Academic Council Meeting No. and Date : July 06, 2023

Agenda Number : 2 **Resolution Number : 30, 31/4.4 & 4.9**

Vidya Prasarak Mandal's

B. N. Bandodkar College of Science (Autonomous), Thane

Syllabus for

Programme : Bachelor of Science

Specific Programme : Microbiology

[T.Y.B.Sc. (Microbiology)]

Revised under Autonomy

From academic year 2023 - 2024

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PREAMBLE

In continuation with syllabus reframing for the first and the second year Microbiology course, the T.Y.B.Sc. syllabus is being revised to be implemented from the year 2023-2024.

In order to impart latest advances in the subject, some of the modules of the earlier syllabus have been upgraded, while some new modules have been added to the syllabus.

The syllabus encompasses basic knowledge in various branches of Microbiology such as Microbial Genetics, Molecular Biology, Virology, Medical Microbiology, Immunology, Microbial Biochemistry and Industrial Microbiology. It also aims to make students aware about interdisciplinary sciences such as Bioinformatics, Intellectual property rights.

Students would be able to gain skill of scientific writing and be made aware about plagiarism and its impact on research fields.

The approach towards designing this syllabus has been to retain the classic concepts of Microbiology as well as include the latest discoveries in Microbiology and related fields.

Eligibility: Learner who has cleared F. Y. B.Sc. (Semester1 and 2) or S. Y. B.Sc. (semester 3 and 4)

Duration: 1 year

Mode of Conduct: Lectures and Laboratory Practical

Program Specific Outcome: Learners would be able to study basis of microbial world by knowing cell structure and functions, biochemistry, genetics, appreciate microbial diversity. Learners would be able to apply knowledge to make positive use of microbial systems for betterment of community and for sustainable development.

VPM's B.N. Bandodkar College of Science (Autonomous), Thane

T.Y.B.Sc. (Microbiology)

Structure of Programme

Course Code	Course Title	No. of lectures	Credits
BNBUSMB5T1	Microbial genetics	**60**	**2.5**
BNBUSMB5T2	Medical Microbiology & Immunology: Part - I	**60**	**2.5**
BNBUSMB5T3	Microbial biochemistry: I	**60**	**2.5**
BNBUSMB5T4	Bioprocess technology: I	**60**	**2.5**
BNBUSMB5T5	Applied Environmental Science		**2**
BNBUSMB5P1	Practical Based on BNBUSMB5T1 & BNBUSMB5T2		**3**
BNBUSMB5P2	Practical Based on BNBUSMB5T3 & BNBUSMB5T4		**3**
BNBUSMB5P3	Practical based on: BNBUSMB5T5		**2**
Total			**16**

Course Code	Course Title	No. of lectures	Credits
BNBUSMB6T1	rDNA Technology, Bioinformatics & Virology	**60**	**2.5**
BNBUSMB6T2	Medical Microbiology & Immunology: Part - II	**60**	**2.5**
BNBUSMB6T3	Microbial biochemistry: II	**60**	**2.5**
BNBUSMB6T4	Bioprocess technology: II	**60**	**2.5**
BNBUSMB6T5	Environmental Management		**2**
BNBUSMB6P1	Practical Based on BNBUSMB6T1 & BNBUSMB6T2		**3**
BNBUSMB6P2	Practical Based on BNBUSMB6T3 & BNBUSMB6T4		**3**
BNBUSMB6P3	Practical based on: BNBUSMB6T5		**2**
Total			**16**

Semester V

Course Code BNBUSMB5T1	Course Title **Microbial Genetics**	Credits 2.5	No. of lectures

Learning Outcomes: Learners will be able to:

1. understand structure and properties of different types of RNA, maturation of RNA and RNA splicing.
2. enlist types of mutation, their cause, effects, and DNA repair
3. explain functioning of operons and other regulatory mechanisms
4. elaborate on different gene transfer mechanisms in bacteria

Unit I: **Translation**	**1.1 Nature of Genetic Code:** a. Overlapping Vs non- overlapping code. 1L b. Revision of genetic code; concept of reading frame 1L **1.2 Transfer RNA, structure of tRNA, tRNA genes.** 3L **1.3 Translation:** Process of Protein Synthesis (Initiation, Elongation, Translocation, Proofreading on the ribosome, Termination)**.** 4L **1.4 From an RNA World to a Protein World:** 3L a. Ribozyme in protein synthesis. b. The Wobble Hypothesis. c. The significance of GTP in protein synthesis. **1.5 Protein synthesis in eukaryotes.** 1L **1.6 Inhibitors and modifiers of protein synthesis in prokaryotes and eukaryotes.** 1L **1.7 Protein sorting in the cell.** 1L	**15**
Unit II: **Mutation and repair**	2.1. **Mutations** 10L • Definition and Types of Mutations. • Mutation rate and mutation frequency. • Types of Point Mutations: transition, transversion, missense, nonsense, neutral, silent, frameshift, leaky mutations. • Reverse Mutations and Suppressor Mutations: Induced Variation in the Genetic Code: Nonsense Suppression. • Spontaneous Vs Induced mutations; Mutagenesis and Mutagens • (Examples of Physical, Chemical and Biological Mutagens); mutator genes and mutational hotspots, • Ames test • loss- of- function and gain- of -function mutation. • Conditionally expressed mutants. 2.2 **DNA Repair:** 5L Photo-reversal, Base Excision Repair, Nucleotide Excision Repair, Mismatch Repair, SOS Repair and Recombination Repair.	**15**
Unit III: Regulation of gene expression	**3.1 Introduction:** (02) Aspects of gene regulation similar and different in bacteria and eukaryotes: Genes and regulatory elements, Levels of gene regulation, DNA binding proteins	**15**

	3.2 Control of transcription in bacteria: Operon structure, Negative and positive control- Inducible and repressible operons **3.3 Lac operon:** Mutations and regulation (04) **3.4 Trp operon** (02) **3.5 Regulation of lytic and lysogenic pathway of lambda phage** (03) **3.6 Regulation of Sigma factor during growth:** Sigma factor control by RNA thermometers and proteolysis (01) **3.7 Regulatory RNAs:** Intro, Mechanism of sRNA function, sRNA molecules expand the reach of regulatory proteins (02) Riboswitches: i. In synthesis of Vitamin B12 ii. As Ribozymes (01)	
Unit IV: **Genetic exchange**	**Genetic analysis of Bacteria (01)** **Gene transfer mechanisms in bacteria** **4.1 Transformation (03)** a. Introduction and History b.Types of transformation in prokaryotes—Natural transformationin *Streptococcus pneumoniae, Haemophilus influenzae*, and *Bacillus subtilis.* c. Mapping of bacterial genes using transformation. d. Problems based on transformation. **4.2 Conjugation (05)** Discovery of conjugation in bacteria a. Properties of F plasmid/Sex factor b. The conjugation machinery c. Hfr strains, their formation and mechanism of conjugation d. F' factor, origin and behavior of F' strains, sexduction e. Mapping of bacterial genes using conjugation (Wolman and Jacob experiment) and Problems based on conjugation **4.3 Transduction (03)** a. Introduction and discovery b. Generalized transduction c. Use of Generalized transduction for mapping genes d. Specialized transduction Problems based on transduction **4.4. Recombination in bacteria (03)** a. General/Homologous recombination b. Molecular basis of recombination c. Holliday model of recombination (Single strand DNA break model only) d. Enzymes required for recombination e. Site –specific recombination	**15**

Course Code BNBUSMB5T2	Course Title Medical Microbiology & Immunology: Part - I	Credits 2.5	No. of lectures

Learning Outcomes: Learners will be able to

1. Understand virulence factors and correlate them with the pathogenesis and clinical features of the disease
2. Comment on the mode of transmission and modes of prophylaxis of the infectious diseases
3. Conceptualize immunogenicity and antigenicity
4. Discuss biological significance of complement, cytokines, MHC, APCs

Unit I: Respiratory and skin infections	Study of infectious diseases of the (wrt. Cultural Characteristics of the etiological agent, pathogenesis; clinical features, laboratory diagnosis, treatment and prevention) 1. **Study of Respiratory tract infection: (8)** a. *S. pyogenes* infections b. Influenza c. Tuberculosis d. Pneumonia caused by *K. pneumoniae* 2**. Study of skin infections (7)** a. Pyogenic skin infections caused by *Pseudomonas* and *S. aureus* b. Leprosy c. Fungal infections- Candidiasis d. Viral Infections- *Herpes simplex*	**15**
Unit II: Gastro-intestinal and urinary infections	Study of infectious diseases (w.r.t. cultural characteristics of the etiological agent, pathogenesis; clinical features, laboratory diagnosis, treatment and prevention) 1. **Study of gastrointestinal tract infections(12)** a. Infections due to Enteropathogenic *E.coli* strains b. Enteric fever- *Salmonella* c. Shigellosis d. Rotavirus diarrhea e. Dysentery due to *Entamoeba histolytica* **2. Study of urinary tract infections (3)**	**15**
Unit III: Immunogen, immunoglobulin and their interactions	**3.1 Antigen and immunogen :** Concept Factors affecting immunogenicity of the molecule (1) **3.2 Haptens and adjuvants** (1) **3.3 Immunoglobulin :** Antigenic determinants on immunoglobulins (isotypes, allotypes, idiotypes**) (1)** Immunoglobulin Superfamily (1) **3.4 Monoclonal antibodies** significance, production, applications (3) **3.5 Antigen-antibody reaction: (8)** a. Properties, types b. Precipitation: SRID, Double immunodiffusion, immuno-electrophoresis, rocket immune-electrophoresis c. Agglutination: bacterial, passive, hemagglutination, HAI	**15**

	d. RIA e. ELISA: types f. Immunofluorescence: direct and indirect g. Western blotting h. Flow cytometry and **FACS**	
Unit IV: Immune components	**Complement: (3)** Activation pathways **:** Classical, alternative, lectin dependant Biological functions and **regulation (tabulated)** **Cytokines: (2)** Concept, properties and attributes, **receptors**, biological functions **MHC: (3)** Introduction**,** polymorphism and polygenism, Classes, Basic structure , functional significance of MHC class I and class II **Antigen presenting cells : (3)** Types , role of APC's in endogenous and exogenous antigen processing and presentation **Molecules interacting with processed antigenic peptide** **TCR and BCR :** T Cell Receptor-structure (alpha-beta, gamma-delta TCR) TCR-CD_3 complex - structure and functions. B cell receptor and co-receptor-structure and function	**15**

Course Code BNBUSMB5T3	Course Title **Microbial Biochemistry: I**	Credits 2.5	No. of lectures

Learning Outcomes: Learners will be able to:

1. Comprehend different types of solute transport process and the differences between them.
2. Explain the electron transport chains in prokaryotes and mitochondria and understand the mechanism of ATP synthesis.
3. Understand various pathways for the breakdown of carbohydrates.
4. Apply the concepts of energetics and catabolism in biodegradation of various substrates.

Unit I: Biological Membrane transport	1. Composition and architecture of membrane a. Lipids and properties of phospholipid membranes b. Integral & peripheral proteins c. Aquaporins d. Mechanosensitive channels 2. Methods of studying solute transport a. Use of whole cell b. Liposomes c. Proteoliposomes 3. Solute transport across membrane a. Passive transport and facilitated diffusion by membrane proteins b. Co-transport across plasma membrane - (Uniport, Antiport, Symport) c. Active transport & electrochemical gradient d. Ion gradient provides energy for secondary active transport e. Lactose transport f. ATPases and transport (only Na-K ATPase) g. Shock sensitive system – Role of binding proteins h. Maltose uptake (Diagram and description) i. Histidine uptake (Diagram and description) j. Phosphotransferase system k. Schematic representation of various membrane transport systems in bacteria.	**15**
Unit II:	1. **Biochemical mechanism of generating ATP:** a. Substrate-Level Phosphorylation, Oxidative Phosphorylation & Photophosphorylation 2**. Electron transport chain** a. Universal Electron acceptors that transfer electrons to E.T.C. b. Carriers in E.T.C: □ Hydrogen carriers– NADH, Flavoproteins, Quinones □ Electron carriers– Iron Sulphur proteins, Cytochrome c. Mitochondrial ETC d. Biochemical anatomy of mitochondria e. Complexes in Mitochondrial ETC f. Schematic representation of Mitochondrial ETC.	**15**

	3. **Prokaryotic ETC** a. Organization of electron carriers in bacteria b. Generalized electron transport pathway in Bacteria c. Different terminal oxidases d. Branched bacterial ETC e. Pattern of electron flow in *E. coli* - aerobic and anaerobic 4. **ATP synthesis** a. Explanation of terms – Proton motive force, Proton pump, Coupling sites, P:O ratio, Redox potential (definition of Standard reduction potential) b. Free energy released during electron transfer from NADH to O_2 c. Chemiosmotic theory (only explanation) d. Structure & function of Mitochondrial ATP synthase e. Structure of bacterial ATP synthase f. Mechanism by Rotational catalysis g. Inhibitors of ETC, ATPase and uncouplers 5. **Other modes of generation of electrochemical energy** a. ATP hydrolysis b. Oxalate formate exchange c. End product efflux, Definition, Lactate efflux d. Bacteriorhodopsin: Definition, function as proton pump and significance 6**. Bioluminescence:** a. introduction, biochemistry c. Schematic diagram d. Significance	
Unit III: Fermentative Pathways & Anabolism of Carbohydrates	**4.1 Fermentative pathways** (with structures and enzymes) 4.1.1 Lactic acid fermentation 4.1.1.1 Homofermentation 4.1.1.2 Heterofermentation 4.1.2 Bifidum pathway 4.1.3 Alcohol fermentation 4.1.3.1 By ED pathway in bacteria 4.1.3.2 By EMP in yeasts **4.2 Other modes of fermentation in microorganisms** 4.2.1 Mixed acid 4.2.2 Butanediol 4.2.3 Butyric acid 4.2.4 Acetone-Butanol 4.2.5 Propionic acid (Acrylate and succinate propionate pathway) **4.3 Anabolism of Carbohydrates** 4.3.1 General pattern of metabolism leading to synthesis of a cell from glucose 4.3.2 Sugar nucleotides 4.3.3 Gluconeogenesis (only bacterial) 4.3.4 Biosynthesis of glycogen 4.3.5 Biosynthesis of Peptidoglycan	**15**

Unit IV: Studying Metabolism & Catabolism of Carbohydrates	**1. Experimental Analysis of metabolism** a. Goals of the study b. Levels of organization at which metabolism is studies c. Metabolic probes. d. Use of radioisotopes in biochemistry □ Pulse labeling □ Assay and study of radiorespirometry to differentiate EMP &ED e. Use of biochemical mutants f. Sequential induction **2. Catabolism of Carbohydrates** a. Breakdown of polysaccharides: Glycogen, Starch, Cellulose b. Breakdown of oligosaccharides - Lactose, Maltose, Sucrose, Cellobiose. c. Utilization of monosaccharides - Fructose, Galactose d. Major pathways – (with structure and enzymes) □ Glycolysis (EMP) Pasteur effect □ HMP Pathway- Significance of the pathway □ ED pathway □ TCA cycle- Action of PDH, Significance of TCA □ Incomplete TCA in anaerobic bacteria □ Anaplerotic reactions □ Glyoxylate bypass **3. Amphibolic role of EMP; Amphibolic role of TCA cycle** **4. Energetics of Glycolysis, TCA and ED** pathway – Balance sheet only. Format as in Lehninger (2.5 ATP/NADH and 1.5 ATP / FADH2) (Based on this format make balance sheet for Glycolysis - Lactic acid and Alcohol fermentation and for ED pathway) 1 L	**15**

Course Code BNBUSMB5T4	Course Title **Bioprocess Technology: I**	Credits 2.5	No. of lectures

Learning Outcomes: Learners will be able to:

- Describe the basic design of bioreactors, composition of media, and sterilization
- Describe methods of product recovery
- Discuss traditional fermentation processes like wine, vinegar etc.
- Demonstrate scientific writing and understand importance of Intellectual Property Rights

Unit I: Upstream processing	1.1 Basic design of a fermenter, sensor, and its types (4), Examples of fermenters - Stirred Tank Reactor, Air Lift, Deep Jet, Photobioreactor (1) 1.2 Development of inoculum (2) 1.3 Fermentation media formulation (3) 1.4 Sterilization of medium: Batch Vs continuous sterilization (2) 1.5 Sterilization of fermenter, feeds (2) 1.6 Scale up and scale down of fermentation (1)	**15**
Unit II: **Downstream Processing**	**2.1 Concept of Fermentation Product Recovery:** Criteria for choice of recovery process (1) **2.2 Removal of insoluble product (5):** Biomass separation from fermentation media a. Foam Fractionation (Floatation) b. Precipitation c. Filtration, filter aids, plate frame, Pressure leaf, rotary vacuum filters d. Centrifugation - Cell aggregation and flocculation, (Basket centrifuge, Tubular bowl centrifuge & Decanter centrifuge) **2.3 Cell Disruption for intracellular products(2):** Physico-mechanical and Chemical & biological methods **2.4 Extraction (2):** Liquid-Liquid Extraction, Solvent extraction and recovery, Reversed Micelle Extraction, Supercritical Fluid Extraction **2.5 Purification: (4)** 2.5.1 Chromatography 2.5.2 Carbon decolorization 2.5.3 Removal of Volatile Products 2.5.4 Membrane processes (Ultra filtration, Reverse osmosis, Liquid membranes) 2.5.5 Drying (Liquid Phase Moisture removal, Solid Phase Moisture Removal) 2.5.6 Crystallization 2.5.7 Whole broth processing **2.6 Treatment of waste in Industry (1)**	**15**
Unit III:	4.1 **Wine (3)** Composition of grape juice Wine manufacturing principles and fermentation Malolactic fermentation Types of Wine	**15**

	Aroma compounds of wine-types and examples (just enlist). 4.2 **Industrial alcohol**: Microorganism, Media, Fermentation, Product recovery (2) 4.3 **Vinegar (acetic acid):** Introduction, biosynthesis, production using generator, production using submerged fermenter, recovery. (2) 4.4 **Baker's yeast (2)** Production of Baker's yeast: Yeast strain used, large-scale production, Fermentation process, harvesting the yeast, packing (compressed and active dry yeast). **4.5 Enzymes:** Use of enzymes in industry (overview) and Production of enzymes. (3) Immobilization of enzymes : Introduction, methods, significance (2)	
Unit IV: Research methodology, Scientific writing, IPR	**4.1 Research Methodology:** Meaning of Research, Objectives & Motivation in Research, Types of Research, Research Approaches, Significance of Research (3) **4.2 Scientific writing:** Process of Scientific writing, Introduction to scientific reports and writings, Types (Research article, review article, scientific communications, case study, scientific report) (3) **4.3 Collection of data:** Collection of Primary Data; Observation Method, Interview Method, Collection of data through questionnaires / schedules, other methods of data collection, collection of secondary data, Selection of appropriate method for data collection, case study method (4) **4.4 Plagiarism:** Introduction to Plagiarism, Examples of Plagiarism, Punishment of Scientific misconduct (1) **4.5 IPR:** Introduction to IPR, Genesis of IPR (WIPO, GATT, TRIPs) (1) **4.6 Types of IP:** Patent, copyrights, geographical indications, trademarks, trade secret, Industrial designs, Plant varieties protection act (1) **4.7 Patent:** Patent Law, Criteria for patenting, Typical patenting procedure, provisional and complete specification, patentable and non-patentable items (2)	**15**

Course Code BNBUSMB5T5	Course Title **Applied Environmental Science**	Credits 2.5	No. of lectures
Learning Outcomes: Learners will be able to: • comprehend impact of the interrelationship between various components of the environment. • create critical and creative thinking during designing, manufacturing, utilization of chemical products, which would reduce or eliminate the use or generation of hazardous substances. • discover and design products, operations or processes, which conserve the energy resources. • summarize the knowledge of various laws and regulations regarding the environment.			
Unit I Introduction to Environment and pollution	1.1 Introduction to Environmental Science-Definition, Scope, Importance. Relationship with other branches of science: environmental biology, environmental chemistry, environmental engineering, environmental geology, environmental physics,environmental management. 1.2 Components of environment; biotic and abiotic. Composition of various segments of environment–atmosphere, hydrosphere, lithosphere, biosphere (with respect to composition and interrelationship). Types of pollution: 1.3 Water pollution: Pesticides and heavy metals. 1.4 Air pollution: Challenges posed by present day pollutants. 1.5 Others- Noise and nuclear pollution. Case Study of Thane Lakes, Case study of Thane Creek, GOI-UNDP Sea Turtle project.		**15**
Unit II Green Chemistry and Sustainability	2.1 The Twelve Principles of Green Chemistry. 2.2 Sustainable Development- Principlesand sustainable development indicators. 2.3 Goals of sustainable development. 2.4 Areas highlighted by Agenda 21. 2.5 Transition from Industrial economy to Green economy. Biography of Vandana Shiva - environmental activist, M.K. Prasad: A relentless green activist, Green Revolution M.S.Swaminathan.		**15**
Unit III Alternate Energy Resources	3.1 Renewable Energy-Definition and concept 3.2 Solar energy, wind energy, tidal energy, nuclear energy with examples. 3.3 Biomass & bio-fuels, petro crops, Algal biofuels 3.4 Use of wastes: Water-based biomass, energy from waste & solid waste Case study: Windmills & Wind Turbines in Maharashtra, Pawanchakki Aurangabad.		**15**
Unit IV Environmental Education and Legislation	4.1 Environmental education programmes in India. 4.2 Environmental organizations & agencies-CITES, EPA, IUCN & MAB. 4.3 Environmental laws in India: Wild life Protection Act, 1972, Water Prevention & Control of Pollution Act, 1974, Air Prevention & Control of Pollution Act, 1981, Environment Protection Act, 1986 & Biological Diversity Act, 2002. (Shifted from Sem VI) Case study: Water Conflicts: Sharing of Cauvery water between Karnataka and Tamil Nadu, Sharing of Godavari water Nashik, Ahmednagar & Marathwada.		**15**

Course Code BNBUSMB5P1	Course Title Practical Based on BNBUSMB5T1 & BNBUSMB5T2	Credits 3	No. of lectures
1.	UV survival curve – determination of exposure time leading to 90% reduction		
2.	Isolation of mutants using UV mutagenesis		
3.	Gradient plate technique (dye resistant mutants)		
4.	Replica plate technique for selection & characterization of mutants – auxotroph &antibiotic resistant		
5.	Isolation and detection of plasmid DNA.		
6.	Acid fast staining.		
7.	Identification of *Candida* species using the germ tube test and growth on Chrom agar		
8.	To determine SLO and SLS activity of *S .pyogenes*		
9.	Study of standard cultures *E. coli, Klebsiella spp., Proteus spp., Pseudomonas spp.,Salmonalla typhi, S. paratyphi A, S. paratyphi B, Shigella spp., S .pyogenes, S. aureus* Identification of isolates obtained from pus, sputum, stool and urine by morphological,cultural and biochemical properties.		
10.	Enteropluri test : demonstration		
11.	Double immunodiffusion		
12.	Demonstration experiments – Widal Qalitative and quantitative		
13.	Antigen Preparation: O & H antigen preparation of Salmonella. Confirmation by slide agglutination		

Course Code BNBUSMB5P2	Course Title Practical Based on BNBUSMB5T3 & BNBUSMB5T4	Credits 3	No. of lectures
1.	Isolation and study of Bioluminescent organisms		
2.	Qualitative and Quantitative assay of Phosphatase		
3.	Isolation and detection of mitochondria		
4.	Study of oxidative and fermentative metabolism		
5.	Study of Homo – Hetero fermentations		
6.	Glucose detection by GOD/POD		
7.	Alcohol Fermentation Preparation and standardization of yeast inoculums for alcohol fermentation Laboratory Alcohol fermentation using jaggery medium, calculation of efficiency of fermentation		
8.	Determine the alcohol tolerance for yeast.		
9.	Determine the sugar tolerance for yeast.		
10.	Chemical estimation of sugar by Cole's ferricyanide method		
11.	Chemical estimation of alcohol		
12.	immobilization of yeast cells for invertase activity - making of beads, Determination of activity and count by hemocytometer and viable count		
13.	scientific report writing (assignment)		

Course Code BNBUSMB5P3	Course Title **Practical based on: BNBUSMB5T5**	Credits 3	No. of lectures

1. Study of Physico-chemical properties of sewage/ effluent water: turbidity, dissolved oxygen, salinity & total hardness.
2. Determination of pH and temperature of water sample.
3. Measurement of intensity of light by Lux meter.
4. Determination of Air Pollution tolerance index: Ascorbic acid content, Total Chlorophyll, Ph of leaf extract, relative water content of leaf.
5. Collection and preservation of phytoplankton and zooplankton samples from different water bodies (river, pond, lake etc.)
6. Study of air micro flora.
7. Study of indoor plants for reduction of pollution (*Adiantum, Ocimum sanctum, Ivy, Chlorophytum, Monstera, Philodendron, Dracena, Chrysanthemum, Gerbera*).
8. Study of product derived by application of green chemistry (Laundry detergents, Polylactic acid packaging, Green paints, Pharmaceutical drugs- Ibuprofen)
9. Study of application of alternative energy resources (Solar panel, Biogas plant, Photovoltaic cell, Windmill, Nuclear reactor, Harnessing tidal energy)
10. Photographic documentation of environment related issues/ conservation Submission of soft & hard copy of 5 original photographs taken by the learner (details required)
11. Visit to any industry/laboratory/plant/national park and submission of report. **(Please refer to Annexure- II for suggested field visit**.)
12. Assignment (may be submitted in a group not exceeding three students).

Please refer to Annexure- I for suggested topics for assignment.

Semester VI

Course Code BNBUSMB6T1	Course Title **rDNA Technology, Bioinformatics & Virology**	Credits 2.5	No. of lectures
Learning Outcomes: Learners will be able to: 1. Comprehend properties and types of plasmids 2. Learn mechanism of transposition 3. Learn advances in and applications of RDT 4. Apply suitable bioinformatics tools			
Unit I: Plasmids & Transposable elements	**1.1Branches of Genetics (1L)** Transmission genetics Molecular genetics Population genetics Quantitative genetics **1.2Model Organisms (2L)** Characteristics of a model organism Examples of model organisms used in study Examples of studies undertaken using prokaryotic and eukaryotic model organisms **1.3Plasmids (9L)** General properties and Types of plasmids Transfer of plasmid DNA Incompatibility Properties of bacterial plasmids (F plasmid, R plasmid, Col plasmids, Ti plasmid) Plasmids in eukaryotes **1.4 Cloning Vectors:** Plasmids as cloning vectors: pUC, lambda phage replacement vectors, cosmids, YAC, BAC, Expression vector (introduction) **Transposable Elements in Prokaryotes (3L)** Insertion sequences Transposons: Types, Structure and properties, Mechanism of transposition, Integrons		**15**
Unit II: Advanced RDT and Bioinformatics	**2.1 Advanced RDT** Genomic, chromosomal and cDNA libraries: definition and construction 3L Southern, Northern and Western hybridization for library screening Advantages and drawbacks of PCR Vs. hybridization for screening **2.2 Bioinformatics** **Introduction** Definition, aims, tasks and applications of Bioinformatics (01) Database, tools and their uses – Importance, Types and classification of databases (01) **Intro to Nucleic acid sequence databases**- EMBL, DDBJ, GenBank, GSDB, Ensembl. (01) **Intro to Protein sequence databases**-PIR, SWISS-PROT,TrEMBL NRL3D.		**15**

	Intro to Protein structure databases- SCOP, CATH, Secondary databases: PROSITE, PRINTS and BLOCKS. KEGG. (01) **Intro to Sequence alignment** - global v/s local alignment, FASTA, BLAST (Different types of BLAST) (04)	
Unit III: Applications of recombinant DNA technology	3.1 DNA polymorphism: SNPs, STRS and VNTRS 1L DNA typing 1L DNA molecular testing for human genetic diseases (RFLP): SCA 1L DNA microarrays (only introduction) 1L Gene therapy 1L, Production of human insulin 1L Genetic engineering of plants: methodology (Ti plasmid vectors, electroporation, gene gun) and applications (only enlist- as per Russel) 6L Genetic engineering of animals- methodology (microinjection), applications- TG livestock: production of pharmaceuticals in milk- Pharming 3L	**15**
Unit IV: Virology	**4.1** Viral classification (Baltimore classification) Concept of satellite and helper viruses, largest virus Mimi virus **4.2** Structure of, Influenza virus, HIV, Rabies. Life cycle of, Influenza Virus and HIV, Rabies in detail**.** **4.3 Cultivation of viruses**- cell culture techniques, embryonated egg, laboratory animals, Cell culture methods: Equipment required for animal cell culture, Isolation of animal tissue **4.4 Visualization and enumeration of virus particles** 4.3.1 Measurement of infectious units 4.3.1.1 Plaque assay 4.3.1.2 Fluorescent focus assay 4.3.1.3 Infectious center assay 4.3.1.4 Transformation assay 4.3.1.5 Endpoint dilution assay 4.3.2 Measurement of virus particles and their components 4.3.2.1 Electron microscopy 4.3.2.2 Atomic force microscopy 4.3.2.3 Haemagglutination 4.3.2.4 Measurement of viral enzyme activity **4.5 Role of viruses in cancer:** Important definitions, characteristics of cancer cell, Human DNA tumor viruses- EBV, Kaposi's sarcoma virus, Hepatitis B and C virus, HPV	**15**

Course Code BNBUSMB6T2	Course Title **Medical Microbiology and Immunology II**	Credits 2.5	No. of lectures
Learning Outcomes: Learners will be able to: 1. Understand characteristics of etiological agent, transmission, pathogenesis along with treatment and prevention of infectious diseases. 2. Enlist common antibiotics and its mode of action 3. Represent pathways of T cell activation and describe B cell activation 4. Comprehend immunohematology, immunodeficiencies and hypersensitivity reactions			
Unit I: Sexually transmitted diseases and infections of CNS	**Study of Diseases with Emphasis on Cultural Characteristics of the Etiological Agent, Pathogenesis, Laboratory, Diagnosis and Prevention.** **1. Study of vector-borne infections - Malaria** **2. Study of sexually transmitted infectious diseases** a. Syphilis b. AIDS c. Gonorrhoea **3. Study of central nervous system infectious diseases** a. Tetanus b. Polio c. Meningococcal meningitis		**15**
Unit II: Chemotherapy of infectious agents	Discovery and Design of antimicrobial agents **(1L)**. **Attributes of an ideal chemotherapeutic agent** - Selective toxicity, Bioavailability of drug, routes of drug administration, LD50, MIC, MBC **(2L).** **Mode of action of antibiotics on-** Cell wall (Beta-lactams- Penicillin and Cephalosporins, Carbapenems) Cell Membrane (Polymyxin and Imidazole) Protein Synthesis (Streptomycin, Tetracycline and Chloramphenicol) Nucleic acid (Quinolones, Nalidixic acid, Rifamyicn) Enzyme inhibitors (Sulfa drugs, Trimethoprim) **(7L).** **List of common antibiotics** - used for treating viral, fungal and parasitic diseases.**(1L)** **Mechanisms of drug resistance** - Its evolution, pathways and origin for ESBL, VRE, MRSA **(2L)** (I) Selection and testing of antibiotics for bacterial isolates by Kirby-Bauer method (II) Methods that detect *S. aureus* resistance to methicillin, and determination of ESBL strains **(2L)**		**15**

Unit III:	**T cell activation** TCR mediated signaling – Overview Costimulatory signals Superantigens induced T cell activation **T cell differentiation:**formation of Memory and Effector cells **Cell mediated effector response** General properties of effector T cells • Cytotoxic T cells and destruction of target cell : perforin/ granzyme pathway • Fas pathway **Killing mechanism of NK cells** **Antibody mediated cell cytotoxicity (ADCC)** **B cell activation** B cell activation by Thymus dependant and independent antigens Signal transduction pathway activated by BCR- overview Role T_H cell in B cell response-Formation of T-B conjugates, CD40/CD40L interaction, T_H cells cytokine signals Affinity maturation, somatic hyper-mutation and class switching **Differentiation**: Generation of plasma cells and memory cells **Humoral Response:** Primary and secondary responses *In-vivo* sites for induction of Humoral response Germinal centers and antigen induced B cell Differentiation Cellular events within germinal centers- Overview	**15**
Unit IV:	**Immunohaematology: (3)** ABO Blood grouping, HDN its detection by Coomb's test **Vaccines : (7)** Introduction, properties of ideal vaccine, Active and passive immunization Types: Killed, attenuated, subunit vaccines, recombinant vector vaccine, DNA vaccine Vaccination schedule in India Modern vaccine delivery systems Challenges in vaccine development (HIV, Maleria) **Hypersenstivity (3)** Gell and Coombs classification, Features of different types of hypersensitivity **Immunodeficiency (2)** Inheited defects in early hematopoiesis, overview of SCID	**15**

Course Code BNBUSMB6T3	Course Title **Microbial Biochemistry II**	Credits 2.5	No. of lectures

Learning Outcomes: Learners will be able to:

1. Describe various catabolic and anabolic reactions of lipids
2. Comprehend metabolic fate of proteins and nucleic acids
3. Know various metabolic regulation mechanisms
4. Understand basics of photosynthesis and assimilatory pathways

Unit I: Lipid Metabolism & Catabolism of Hydrocarbons	**Introduction to Lipids** Lipids –Definition, classification & functions Types and role of fatty acids found in bacteria Common phosphoglycerides in bacteria Action of lipases on triglycerides /tripalmitate **Catabolism of Fatty Acids and PHB** Oxidation of saturated fatty acid by β oxidation pathway Energetics of β oxidation of Palmitic acid Oxidation of propionyl CoA by acrylyl- CoA pathway and methylcitrate pathway PHB as a food reserve and its degradation **Anabolism of Fatty Acids & Lipids** Biosynthesis of straight chain even carbon saturated fatty acid (palmitic acid) Biosynthesis of phosphoglycerides in bacteria Biosynthesis of PHB **Catabolism of aliphatic hydrocarbons** Organisms degrading aliphatic hydrocarbons Hydrocarbon uptake mechanisms Omega oxidation pathway- Pathway in *Corynebacterium* and yeast Pathway in *Pseudomonas*	**15**
Unit II: **Metabolism of Proteins and Nucleic Acids**	**2.1 Protein / amino acid catabolism (3)** 2.1.1 Enzymatic degradation of proteins 2.1.2 General reactions of amino acids catalysed by 2.1.2.1 Amino acid decarboxylases 2.1.2.2 Amino acid deaminases 2.1.2.3 Amino acid transaminases 2.1.2.4 Amino acid racemases 2.1.3 Metabolic fate of amino acids - Glucogenic and ketogenic amino acids 2.1.4 Fermentation of single amino acid - Glutamic acid by *Clostridium tetanomorphum* 2.1.5 Fermentation of pair of amino acids -Stickland reaction (include enzymes) 2.1.6 Incorporation & Detoxification of Ammonia	**15**

	2.1.7 Nitrogen excretion & urea cycle **2.2 Anabolism of amino acids (3)** 2.2.1 Schematic representation of amino acid families 2.2.2 Overview of amino acid biosynthesis (Lehninger fig 22.11) 2.2.3 Biosynthesis of amino acids of Serine family (Serine, Glycine and Cysteine) 2.2.4 Biosynthesis of Phenylalanine, Tyrosine & Tryptophan from Chorismate **2.3 Catabolism of Nucleotides (5)** 2.3.1 Degradation of purine nucleotides up to uric acid formation 2.3.2 Salvage pathway for purine and pyrimidine nucleotides **2.4 Biosynthesis of nucleotides (4)** 2.4.1 Nomenclature and structure of nucleotides 2.4.3 Biosynthesis of pyrimidine nucleotides 2.4.4 Biosynthesis of purine nucleotides 2.4.5 Biosynthesis of deoxyribonucleotides	
Unit III: **Metabolic Regulation**	**3.1 Definition of terms and major modes of regulation (2)** **3.2 Regulation of enzyme activity (5)** 3.2.1 Noncovalent enzyme inhibition 3.2.1.1 Allosteric enzymes and feedback inhibition (Allosteric regulation of isoleucine biosynthesis) 3.2.1.2 Patterns of FBI, combined activation and inhibition (FBI in the biosynthesis of adenine and guanine nucleotides in *E. coli*) 3.2.2 Covalent modification of enzymes (2) 3.2.2.1 Monocyclic cascades 3.2.2.2 Examples of covalent modification (without structures) 3.2.2.3 Regulation of Glutamine synthetase **3.3 DNA binding proteins and regulation of transcription by positive & negative control (3)** 3.3.1 DNA binding proteins 3.3.2 Negative control of transcription: Repression and Induction 3.3.3 Positive control of transcription: Maltose catabolism in *E. coli* **3.4 Global regulatory mechanisms (2)** 3.4.1 Global control & catabolite repression 3.4.2 Stringent response **3.5 Regulation of EMP and TCA cycle -** (Schematic and Regulation of Pyruvate dehydrogenase Complex) (1)	**15**

Unit IV: Prokaryotic Photosynthesis & Inorganic Metabolism	1. Photosynthesis a. Definition of terms in photosynthesis (light and dark reactions, Hill reaction & reagent, Photophosphorylation) b. Photosynthetic pigments c. Location of photochemical apparatus d. Photochemical generation of reductant 2. Light reactions in: a. Purple photosynthetic bacteria b. Green sulphur bacteria c. Cyanobacteria (with details) 3. Dark reaction a. Calvin Benson cycle b. Reductive TCA cycle 4. Inorganic Metabolism a. Assimilatory pathways: □ Assimilation of nitrate, □ Ammonia fixation– Glutamate dehydrogenase, Glutamine synthetase, GS-GOGAT, □ Biological nitrogen fixation (Mechanism for N 2 fixation and protection of nitrogenase) □ b. Dissimilatory pathways: □ Nitrate as an electron acceptor (Denitrification in Paracoccus denitrificans) b. Dissimilatory pathways: 5. Lithotrophy–Enlist organisms and products formed during oxidation of Hydrogen, carbon monoxide, Ammonia, Nitrite, Sulphur, Iron.	**15**

Course Code BNBUSMB6T4	Course Title **Bioprocess Technology: II**	Credits 2.5	No. of lectures

Learning Outcomes: Learners will be able to:

1. Understand applications of ultracentrifugation, spectrophotometer and learn advances in process control
2. know basic protocols and applications of ATC and PTC
3. Learn the salient features of quality management and regulatory procedures.
4. Describe various aspects of fermentation of penicillin, streptomycin, glutamic acid etc.

Unit I: Instrumentation and process control	**1.1 Ultra centrifuge and its application (1)** **1.2 Spectrophotometer:** Principles, working and application of (4) Spectrophotometry: UV, Visible & IR , **nanodrop** AAS & AES (Flame photometry) **1.3 Computer control of fermentation processes (7)** Principal operating characteristics of fermenters (1) Common measured and controlled parameters Instrumentation and interfacing technique Computer applications in automation, control strategies fault analysis , fermentation research (4) **1.4 Microfluidic devices in bioprocess (3)** introduction, concept, significance	**15**
Unit II: Animal and Plant Tissue Culture	**2.1 Animal Tissue Culture: (9L)** Introduction & types Design of ATC laboratory :1 Enlisting and significance of Glassware, plasticware and equipment for ATC: 1 Sterilization protocol: 1 Tissue Culture media: 1 Culture of cell lines: 3 (Setting up, maintenance, cryopreservation) Applications :3 **2.2 Plant Tissue Culture: (6L)** Introduction PTC media :1 Techniques in plant tissue culture: 3 • Sterilization procedure • Preparation of aseptic plants • Aseptic techniques • Incubation of culture • Callus culture Applications: 2	**15**
Unit III: **QA, QC and Assays**	**3.1 Quality assurance and Quality control (5L)** 3.1.1 Definitions, Chemical and pharmaceutical products 3.1.2 Variables of batch process	**15**

	3.1.3 Q.A and Q.C wrt.- Raw materials, method of manufacturing, in process items, finished products, label and labeling, packaging materials 3.1.4 Control of microbial contamination during manufacturing - **3.2 Sterilization control and assurance (3L)** **3.4 Bioassay (5L)** 3.4.1 Introduction 3.4.2 Types: Diffusion, End Point, Turbidometric, Metabolic Response, Enzymatic.	
Unit IV: Industrial Fermentations	**Penicillin and semisynthetic penicillins:** Introduction, strain development, production methods. Semisynthetic penicillins: Examples, production, advantages. (Crueger 233-240) **Aminoglycoside: Streptomycin:** Aminoglycoside antibiotics, strain development, production method, recovery. (Crueger 250-256) **Vitamin B $_{12}$:** Occurrence and economic significance, structure, biosynthesis, production based on media containing carbohydrates by- *Propionibacteria* and *Pseudomonas,* recovery. (Crueger 219-222) **Citric acid:** Introduction, strains used for production, , nutrient media, production processes- surface and submerged, product recovery. (Cruger 134-142) **Glutamic acid:** Production strains, effect of permeability on production, conditions of manufacturing, production process and recovery. (Crueger 158-164.) **Mushroom cultivation (Agaricus):** Edible mushroom species, preparation of substrate- composting- phase I and phase II, Factors affecting composting, preparation of spawn, casing, induction of fruiting body formation, harvesting. (Peppler Volume II- 179 – 196; An introduction to industrial microbiology. P.K Sivakumar. S. Chand. 156- 159.	**15**

Course Code BNBUSMB6T5	Course Title **Environmental Management**	Credits 2.5	No. of lectures

Learning Outcomes: Learners will be able to:

- 1. study and comprehend the treatment practices applied for domestic wastewater and industrial effluents.
- develop aptitude to examine and assess the outcome of the framework of current biodiversity hotspots, biosphere reserves and ecotourism.
- relate the impacts of climate change to the environment.
  plan &execute environmental auditing.

UNIT I **Ecological Restoration**	1.1 Domestic wastewater treatment. 1.2 Effluent treatment of Industrial waste. 1.3 Bioremediation. 1.4 Alternatives to conventional resources: biodegradable plastic, biodiesel, bio ethanol biopesticides. 1.5 Developing effluent treatments. Case study: Maharashtra Nature Park Society, Sion	**15**
UNIT II **Biodiversity Conservation and Ecotourism**	2.1 Hotspots of biodiversity and biosphere reserve. 2.2 Strategies for biodiversity conservation (in-situ and ex-situ). 2.3 Commercial wildlife photography. 2.4 Ecotourism–definition, policies and practices. 2.5 Eco sensitive zones of Thane Creek Flamingo Case study Tungareshwar Wildlife Sanctuary (TWLS) and Tansa Wildlife Sanctuary (TWS), Sanjay Gandhi National Park Borivali, Aarey forest, Mumbai.	**15**
UNIT III **Climate Change**	3.1 Introduction to climate change, global warming and its effects. 3.2 Geospatial technology- Remote Sensing & GIS. 3.3 Role of IPCC in climate change monitoring;, Earth Summit & UN Convention on Climate Change 3.4 COP 26. 3.5 The National Action Plan on Climate Change (NAPCC), Paris Agreement 3.6 Role of Ministry of Environment, Forests & Climate Change.	
UNIT IV **Environmental Audit**	4.1 Concept & economics of pollution control. 4.2 Concept, Objective and Scope of environmental audit. 4.3 Types of environmental audit 4.4 Green Audit Methodology 4.5 Benefits of environmental auditing.	

Course Code BNBUSMB6P1	Course Title Practical Based on BNBUSMB6T1 & BNBUSMB6T2	Credits 3	No. of lectures
1.	Enrichment of coliphages, phage assay (pilot & quantitative).		
2.	Restriction digestion of lambda phage /any plasmid DNA (Demo)		
3.	Restriction digestion of lambda phage /any plasmid DNA (Demo)		
4.	Beta galactosidase assay		
5.	Bioinformatics practicals: Visiting NCBI and EMBL websites & list services available, software tools availableand databases maintained, Visiting & exploring various databases mentioned in syllabus and Using BLAST and FASTA for sequence analysis, six frame translation of nucleotide sequence, restriction analysis of given nucleotide sequence, pairwise and multiple alignment of protein sequence, phylogenetic tree building		
6.	Animal cell culture (Demo) Primary explant culture Cell culture processing Trypsinization Determination of cell viability Cryopreservation protocol		
7.	Demonstration of malarial parasite in blood films (Demo)		
8.	Determination of MIC and MBC of an antibiotic.		
9.	Selection and testing of antibiotics using the Kirby-Bauer method		
10.	Synergistic activity determination		
11.	Blood grouping – Direct & Reverse typing		
12.	Determination of Isoagglutinin titer		
13.	Coombs Direct test		
14.	Demonstration : VDRL		

Course Code BNBUSMB6P2	Course Title Practical Based on BNBUSMB6T3 & BNBUSMB6T4	Credits 3	No. of lectures
1.	Detection of PHB producing bacteria		
2.	To study catabolite repression by diauxic growth curve		
3.	Protein estimation by Lowry's method		
4.	Estimation of uric acid		
5.	Qualitative and Quantitative assay of Protease		
6.	Qualitative detection of Lipase		
7.			
8.	Study of Lithotrophs – Nitrosification and Nitrification		
9.	Bioassay of an antibiotic (Ampicillin / Penicillin)		
10.	Bioassay of Cyanocobalamin		
11.	Plant tissue culture – preparation of medium, preparation of Explant, Callus culture (Demo)		
12.	Sterility testing of injectable		
13.	Bioassay of Penicillin		
14.	Vit B12 Bioassay		
15.	Stoke's method		
16.	Validation and Calibration of Instruments		
17.	Estimation of phenol		
18.	Chemical estimation of Penicillin		
19.	Industrial Visit		

Course Code BNBUSMB6P3	Course Title **Practical based on: BNBUSMB6T5**	Credits 3	No. of lectures

Project and submission of report (Project report may be submitted in a group not exceeding three students) **(Please refer to Annexure- III for suggested project**.)

1. Study of physical properties of soil: pH, Temperature, moisture, & texture of soil.
2. Study of chemical properties of soil: Organic matter
3. Estimation of calcium carbonate from soil.
4. Population analysis by Quadrant method & Line transect method.
5. Observation & study of indicator species.
6. Study of air & noise pollution monitoring devices, geospatial instruments.
7. Study of any five biodiversity hotspots, bio reserves of India.
8. Study of biodegradable plastic products, biopesticides brands.
9. To make eco-friendly products (colors, bags, lanterns, idols).
10. Demonstrate effects of global warming using jar experiment.

Visit to any industry/laboratory/plant/national park and submission of report. **(Please refer to Annexure-II for suggested field visit**.)

References:

SEMESTER-V

BNBUSMB5T1:

Sr. No.	Title	Author/s	Publisher	Edition	Year
1.	Genetics: A Conceptual Approach	Benjamin A. Pierce	WH Freeman	3rd	2007
2.	iGenetics: A Molecular Approach	Peter Russel	Benjamin Cummings	3rd	2010
3.	Fundamental bacterial genetics	Trun & Trempy	Wiley-Blackwell	-	2004
4.	Microbiology- an evolving science	John W. Foster, Joan L. Slonczewski	W. W. Norton & company Ltd.	International student edition 4e	2017

BNBUSMB5T2:

Sr. No.	Title	Author/s	Publisher	Edition	Year
1.	Textbook of Microbiology	Textbook of Microbiology	Textbook of Microbiology	Textbook of Microbiology	Textbook of Microbiology
2.	Jawetz's Medical Microbiology	Karen C. Carroll	McGraw Hill	26th	2013
3.	Mims' Medical Microbiology and Immunology	Richard V. Goering, Mark Zuckerman	Elsevier	6th	2018
4.	Kuby Immunology, 1.	W H Freeman		6th Edition	
5.	Immunology: Essential & Fundamental	Pathak & Palan,	Capital publishing	, 1st& 3rd edition,	

BNBUSMB5T3:

Sr. No.	Title	Author/s	Publisher	Edition	Year
1.	General Microbiology	Stanier, R. Y., M. Doudoroff and E. A.	The Macmillan press Ltd	5th	General Microbiology

		Adelberg			
2.	Outlines of Biochemistry	Conn, E.E., P. K .Stumpf, G. Bruening and R. Y. Doi	John Wiley & Sons. New York	5th	Outlines of Biochemistry
3.	Bacterial Metabolism	Gottschalk,G	Springer Verlag	2nd	Bacterial Metabolism
4.	The Physiology and Biochemistry of Prokaryotes	White, D	Oxford University Press	3rd	The Physiology and Biochemistry of Prokaryotes
5.	Lehninger, Principles of biochemistry	Nelson, D. L. and M.M. Cox	W. H. Freeman and Company	4th	Lehninger, Principles of biochemistry
6.	Chemical Microbiology	Rose, A.H	Butterworth-Heinemann	3rd	Chemical Microbiology
7.	Biochemistry	Mathews, C.K., K.E. van Holde, D.R. Appling, S, J, Anthony-Cahill	Pearson	4th	Biochemistry
8.	Biochemistry	Zubay, G. L	Brown publishers	4th	Biochemistry

BNBUSMB5T4:

Sr. No.	Title	Author/s	Publisher	Edition	Year
2.	Research Methodology	C R Kothari	New Age International Publishers	2nd	2004
3.	Entrepreneurship & Business of Biotechnology	S N Jogdand	Himalaya Publishing House	1st	2007
4.	Writing Scientific Research	Margaret Cargill & Patrick	John Wiley &	1st	2009

	Articles: Strategy & Steps	O'Connor	Sons		
5.	Successful Scientific Writing	J Matthews & R Matthews	Cambridge University Press	3rd	2008
6.	A complete guide to referencing and avoiding plagiarism	Colin Neville	McGraw Hill	1st	2007
7.	Microbiology and Technology of fermented foods.	Robert Hutkins	Wiley publications.	2nd edition	
8.	Modern Industrial Microbiology and Biotechnology'	Okafor Nduka	Science Publications Enfield, NH, USA		(2007)
9.	Industrial Microbiology	Prescott and Dunn	McMillan Publishers.	4th edition,	1982
10.	Industrial Microbiology"	Casida L. E.,	Reprint, New Age International (P) Ltd, Publishers, New Delhi		2009
11.	Biotechnology -"A Textbook of Industrial.	Crueger W. and Crueger A.			2000

SEMESTER-VI

BNBUSMB6T1:

Sr. No.	Title	Author/s	Publisher	Edition	Year
1.	Genetics: A Conceptual Approach	Benjamin A. Pierce	WH Freeman	3rd	2007
2.	iGenetics: A Molecular Approach	Peter Russel	Benjamin Cummings	3rd	2010
3.	Molecular Biology	David Friefelder	Narosa Publishing House	2nd	2004

4.	Principles of Gene Manipulation and Genomics	S.B. Primrose	Wiley Blackwell	7th	2013
5.	Basic Bioinformatics	S. Ignacimuthu	Narosa Publishing House	2nd	2012
8.	Understanding Viruses	Teri Shors	Jones & Bartlett Learning	2nd	-
9.	Principles of Virology	Flint, Racaniello, Rall, Skalka, Enquist	ASM Press	4th	2015

BNBUSMB6T2:

Sr. No.	Title	Author/s	Publisher	Edition	Year
1.	Jawetz, Melnick and Adelberg's Medical Microbiology.	G.F.Brooks, Morse, Carroll, Mietzner, Butel.	Lange publication	26th	2013
2.	Mim's Medical Microbiology.	Goering, Mark Zuckerman, Dockrell, chiodini	Elsevier limited	6th	2019
3.	Kuby Immunology, 2.	W H Freeman		6th	
4.	Immunology: Essential & Fundamental	Pathak & Palan,	Capital publishing	2nd	2005
5.	Textbook of basic and clinical immunology	Sudha gangal and Shubhangi Sontakke	Universities press		2013

BNBUSMB6T3:

Sr. No.	Title	Author/s	Publisher	Edition	Year
1.	Principles of Biochemistry	Lehninger	W.H. Freeman & Company	6th	2013
2.	Textbook of Biochemistry for Medical Students	D M Vasudevan, Sreekumari S, Kannan Vaidyanathan	Jaypee Brothers Medical Publishers	9th	2019

3.	General Microbiology	Stanier, R. Y., M. Doudoroff and E. A. Adelberg	The Macmillan press Ltd	5th	2004
4.	Outlines of Biochemistry	Conn, E.E., P. K .Stumpf, G. Bruening and R. Y. Doi	John Wiley & Sons. New York	5th	1987
5.	Bacterial Metabolism	Gottschalk,G	Springer Verlag	2nd	1985
6.	The Physiology and Biochemistry of Prokaryotes	White, D	Oxford University Press	3rd	1995
7.	Lehninger, Principles of biochemistry	Nelson, D. L. and M.M. Cox	W. H. Freeman and Company	4th	2005

BNBUSMB6T4:

Sr. No.	Title	Author/s	Publisher	Edition	Year
1.	Principles of fermentation technology	P.F. Stanbury, A. Whitaker, S.J. Hall.	Butterworth Heinemann, oxford	2nd edition	2000
2.	Principle and Practice of Animal Tissue Culture	Sudha Gangal	University Press	2nd	2010
3.	Introduction to Plant Tissue Culture	M.K. Razdan	Oxford and IBH Publishing	2nd	2019
4.	Plant Tissue Culture	Kalyan Kumar De	New Central Book Agency	-	2008
5.	Principle and Practice of Animal Tissue Culture	Sudha Gangal	University Press	2nd	2010
6.	Biophysical Chemistry: Principles and Techniques	Upadhyay and Upadhyay Nath	Himalaya Publishing House	4th Ed	2014
7.	Fermentation Technology	H.A. Modi	Pointer Publications	8th Ed	2009
8.	Modern Industrial Microbiology and	Okafor Nduka	Science publications	-	2007

	Biotechnology		USA		
9.	An introduction to industrial microbiology...	P.K Sivakumar	S. Chand		
10.	Microbial Technology’’. Vol. 1 & 2	Peppler, H. J. and Perlman,	Academic Press.		(1979
11	"Biotechnology -"A Textbook of Industrial.	Crueger W. and Crueger A.			2000
12	Industrial Microbiology	A.H. Patel	McMillan India		2007
13	Bioprocess microfluidics: applying microfluidic devices for bioprocessing https://doi.org/10.1016/j.coche.2017.09.004	Marco PC Marques and Nicolas Szita	Available online at www.sciencedirect.co		2017

References and Additional Reading USACEVS501 & USACEVS601

1) A Text Book in Environmental Science, V. Subramanian, Narosa Publishing House. 2002.

2) An Advanced Textbook on Biodiversity, K.V. Krishnamurthy, Oxford & IBH Publishing Co. Pvt. Ltd. 2009.

3) Atmosphere, Weather & Climate, R.G. Barry & R.I. Charley, ELBS 1982.

4) Bioresource Ecology, T. N. Anatha krishnan, Oxford & IBM Publishing Company, New Delhi 1982.

5) Concepts of Ecology, E. J. Kormandy, Prentice Hall of India (Pvt.) Ltd.

6) Ecological Methods of Field & Laboratory Investigations, P. Michael, Tata Mc Graw Hill.

7) Ecology & Quality of our Environment, Charles H. Southwid, D. Van Nostrand Co. N.Y. 1976.

8) Ecotourism, Ecorestoration& Development, Solomon Raju, New Central book agency, 2007.

9) Environment, e-book, Shankar A.G.

10) Wildlife photography- Advanced field techniques for amazing images, Classen, Joe.

11) Environmental Biology, P.D. Sharma, Rastogi Publications 1996.

12) Environmental, Chemical & Biological Analysis, H.V. Jadhav & S.N. Jogdand, Himalaya Publishing House.

13) Environmental Impact Assessment Methodologies, Anjaneyulu Y., B.S Publication, Hyderabad. 2002.

14) Environmental Management, Khitolia, Chand Publications.

15) Environmental Management. Environmental Engineering Series; Vijay Kulkarni &T. V. Ramchandra, Publ. Commonwealth of Learning, Indian Institute of Science(IISC), Bangalore. 2011.

16) Environmental Pollution & Health Hazards in India, R. Kumar, Abhish Publ. House, New Delhi 1987. 17) Environmental Pollution & Management, Pramod Singh, Chugh Publ. Allahabad 1985.

18) Environmental Science Ahluwalia V.K. & Malhotra Sunita:. Ane Books India 2006. 19) Environmental Science, J. Turk, A. Turk & K. Arms, Saunders College Publishing 1983.

20) Environmental Science, S.C. Santra, New Central Book Agency (P) Ltd. 2001.

21) Environmental Science – Earth as living Planet, Daniel Botkin & Edward Kellere, J. Wiley & Sons 1995.

22) Environmental Studies, Sharma Narendra, Prashant Publications.

23) Environmental Studies: From crisis to cure, Rajagopalan R., Oxford Higher Education.

24) Fundamentals of Ecology, E. P. Odum, W.B. Saunders Company.

25) Global Environmental Issues – A Climatological Approach, David D. Kemp, Roult Ledge & Company, London & N. Y. 1990.

26) Indicator of Environmental Quality, Williams A. Thomas, Plenum Press, N.Y. & London 1971.

27) Industrial Hygiene & Chemical Safety, Fulekar .M.H., I. K. International Pvt Ltd, 2006.

28) Introduction to Climatology for the Tropics, J.O. Ayoade, J. Wiley & Sons 1983.

29) Management of Municipal solid waste; Environmental Engineering Series, T. V. Ramchandra, Publ.Common wealth of Learning, Indian Institute of Science (IISCBangalore.2011.

30) Pollution Control in Process Industries, S.P. Mahajan, TMH 1988.

31) Practical Methods in Ecology & Environmental Science,Trivedi, Goel &Trisal, Environmental Publications,Karad1987.

32) Text book of Environmental Chemistry & Pollution Control. Revised edition,Dara S.S. & Mishra D.D.,S. Chand Publications.

33) Waste Water Treatment for Pollution Control, Soli J. Arcivala, TMH 1986.

34) Water & Water Pollution Handbook, L.L. Caccio, Marcel Dekker Inc. N.Y. 1971.

35) https://www.un.org/en/climatechange/cop26

36) https://dst.gov.in/sites/default/files/NMSKCC_mission%20document%201.pdf

Evaluation Scheme

Internals:

Class test	Assignment/ Study tour with report/Journal Movie club presentation/ Presentation of mini-research project work/ volunteering for Department fest/ poster making/ exhibition/ Departmental contribution/ case study presentation/Review writing	Attendance, Active Participation and Leadership Qualities	Total
20	10	10	40

Internal Examination: **Based on Unit 1 / Unit 2 / Unit 3/ Unit 4**

Duration: 40 mins **Total Marks: 20**

No. of Questions: 15

Q. 1	**Answer the following choosing the correct alternative.**							**10**
	1	Based on Unit I / II / III/ IV						
	a		b		C		d	
	2	Based on Unit I / II / III/ IV						
	A		b		C		d	
	3	Based on Unit I / II / III/ IV						
	A		b		C		d	
	4	Based on Unit I / II / III/ IV						
	A		b		C		d	
	5	Based on Unit I / II / III/ IV						
	A		b		C		d	
	6	Based on Unit I / II / III/ IV						
	A		b		C		d	
	7	Based on Unit I / II / III/ IV						
	A		b		C		d	
	8	Based on Unit I / II / III/ IV						
	A		b		C		d	
	9	Based on Unit I / II / III/ IV						
	A		b		C		d	
	10	Based on Unit I / II / III/ IV						
	A		b		C		d	
Q.2	**Answer the following choosing the correct alternative.**							**10**
	1	Based on Unit I / II / III/ IV						
	A		b		C		d	

	2	Based on Unit I / II / III/ IV							
	A		b		C		d		
	3	Based on Unit I / II / III/ IV							
	A		b		C		d		
	4	Based on Unit I / II / III/ IV							
	A		b		C		d		
	5	Based on Unit I / II / III/ IV							
	A		b		C		D		

Theory Examination: Suggested Format of Question paper

Duration: 2 Hours Total Marks: 60

All questions are compulsory

Q. 1	Answer ***any two*** of the following		**12**
	A	Based on Unit I	
	B	Based on Unit I	
	C	Based on Unit I	
	D	Based on Unit I	
Q. 2	Answer ***any two*** of the following		**12**
	A	Based on Unit II	
	B	Based on Unit II	
	C	Based on Unit II	
	D	Based on Unit II	
Q. 3	Answer ***any two*** of the following		**12**
	A	Based on Unit III	
	B	Based on Unit III	
	C	Based on Unit III	
	D	Based on Unit III	

Q. 4	Answer ***any two*** of the following		**12**
	A	Based on Unit IV	
	B	Based on Unit IV	
	C	Based on Unit IV	
	D	Based on Unit IV	
Q. 5	Answer ***any six*** of the following		**12**
	a	Based on Unit I	
	b	Based on Unit I	
	c	Based on Unit I	
	d	Based on Unit II	
	e	Based on Unit II	
	f	Based on Unit II	
	g	Based on Unit III	
	h	Based on Unit III	
	i	Based on Unit III	
	j	Based on Unit IV	
	k	Based on Unit IV	
	l	Based on Unit IV	

For Applied component Refer to Environment Science Syllabus that would involve BNBUSMB5T5 theory and BNBUSMB5P3 practical for semester 5

And

BNBUSMB6T5 theory and BNBUSMB6P3 practical for semester 6

Marks Distribution and Passing Criterion for Each Semester

Theory					Practical		
Course Code	Internal	Min marks for passing	Theory Examination	Min marks for passing	Course Code	Practical Examination	Min marks for passing
BNBUSMB5T1	**40**	**16**	**60**	**24**	BNBUSMBT5P1	**100**	**40**
BNBUSMB5T2	**40**	**16**	**60**	**24**			
BNBUSMB5T3	**40**	**16**	**60**	**24**	BNBUSMB5P2	**100**	**40**
BNBUSMB5T4	**40**	**16**	**60**	**24**			
BNBUSMB5T5	**40**	**16**	**60**	**24**	BNBUSMB5P3	**100**	**40**

Theory					Practical		
Course Code	Internal	Min marks for passing	Theory Examination	Min marks for passing	Course Code	Practical Examination	Min marks for passing
BNBUSMB6T1	**40**	**16**	**60**	**24**	BNBUSMB6P1	**100**	**40**
BNBUSMB6T2	**40**	**16**	**60**	**24**			
BNBUSMB6T3	**40**	**16**	**60**	**24**	BNBUSMB6P2	**100**	**40**
BNBUSMB6T4	**40**	**16**	**60**	**24**			
BNBUSMB6T5	**40**	**16**	**60**	**24**	BNBUSMB6P3	**100**	**40**

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ANNEXURES

Annexure I: Suggested topics for assignment USACEVS5P1

(Teachers are expected to develop additional innovative topics, varying every year, to be assigned to the students).

1. List out the instruments or funding agencies or permits required for setting up an environment testing laboratory.

2. Survey of NGO's working in the environmental field in your area.

3. Preparation of proposal for green building and sustainable development.

4. Prepare a cost sheet for setting up a biodegradable plastic unit.

5. Make an inventory of the water bodies presently existing/which existed in the urban/rural area of about 5kms. 6. Find out information regarding pollution testing booths that the Government proposes to set up. (List out the personnel who will man the booths and the indigenous equipment that these booths will have).

7. Make a report on amenities, trees, dimensions of open spaces in your locality. Assess their role in maintaining the ecological balance in the region.

8. Survey housing societies/institutions/organizations to find out whether they are converting household/kitchen waste into anything utilizable like vermicomposting etc.

9. Meet entrepreneurs involved with manufacture of eco-friendly products/best out of waste etc. Make a report regarding how the entrepreneur decided to pursue such an initiative, its need, the process and benefits to the environment.

10.Calculate the carbon footprint of your family/class-room or laboratory/housing society by visiting the appropriate site on the internet.

11.Visit architectural /horticulturist firms that deal with vertical gardening /urban farming and prepare a first-hand report on the concept, where implemented and the advantages.

All topics mentioned above are suggestive, more creative and innovative topics are expected from the students, under the able guidance of the concerned teacher, to suit the expertise, human resources, infrastructure and local needs as also the interest of the students. The assignment may be submitted in a group not exceeding three students.

Annexure II: Suggested Field Visits USACEVS5P1 and USACEVS6P1

There shall be various short and long excursions / study tours / field visits / industrial visits in every semester, at least one of which shall be financially affordable to every student in the class; and that assessment and marks of field trips shall be solely based upon such where no student was restrained for financial limitations.

• Field visits are to be organized to facilitate students to have firsthand experience & exposure to technology/production/functioning of organization/units or witness a relevant activity.

• Each student must make at least 01 (one) such visit to the units/treatment plants/aquatic or terrestrial habitat organized by the College.

• The list is suggestive and not exhaustive.

1. Visit to the Sewage treatment plant.

2. Visit to the Vermicomposting unit.

3. Visit to the Air Monitoring Laboratory.

4. Visit to the Environment Pollution Detecting Laboratory.

5. Visit to Cooling towers in industries.

6. Visit to RainWater Harvesting System.

7. Visit to the Biogas Plant.

8. Visit to the Green Building/Ecotel Hotel.

9. Visit to the Water Filtration Plant.

10. Visit to the office of Pollution Control Board.

11. Visit to Greenhouse.

12. Visit to Solid Waste Management Plant.

13. Visit to hydro/thermal power plants.

14. Visit to Environmental Agencies-CITES

15. Visit to National Parks, Sanctuaries, Biosphere Reserves etc. in Maharashtra/India/abroad.

16. Visit to NEERI. 17. Visit to Enviro Vigil, CSM Hospital Campus, Kalwa (W), Thane.

17. Visit to Maharashtra Nature Park, Sion

Annexure III: Suggested Topics for Projects USACEVS6P1

(Teachers are expected to develop additional innovative topics, varying every year, to be assigned to the students).

1) Effects of anthropogenic activities on different ecosystems; for example, mangroves/ wetlands.

2) Effect of tourism activities on different ecosystems.

3) Assessment of ecotourism potential-SGNP, different sanctuaries.

4) Energy/water audit in your area.

5) Costing, accounting & budgeting of eco-friendly idols during festivals.

6) Costing, accounting & budgeting for paper making from waste.

7) Study the role of microbes in biodegradation of: plastic, pesticides, heavy metals, hydrocarbons, etc.

8) Preparation of feasibility Report of eco-friendly products.

9) Preparation of feasibility report of environment testing laboratory.

10) Preparation of feasibility report for manufacture of any domestic pollution control device.

The project may be submitted in a group not exceeding three students.