology, Caister Academic Press, Germany, ISBN: 978-1-904455-98-1	

MB - 303: Practical Paper-III

Total Hours: 30 **Credits: 2**

Sr. No.	Title of practical	Hours
Course objective	To introduce the students to various structural, biochemical, environmental and microscopic aspects of microorganisms along with study of extremophiles	
Learning outcomes	After successful completion of this course, students are expected to: • learn proper handling of micropipette, pH meter, graduated pipette and volumetric flask along with their calibrations. • perform specific staining techniques and acquired skill of handling microscope while observing stained preparations. • able to demonstrate basic biochemical characteristics of bacteria. • able to check potability of water. • know characteristics and significance of extremophiles. • different environmental aspects of microorganisms.	
1.	Handling and calibration of pipette, volumetric flask, micropipette, and pH meter	04
2.	Cell wall staining by any suitable method.	04
3.	Flagella staining by any suitable method.	04
4.	Biochemical Test: IMViC test and TSI test.	04
5.	Sugar Fermentation: Glucose, Lactose, Sucrose and Fructose.	04
6.	Presumptive Coliform test for checking potability of water (MPN).	04
7.	Confirmed and Completed Coliform test for assessing potability of water.	04
8.	Determination of microflora of soil/food	04
9.	Screening of *Actinomycetes* and fungi from soil	04

10.	Detection of microbial enzymes from microbes: Amylase, Lipase, Coagulase, Nitrate reductase, Catalase, Gelatinase, Protease, Urease	04
11.	Enzyme activity assay (amylase/ protease)	04
12.	Preparation of Buffers (0.1 M Phosphate Buffer – 6.8 to 7.4) and check the buffering capacity of same prepared buffer	04
13.	Microscopic observation of Rhizobia from root nodules/ Mycorrhizal spores from soil.	04
14.	Isolation of Halophiles / Alkalophiles / Acidophiles/ Thermophiles	04
NOTE: Mandatory to perform at least 12-13 practicals		
Suggested Readings	1. Alcamo, I.E. (2001) Laboratory Fundamentals of Microbiology, Jones and Bartlett, 2. Aneja, K.R (1996) Experiments in Microbiology, 3rd edition, Wishwa Prakashan, New Delhi. 3. Benson, H. (2001) Microbiological Applications Lab Manual, 8th edition, The McGraw-Hill Companies, New York. 4. Dubey, R.C. and Maheshwari D.K (2004) Practical Microbiology, S. Chand and Co., New Delhi. 5. Harley, J.P. and Prescott, L.M (1996) Laboratory Exercise in Microbiology, 3rd edition, WCB/McGraw Hill. 6. Jayaraman, I. (1981) Laboratory Manual in Biochemistry, Wiley Eastern Ltd., New Delhi. 7. Norris, J.R. (1969) Methods in Microbiology Vol. I, 1st Edn. Academic Press Inc., London. 8. Parija, S.C. (2007) Textbook of Practical Microbiology, Ahuja Publishing House, New Delhi. 9. Plummer, D.T. (1992) An Introduction to Practical Biochemistry, Tata McGraw Hill Publisher, New Delhi. 10. Sharma, K. (2007) Manual of Microbiology Tools and Techniques, Anne's Book India, New Delhi.	

S. Y. B. Sc. Semester III: Skill Enhancement Course (SEC)

MB SEC- I: Microbiological Analysis of Air, Water and Soil

Total Hours: 30 **Credits: 2**

Unit	Topics	Lectures
Course objective	• To highlight the number and range of pathogens that may be found in air, water and soil. • To describe some of the key preventative and monitoring actions which maintain and improve microbiological quality of water, air and soil. • To introduce the concept and use of indicator bacteria specially in water quality monitoring. • To describe the principal indicator bacteria used and their key characteristics which make them suitable for use as indicators. • To emphasize the value of *E. coli* and thermotolerant fecal coliforms as routine indicators	
Learning outcomes	After successful completion of this course, the students are expected to: • competently explain various aspects of environmental microbiology • aware about the pollution, Water and air-borne diseases and their transmission, methods of determination of sanitary quality of water and sewage treatment methods employed in waste water treatment. • appreciate the diversity of microorganisms and learn the abundance, distribution and significance of microorganism in the environment such as bioremediation and plant microbe interactions	

	• understand various biogeochemical cycles - microbes involved and biochemical mechanisms of Carbon, Nitrogen, Phosphorus cycles etc.	
UNIT-1:	**Microbiological analysis of air and soil**	**20**
	• Concept of air and soil microbiology	
	• Aero-microbiology: ➢ Bio-aerosols, droplet nuclei, Air borne microbes, impact on human health and environmental, Significance in food, pharma industries, allergens, surgical operation theatres ➢ Techniques for microbial sampling of air from various sources, Aerosol sampling, fate of aerosols, inactivation by UV light and HEPA filter ➢ Assessment of air quality by solid, liquid impingement, Enumeration of microflora by different techniques, ➢ Air borne transmission of microbes, their diseases and preventive control measures	**10**
	• Soil microbiology: ➢ Biogeochemical cycles: C, P, N, S ➢ Soil horizons, classification of soils ➢ Microflora of various soil types and salt affected soils ➢ Rhizosphere microflora ➢ Preparation of Winogradsky's column to study soil microflora Enumeration of soil microflora by different techniques,	**10**
UNIT-2:	**Water microbiology**	**10**
	• Water ecosystem: Fresh water (Ponds, Lakes, Stream); Marine water (Estuaries, mangroves, deep sea, hydrothermal vents, saltpans, Coral reef)	
	• Microflora of water	
	• Bacterial assessment of water and potability of water	
	• Indicator bacteria: *E. coli*, *Staphylococcus aureus*, *Clostridium perfringens*, MPN (Black, White), MPN index, IMViC test	
	• Physiochemical characteristics of water: TSS, TDS, DO, BOD and COD	
	• Brief account of water borne diseases and their control measures	
Suggested Readings	1. Clesceri L S., Greenberg, A. E, and Eaton A. D. (1998) Standard Methods for Examination of Water and Wastewater, 18th Edition, American Public Health Association, Washington. 2. Maier R.M., pepper, I.L. and Gerba, C.P. (2009) Environmental Microbiology, 2nd edn., Academic Press, NY 3. Salle, S.J. (1974) Fundamental Principals of Bacteriology, 2nd edition, Tata McGraw Hill Publishing Co. Ltd., New Delhi. 4. SubbaRao, N.S. (1999) Soil Microbiology, 4th edn., Oxford and IBH Publ. Co., New Delhi 5. Coyne, M.S. (2001) Soil Microbiology: An Exploratory Approach, Delmar Thomson Learning 6. Alexander, M. (1977) Introduction to Soil Microbiology, John Wiley and sons Inc. New York 7. Burns, R.G. and Slater, J.H. (1982) Experimental Microbial Ecology, Blackwell Scientific Publ., Oxford 8. Atlas, R.M. and Bartha, R. (2000) Microbial Ecology, 4th edn., Benjamin/Cumming Science Publ., USA 9. Benson, H. (2001) Microbiological Applications Lab Manual, 8th edition, The McGraw-Hill Companies, New York. 10. Dubey, R.C. and Maheshwari D.K (2004) Practical Microbiology, S.	

	Chand and Co. New Delhi. 11. Harley, J.P. and Prescott, L.M (1996) Laboratory Exercise in Microbiology, 3rd edition, WCB/McGraw Hill, London	

S. Y. B. Sc. Semester IV: Microbiology

MB - 401: Genetics and Immunology

Total Hours: 30 **Credits: 2**

Unit	Topics	Lectures
Course objective	To acquaint students with basic concepts of microbial Genetics and Immunology	
Learning outcomes	After successful completion of this course, the students are expected to: • understand the basic of microbial enzymology, nature of enzyme, their nomenclature, working mechanism, classification based on their action etc. • understand the concepts like gene, chromosome, Structural organization of chromosome, extra chromosome: plasmid and its types • know general terms used in genetics • aware about genetic code • learn mutation, type, agent causing mutation and their mechanism, test to detect mutation etc. • learn about infection: mode and source. • understand antigen, antibody and their role in immunity and immune response. • know about antibody diversity. • understand blood grouping system. • cognizant about vaccine, anti-sera and toxoid	
UNIT-1:	**Genes and chromosomes**	**10**
	• Concept of gene, genome, allele, genotype, phenotype, recon, muton, cistron, intron, exon, haploid, diploid, lethal gene, partially diploid, homologous, heterologous etc.	
	• Typical structure of prokaryotic and eukaryotic chromosome	
	• Structural organization of prokaryotic and eukaryotic chromosome	
	• Concept of Chromosome variation (Euploidy, Aneuploidy and Polyploidy and Mitotic Non-disjunction), giant chromosome.	
	• Plasmid: Concept, types, structure and properties, incompatibility	
	• Genetic code and its properties	
UNIT-2:	**Mutations**	**10**
	• Concept and significance of mutations	
	• Types of mutation: Base pair substitutions, frame shift, deletion, inversion, insertions, Tandem duplications, missense, nonsense, neutral, silent, pleiotropic and suppressor mutations Useful phenotypes: Auxotrophic, Conditional, Lethal, Resistant	
	• Spontaneous and induced types of mutation	
	• Mechanism of Spontaneous mutations	
	• Mechanism of induced mutations: Physical (UV, Gamma, and X-rays), Chemical (Base analogues, deaminating agents, alkylating agent, intercalating agent)	
	• Methods to study mutations: ➢ Fluctuation test ➢ Replica plate technique ➢ Ame's test	
	• DNA repair and types of repair systems	
UNIT-3:	**Infection and Immunity**	**10**
	• Infection: Types, Mode and sources of transmissions	

	• Immunity: concept, types (Innate, Acquired) and components of immune system and properties of immune system • Immune Cells (stem cell, T cell, B cell, NK cell, Macrophages, Dendric cell) and organs (Bone marrow, thymus, lymph node, spleen, GALT, CALT) involved in immune response	
	• Non-specific immune response	
	• Specific immune response: Primary and secondary	
	• Type of immune response: Humoral and cell mediated, T and B cells characteristics	
	• Antigen: Concept of hapten, adjuvants, immunogen, epitope and paratope, T- dependent and T-independent antigens	
	• Types and properties of antigen	
	• Blood group: ABO antigen, Bombay blood group antigen, D-antigen and its variants, blood transfusion and rh incompatibilities	
	• Antibody: Types, structure and properties of each antibody, antigenic determinants on antibodies (isotypic, allotypic, ideotypic)	
	• Concept of Antibody diversity	
	• Vaccine, immune sera and toxoid	
Suggested Readings	1. Wiley, JM, Sherwood, LM and Woolverton, CJ. (2013) Prescott's Microbiology. 9th Edition. McGraw Hill International, New York. 2. Frobisher M. Hinsdill, Crabtree and Goodheart (1974) Fundamentals of Microbiology, 9th edition, WB Saunder's Co., USA. 3. Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2014) Brock Biology of Microorganisms, 14th edition, Pearson International Edition, New Delhi 4. Pelczar MJ, Chan ECS and Krieg NR. (1993) Microbiology. 5th edition. McGraw Hill Book Company, New York 5. Tortora, Funke and Case (2010) Microbiology, 10th edition, Brenjamin Cummings Inc, California. 6. Modi, H. A. (2014) Elementary Microbiology, Vol. 1 and 2, Akshar Prakashan, Ahmedabad. 7. Stanier, RY, Ingraham, JL, Wheelis, ML and Painter, PR. (2005) General Microbiology, 5th edition, McMillan, London 8. Salle, S.J. (1974) Fundamental Principals of Bacteriology, 2nd edition, Tata McGraw Hill Publishing Co. Ltd., New Delhi. 9. Pawar, CB, and Daginawala, HF. (1998) General Microbiology, Vol. I and II, 1st edition, Himalaya Publishing House, Mumbai. 10. Ananthanarayan, P., Paniker, C. K. J. (1990) Textbook of Microbiology, Orient Longman, Madras. 11. Kimball, J. W. (1990) Introduction to Immunology, MacMillan Publishing Company, New York. 12. Kuby, J. W. H. (1994) Immunology, W.H. Freeman and Company, New York. 13. Riott, I.M. (1998) Essential Immunology, ELBS Blackwell Scientific Publications, Oxford 14. Maloy, S.R., Freifelder, D. and Cronan, J.E. (1994) Microbial Genetics, 2nd edn., Jones and Bartlett Publishers 15. Keya Chaudhari (2014) Microbial Genetics, TERI Press, New Delhi ISBN: 9788179933237 16. Abbas AK, Lichtman AH, Pillai S. (2007) Cellular and Molecular Immunology, 6th edition, Saunders Publication, Philadelphia	

MB - 402: Basic Industrial Microbiology

Total Hours: 30 **Credits: 2**

Unit	Topics	Lectures
Course objective	To acquaint students with basic concepts of industrial microbiology.	
Learning outcomes	After successful completion of this course, the students are expected to: • understand the basics of fermentation technology, screening techniques, microbial culture preservation techniques etc. • know the concepts of inoculum development and media sterilization for fermentation process. • learn about the typical structure of fermenter and its parts, types of fermentation processes and synchronous growth. • aware about the detail downstream process of fermentation of important microbial products.	
UNIT-1:	**Basics of fermentation technology**	**10**
	• Characteristics of industrial strains	
	➢ Screening of industrially important microorganisms ➢ Primary and Secondary Screening with examples ➢ Screening for Amino acid / vitamin producers ➢ Screening for Antibiotic Producers ➢ Strain improvements ➢ Culture collection centers: National (NCIM, MCC) International (ATCC) and their role ➢ Preservation of microbial culture: Soil culture, Oil overlay, Liquid nitrogen Freezing, drying, Lyophilization ➢ Working and stock culture	
	• Inoculum ➢ Inoculum source and Characteristics ➢ Acclimatization ➢ Inoculum development and Characteristics features	
	• Fermentation media ➢ Raw materials used in media production, Screening and Selection of raw materials, typical composition and criteria for selection ➢ Synthetic media, Complex media and Natural media ➢ Sterilization: Batch Sterilization, Continuous Sterilization	
UNIT-2:	**Fermentation**	**10**
	• Criteria for fermenter design and construction	
	• Fermenter types and parts (Impeller, baffles, sparger, stuffing box)	
	• Measurement and control of fermentation parameters: pH, temperature, dissolved oxygen, foaming and aeration	
	• Fermentation process: Submerged (Batch, Fed batch, Dual/ Multiple) Solid state fermentation, concept, characteristics and applications	
	• Continuous Cell growth: Chemostat and Turbidostatic	
	• Synchronous cell growth: Physical and Chemical methods ➢ Applications of synchronous culture	
UNIT-3:	**Downstream processing**	**10**
	• Product isolation methods ➢ Cell removal ➢ Cell disruption: Chemical methods, Ultra sonication and Enzymatic methods	
	• Recovery of fermentation products	

	• Filtration: Theory, Filter bids, (Examples: Pressure leaf filters, Rotatory vacuum filters)	
	• Centrifugation: Theory, Types: Basket centrifuge, Tubular bowl, Multi-chamber centrifuge	
	• Solvent recovery: Two phase aqueous extraction, superficial fluid extraction, countercurrent extraction	
	• Chromatography: Ion exchange, Adsorption, Affinity chromatography, GC and HPLC	
	• Membrane process: Ultrafiltration, Reverse Osmosis, Drying, Crystallography	
Suggested Readings	1. Casida, L.E (1998) Industrial Microbiology New Age International Publishers, New Delhi 2. Crueger, W. and Crueger, A. (2000) Biotechnology: A Textbook of Industrial Microbiology, Panima Publ Co., New Delhi 3. Stanbury, P.F., Whitaker, A. and Halt G. (1995) Principles of Fermentation Technology, Pergamon Press, New York. 4. Whitaker, A. and Stanbury, P.F. (1995) Principles of Fermentation Technology, Butterworth-Heinemann 5. Patel A. H. (1996); Industrial Microbiology McMillan Publication, New Delhi. 6. Prescott S.C and Dunn C.G. (1983) Industrial Microbiology, McGraw Hill Book Co. Inc., New York. 7. Tortora, Funke and Case (2010) Microbiology, Brenjamin Cummings Inc., California 8. Stanier, R.Y., Ingraham, J.L., Wheelis M.L., Painter R.K. (1995) General Microbiology, MacMillan Press Ltd., London. 9. Frobisher M. (1974); Fundamentals of Microbiology, Hinsdill, Crabtree and Goodheart Edition, WB Saunder's Co., USA. 10. Pelczar MJ, Chan ECS, Krieg NR (1998) Microbiology Tata McGraw Hill Publishing Co. Ltd., New Delhi.	

MB - 403: Practical Paper - IV

Total Hours: 30 **Credits: 2**

Sr. No.	**Title of practical**	**Hours**
Course objective	To enhance practical skills of students in concern with Genetics, Industrial microbiology and enzymology.	
Learning outcomes	<u>After successful completion of this course students are expected to:</u> 1. Structure and functions of nucleus and volutin granules. 2. Able to carry out titrations skillfully. 3. Understand structure, working principle and significance of each and every part of fermenter. 4. Know chromatography techniques. 5. Students can be able to detect blood groups and perform cross-matching. 6. Understand concept of stock solutions and can prepare required stock concentration by proper dilutions. 7. Get knowledge about enzymes; successfully detect various enzymes produced by microorganisms.	
1	Nucleus staining by any suitable method	04
2	Volutine granules staining by any suitable method.	04
3	Isolation of antibiotic resistant mutants.	04
4	Isolation of UV induced auxotrophic mutants.	04
5	Estimation of acetic acid from vinegar by titrimetric method.	04
6	Screening of antibiotic producing microbes by Crowded plate technique and Organic acid producing microbes by Indicator dye method.	04

7	Recovery of organic acid from fermentation broth and detection using Paper chromatography and Thin Layer chromatography	04
8	Determination of ABO and Rh blood group and cross matching of blood	04
9	Separation of lymphocytes from whole blood and count using hemocytometer	04
10	Preparation of different dilutions from given stock solutions of antibiotic.	04
11	Growth curve of bacteria by cell number measurement using absorbance	04
12	Preservation of fungal spore culture using soil culture method and validating its viability	04
13	Fermentative production of alcohol and recovery of alcohol using distillation	04
14	Demonstration of a typical fermenter	04
NOTE: Mandatory to perform at least 12-13 practical		
Suggested Readings	1. Aneja, K.R. (1996) Experiments in Microbiology, 3rd edition, Wishwa Prakashan, New Delhi. 2. Benson, H. (2001) Microbiological Applications Lab Manual, 8th edition, The McGraw-Hill Companies, New York. 3. Dubey, R.C. and Maheshwari D.K. (2004) Practical Microbiology, S. Chand and Co., New Delhi. 4. Harley, J.P. and Prescott, L.M. (1996) Laboratory Exercise in Microbiology, 3rd edn., WCB/McGraw Hill Publ. Co., London 5. Jayaraman, I (1981) Laboratory Manual in Biochemistry, Wiley Eastern Ltd., New Delhi. 6. Norris, J.R. (1969) Methods in Microbiology Vol. I, 1st edition, Academic Press Inc., London. 7. Parija, S.C. (2007) Textbook of Practical Microbiology, Ahuja Publishing House, New Delhi. 8. Plummer, D.T. (1992) an Introduction to Practical Biochemistry, Tata McGraw Hill Publisher, New Delhi. 9. Sharma, K. (2007) Manual of Microbiology Tools and Techniques, Ane's Book India, New Delhi.	

S. Y. B. Sc. Semester IV: Skill Enhancement Courses (SEC)

SEC-II: Biofertilizers and Biopesticides

Total Hours: 30 **Credits: 2**

Unit	Topics	Lectures
Course objectives	• To aware the students to the adverse effects of plant production and protection of chemicals on the biotic and abiotic components of environment. • To familiarize students with the microbes used as biofertilizers for various crop plants and their advantages over chemical fertilizers.	
Learning outcomes	After successful completion of this course students are expected to: 1. Completion of the course will give an overview of relevant use of microbial biofertilizers and biopesticides. 2. The students will become familiar with the vast reserves of available microbial biodiversity that provide abundant opportunities to harness the ability of micro - organisms and their chemical constituents 3. To sustainably minimize damage from pests or increase agricultural productivity and production.	
UNIT-1:	**Biofertilizers**	18
	General account of the microbes used as biofertilizers for various crop plants and their advantages over chemical fertilizers	
	Screening and isolation of symbiotic and non-symbiotic nitrogen fixing bacteria for production of biofertilizer	

	Rhizobium: Isolation, characteristics, types, inoculum production and field application, legume/pulses plants	
	Frankia: Isolation, characteristics, *Alder*, *Casurina* plants, non-leguminous crop symbiosis	
	Cyanobacteria, *Azolla*: Isolation, characterization and role in crop cultivation	
	Non-symbiotic nitrogen fixing bacteria: *Azospirillum*, *Azotobacter*: isolation, characteristics, mass inoculum production and field application	
	PGPR, phosphate solubilizing bacteria and Mycorrhizal biofertilizers: isolation, characteristics, mass inoculum production and field application	
	Application of biofertilizers: Liquid, and preparation of carrier-based formulation, Seed bacterization, soil broadcasting	
	Bio-efficacy and quality parameters	
UNIT-2:	**Biopesticides**	12
	General account of microbes used as biopesticides / bioinsecticides and their advantages over synthetic pesticides	
	Screening and isolation of bioagents	
	Bacillus thuringiensis, Pseudomonas fluorescence, Trichoderma viridae: Mode of action, mass production, formulation, Field applications NPV and *Beauveria bassiana: A*ction, Cultivation and field applications	
	Advantages and disadvantages of biopesticides	
	Bio-efficacy and quality parameters assessment	
Suggested Readings	1. Kannaiyan, S. (2003) Biotechnology of Biofertilizers, CHIPS, Texas. 2. Rai M. K. (2005) Hand Book of Microbial Biofertilizers, The Haworth Press, Inc. New York. 3. Reddy, S.M. et. al. (2002) Bioinoculants for sustainable Agriculture and Forestry, Scientific Publishers, New Delhi 4. Subba Rao N.S (1995) Soil microorganisms and plant growth Oxford and IBH Publishing co. Pvt. Ltd., New Delhi. 5. Saleem F and Shakoori AR (2012) Development of Bioinsecticide, Lap Lambert Academic Publishing GmbH KG 6. Aggarwal SK (2005) Advanced Environmental Biotechnology, APH Publication, New Delhi	