Resolution No.: AC/

Bharatiya Vidya Bhavan's

M. M. College of Arts, N.M. Institute of Science, H.R.J. College of Commerce

(Bhavan's College, Andheri West (Autonomous)

(Affiliated to University of Mumbai)

Revised Syllabus for T.Y.B.Sc.

Program: B.Sc.

Course: Microbiology (BHUSMB)

(Credit Based Semester and Grading System with effect from the academic year 2023 – 2024)

PREAMBLE

Choice Based Credit System (CBCS) was introduced by the University of Mumbai on recommendations of the University Grants Commission (UGC) from the academic year 2016-2017. Its main objective was to provide flexibility in designing curriculum and assigning credits based on the course contents and number of hours of teaching. The standing committee constituted by the UGC conferred Autonomous status to Bhavan's College, Andheri (affiliated to the University of Mumbai) for a period of 10 years with effect from the academic year 2019-20. In light of this, the F.Y.BSc. Curriculum was updated and has been implemented from the academic year 2021-22 and T.Y. BSc curriculum was updated and has been implemented from the academic year 2022-23. Subsequently, the process of restructuring the T.Y. BSc syllabus according to the CBCS pattern was initiated for its implementation from academic year 2023-24.

The T.Y. BSc degree course of Bachelor of Science (Choice Based Credit System) in Microbiology has been revised so as to cover fundamental and applied knowledge on the important fields of Microbiology viz - Immunology, Genetics, Biochemistry, Medical Microbiology and Industrial Microbiology. The students opting this course will get an enhanced theoretical and practical knowledge in the above fields. The course will empower the students with the necessary skill-set essential in a Microbiology Laboratory.

Thus, the board of studies for Microbiology has approved the T.Y. BSc syllabus for its implementation in 2023-24.

PROGRAM OUTCOMES

A student completing Bachelor's Degree in Science program will be able to:

1. Develop a strong understanding about the fundamental concepts and principles of the wide areas spanning the subject of Microbiology.
2. Demonstrate proficiency in basic and advanced laboratory techniques that are required at Industrial levels.
3. Improve critical thinking & observation skills through the robust practical sessions involving diverse applications of Microbes.
4. Work cohesively in teams and demonstrate appropriate interpretation skills and documentation capabilities.
5. Become knowledgeable citizens of the country who can make their successful careers in diverse fields of Microbiology and Applied Research thereby contributing to the progress and development of the Nation.

PROGRAM SPECIFIC OUTCOMES

A student completing T.Y.B. Sc Course in the Bachelor's Degree Program with the subject of Microbiology will be able to:

1. Understand the basic concepts and applications of diverse disciplines of Microbiology viz Microbial Genetics, Medical Microbiology, Immunology, and Microbial Biochemistry.
2. Become aware about the applied subjects of Microbiology like Food Microbiology, Industrial Microbiology and describe the role of microbes in Food industry and Industrial Fermentations.
3. Gain thoughtful knowledge and expertise in handling pathogenic and non-pathogenic microorganisms in the laboratory and also exploring their characteristics.
4. Appreciate and understand the allied concepts of Bioinformatics, IPR, Tissue Culture and recombinant DNA technology.

COURSE OUTLINE

SEMESTER V

Course Code	Title	Credits	Lectures /Semester
BHUSMB501	Microbial Genetics & Virology [T]	2.5	60L
BHUSMB501P	Microbial Genetics & Virology [P]	1.5	60L
BHUSMB502	Medical Microbiology & Immunology – I [T]	2.5	60L
BHUSMB502P	Medical Microbiology & Immunology – I [P]	1.5	60L
BHUSMB503	Microbial Biochemistry – I [T]	2.5	60L
BHUSMB503P	Microbial Biochemistry – I [P]	1.5	60L
BHUSMB504	Bioprocess Technology – I [T]	2.5	60L
BHUSMB504P	Bioprocess Technology – I [P]	1.5	60L
Total		**16 Credits**	**480 L**

SEMESTER VI

Course Code	Title	Credits	Lectures /Semester
BHUSMB601	Microbial Genetics, rDNA Technology & Bioinformatics [T]	2.5	60L
BHUSMB601P	Microbial Genetics, rDNA Technology & Bioinformatics [P]	1.5	60L
BHUSMB602	Medical Microbiology & Immunology – II [T]	2.5	60L
BHUSMB602P	Medical Microbiology & Immunology – II [P]	1.5	60L
BHUSMB603	Microbial Biochemistry – II [T]	2.5	60L
BHUSMB603P	Microbial Biochemistry – II [P]	1.5	60L
BHUSMB604	Bioprocess Technology – II [T]	2.5	60L
BHUSMB604P	Bioprocess Technology – II [P]	1.5	60L
Total		**16 Credits**	**480 L**

T.Y. B.Sc. – MICROBIOLOGY [THEORY]
(SEMESTER V)

Course Code	Title	Credits & Lectures/Semester
BHUSMB501	**MICROBIAL GENETICS AND VIROLOGY**	**2.5 Credits [60 Lectures]**
Unit I	DNA Replication	**15L**
Unit II	Transcription, Genetic Code & Translation	**15L**
Unit III	Mutation and Repair	**15L**
Unit IV	Virology	**15L**
BHUSMB502	**MEDICAL MICROBIOLOGY AND IMMUNOLOGY - PART I**	**2.5 Credits [60 Lectures]**
Unit I	Antimicrobial chemotherapy	**15L**
Unit II	Diagnostic Microbiology	**15L**
Unit III	General Immunology I	**15L**
Unit IV	General Immunology II	**15L**
BHUSMB503	**MICROBIAL BIOCHEMISTRY – PART I**	**2.5 Credits [60 Lectures]**
Unit I	Biological membranes and transport	**15L**
Unit II	Bioenergetics -Oxidative phosphorylation	**15L**
Unit III	Bioenergetics-Photophosphorylation & Chemolithorophy	**15L**
Unit IV	Analysis of Metabolism & Catabolism of Carbohydrates	**15L**
BHUSMB504	**BIOPROCESS TECHNOLOGY – PART I**	**2.5 Credits [60 Lectures]**
Unit I	Upstream Processing - I	**15L**
Unit II	Upstream Processing - II	**15L**
Unit III	Fermentation equipment & instrumentation control, Instrumentation	**15L**
Unit IV	Traditional Industrial Fermentations	**15L**

LEARNING OBJECTIVES - MICROBIAL GENETICS [BH. USMB501]

Microbial Genetics (USMB-501) is a course in Genetics for T.Y.B.Sc. undergraduate students in Semester V that deals with various concepts of Genetics.
The learning objectives include the following:
DNA Replication: The learner will understand the events occurring in both Prokaryotic and Eukaryotic DNA replication, with a focus on the involvement of Proteins and Enzymes at the cellular level. The topic will also include the assembly of Eukaryotic chromosome.

Transcription, Genetic Code and Translation: This module aims at the learner understanding the basis of gene expression and the Central Dogma and the molecular basis of protein synthesis in Prokaryotes and Eukaryotes. The module deals with the structure and properties of different forms of RNA, maturation of RNA and RNA splicing.

Mutation and DNA repair: The molecular basis and types of mutation, their cause, effect and DNA repair is studied. The basic concepts related to molecular biology are explained.
Virology: This module deals with basic structure and life cycle of different viruses and cultivation of viruses. It also comprises of various methods used for visualization and enumeration of virus particles and also the role of viruses in causing cancer.

LEARNING OUTCOMES:

DNA Replication: The learner will understand the sequence of events, mechanism, enzymes and proteins involved in replication of DNA in prokaryotes and eukaryotes.

Transcription, Genetic Code and Translation: The student will know the central dogma of biology its two-step transcription and translation, maturation of RNA.

Mutation and DNA repair: The learner will know the concept of mutation, its types, causes and their effects. This module will also make them understand types of mutagens, damage to DNA due to mutagenesis, various mechanisms of DNA repair.
Virology: The learner will understand the basic structure and life cycle of different viruses and their cultivation. The student will get basic knowledge on Prions, Viroid and viruses causing cancer.

MICROBIAL GENETICS [BH. USMB501] - DETAILED SYLLABUS

Course Code	Unit	Sub unit	Title	No of lectures	Credit
BHUSMB501			**MICROBIAL GENETICS**	**60**	**2.5**
	I		**DNA REPLICATION**	**15**	
		1.1	**Introduction**	**1L**	
		1.2	**Modes of DNA Replication -** Conservative, dispersive, semi-conservative, bidirectional and semi-discontinuous	**2L**	
		1.3	**Models of DNA Replication:** - Theta model of replication & Rolling circle mode of DNA replication	**2L**	
		1.4	**Prokaryotic DNA replication -** Details of molecular mechanisms involved in Initiation, Elongation and Termination	**4L**	

		1.5	**Enzymes and proteins associated with DNA replication**- Primase, Helicase, Topoisomerase, SSB, DNA polymerases, Ligases, Ter and Tus proteins.	**2L**	
		1.6	**Eukaryotic DNA replication** - Molecular details of DNA synthesis, replicating the ends of the chromosomes assembling newly replicated DNA into nucleosomes**.**	**3L**	
	II		**TRANSCRIPTION, GENETIC CODE & TRANSLATION**	**15L**	
		2.1	**Central Dogma: An Overview, Transcription process**	**1L**	
		2.2	**Transcription in bacteria** - Initiation of transcription at promoters, elongation of an RNA chain, termination of an RNA chain	2L	
		2.3	**Transcription in Eukaryotes -** Eukaryotic RNA polymerase, Transcription of protein- coding genes by RNA polymerase II, Transcription initiation, the structure and production of Eukaryotic mRNAs, Production of mature mRNA in Eukaryotes, Processing of Pre-mRNA to mature mRNA. Self-Splicing of Introns, RNA editing	3L	
		2.4	**Genetic code** - Nature of genetic code and characteristics of genetic code.	2L	
		2.5	**Translation process** - Transfer RNA, structure of tRNA, tRNA genes, Recognition of the tRNA anticodon by the mRNA codon, Adding of amino acid to tRNA, Ribosomal RNA and Ribosomes, Ribosomal RNA Genes, Initiation of translation, Initiation in Bacteria, Initiation in eukaryotes, Elongation of the polypeptide chain, termination of translation, protein sorting in the cell	7L	
	III		**MUTATION AND REPAIR**		
		3.1	**Mutation** **Terminology:** alleles, homozygous, heterozygous, genotype, phenotype, Somatic mutation, Germline mutation, Gene mutation, Chromosome mutation, phenotypic lag, hotspots and mutator genes.	2L	
		3.2	**Types of mutations:** Point mutation, reverse mutation, suppressor mutation, frame shift mutation, conditional lethal mutation, base pair substitution, transition, transversion, missense mutation, nonsense mutation, silent mutation, neutral mutation, pleiotropic mutations.	2L	
		3.3	**Causes of mutation:** Natural/spontaneous mutation-- replication error, depurination, deamination. Induced mutation: principle and mechanism with illustrative diagrams for:	2L	
		3.4	a. Chemical mutagens - base analogues, nitrous acid, hydroxyl amine, intercalating agents and alkylating agents. b. Physical mutagens c. Biological mutagens (only examples)	3L	

		3.5	a. Fluctuation test. b. Ames test c. Detection of mutants	3L	
		3.6	**DNA Repair** a. Light repair: - Photoreactivation b. Dark Repair: - Nucleotide excision repair c. List other repair mechanisms.	3L	
	IV		**VIROLOGY**		
		4.1	**Structure of TMV, Influenza virus and HIV**	2L	
		4.2	**Life cycle of TMV, Influenza Virus and HIV.**	3L	
		4.3	**Cultivation of viruses-** Cell culture techniques & Embryonated egg	2L	
		4.4	**Visualization and enumeration of virus particles** Measurement of infectious units :- a. One step growth curve of bacteriophages b. Endpoint dilution assay c. Fluorescent focus assay [principle] d. Infectious center assay [principle] e. Transformation assay [principle]	3L	
		4.5	**Measurement of virus particles and their components** a. Electron microscopy [principle] b. Atomic force microscopy [principle] c. Haemagglutination assay. d. Measurement of viral enzyme activity	2L	
		4.6	**Role of viruses in cancer** a. Important Definitions, Characteristics of cancer cell b. Human DNA tumor viruses: - EBV, Kaposi sarcoma virus, Papilloma virus	3L	

Course Code: BHUSMBP05
[Practicals Based on BH. USMB501, Credits -1.5, Lectures- 60, Notional Periods-15]

1. UV survival curve – determination of exposure time leading to 90% reduction, Light repair & dark repair effect.
2. Isolation of antibiotic resistant mutants using UV mutagenesis
3. Gradient plate technique (dye resistant mutant)
4. Replica plate technique for selection & characterization of mutants – auxotroph & antibiotic resistant
5. One step growth curve of coliphage
6. Haemagglutination assay (Demo)

TEXTBOOKS AND REFERENCE BOOKS

1. Peter J. Russell (2006), "I Genetics-A molecular approach", 2nd edition.
2. Fairbanks and Anderson, (1999), "Genetics", Wadsworth Publishing Company.
3. Prescott, Harley and Klein, "Microbiology", 7th edition Mc Graw Hill international edition.
4. Robert Weaver, "Molecular biology", 3rd edition. Mc Graw Hill international edition.

5. Nancy Trun and Janine Trempy, (2004), "Fundamental bacterial genetics", Blackwell Publishing
6. Snustad, Simmons, "Principles of genetics", 3rd edition. John Wiley & sons, Inc.
7. Edward Wagner and Martinez Hewlett, (2005) "Basic Virology", 2nd edition, Blackwell Publishing
8. Teri Shors,.(2009), "Understanding viruses", Jones and Bartlett publishers.
9. Flint, Enquist, Racanillo and Skalka, "Principles of virology", 2nd edition. ASM press.
10. M. Madigan, J. Martinko, J. Parkar, (2009), "Brock Biology of microorganisms", 12th edition, Pearson Education International.

[BH. USMB502] -MEDICAL MICROBIOLOGY & IMMUNOLOGY – PART- I

LEARNING OBJECTIVES

The course in medical microbiology & Immunology has been designed to help students to build on the basic information regarding the host pathogen interactions and defense mechanisms that they have gained in S.Y.B.Sc. This course begins with a unit entirely based on chemotherapy that discusses various antimicrobial drugs and basic & advanced laboratory testing methods. It also covers various mechanisms used by pathogens in generation of multiple resistance strains. When dealing with infectious diseases, it is imperative for the students to learn about the logical thought process behind the diagnosis of various infections in the laboratory. With the world changing rapidly, newer and much advanced diagnostic techniques are slowly taking precedence. Taking cognizance of this, the second unit is designed which covers the preliminary [basic] and advanced diagnostic techniques. Immunology is an integral part of Medical Microbiology and this course is designed for T.Y.B.Sc. Microbiology students, on the assumption that the students have achieved a basic understanding of Innate Immunity and Host Defence Mechanisms in their lower classes. The two units of Immunology cover the basics of antigen, antibody, immunological reactions [applications] in addition to the concept of cytokines and the role of immunohematology in blood transfusion.

LEARNING OUTCOMES

After completing this course, the student should be able to

1. Understand the characteristics and mode of action of various antibiotics
2. Explain the concept and mechanisms used by pathogens to develop resistance to antibiotics.
3. Gather the basic understanding on the preliminary identification methods to diagnose an infectious disease in the laboratory.
4. Understand the principle and applications of various automated and molecular diagnostic techniques
5. Understand and explain the basic concepts of antigen, structure and function of antibody & their applications [antigen antibody reactions]
6. Explain the names and role/functions various signalling molecules and their receptors
7. Gather the basic understanding on the important concepts in Immunohematology and its applications

DETAILED SYLLABUS

Course Code	Unit	Sub unit	Title	No of lectures	Credit
BHUSMB 502			**MEDICAL MICROBIOLOGY & IMMUNOLOGY – PART I**	**60**	**2.5**
	I		**ANTIMICROBIAL CHEMOTHERAPY**	15	
		1.1	**Antimicrobial Compounds – Safety Net of Modern Medicine** a. Importance of antimicrobial compounds b. Killing v/s inhibiting growth	1L	
		1.2	**Antibiotics** a. Characteristics of antibiotics b. Process of antibiotic discovery c. Economics of antibiotic discovery	2L	
		1.3	**Mechanism of Antibiotic action** a. Targets of Antibiotic action b. Cell wall synthesis inhibitors c. Protein synthesis inhibitors d. Quinolones – inhibitors of DNA replication e. Rifampin – an Inhibitor of RNA synthesis f. Trimethoprim and Sulfonamides g. Metronidazole h. Newer antibiotics	7L	
		1.4	**Emerging Antibiotic resistance** a. Mechanisms of antibiotic resistance – Overview b. Types of resistance – intrinsic and acquired c. Limiting access of the antibiotic d. Enzymatic inactivation of the antibiotic e. Active efflux of antibiotic f. Modification of the antibiotic target g. Antibiotic tolerance	5L	
	II		**DIAGNOSTIC MICROBIOLOGY**	**15**	
			Preliminary Identification methods a) Sample collection requirements for specific sites – Respiratory tract, GI tract, Urine, Blood, CSF, Wound abscess b) Sample collection and processing c) Initial sample plating and identification – microscopic examination, selection and inoculation in primary media d) Preliminary biochemical tests – carbohydrate utilization, catalase, oxidase, coagulase, spot indole, PYR hydrolysis	5L	
			Automation, Immunodiagnostics & Molecular methods a. Multi test systems b. Automated identification systems [Principles and application]	7L	

			c. Immunserological techniques [Principles and applications] d. Molecular techniques • Production of nucleic acid probes • Detection of hybridization with labels and reporter molecules • Preparation of target nucleic acid • Hybridization of target and probe • Detection of hybridization & reaction fragments e. Amplification methods • Amplification of nucleic acid, target amplification • Application of PCR • RFLP – significance only • Nucleic acid sequencing – significance only		
			Antimicrobial susceptibility testing a) Disc diffusion method – Stoke's method & Kirby Bauer method b) Quantitative dilution susceptibility testing c) Agar dilution susceptibility testing d) Microbroth dilution test e) Serum bactericidal test f) Ditch plate test	3L	
	III		**GENERAL IMMUNOLOGY I**	15	
		3.1	**Overview of the Immune System** a. Historical perspective of Immunology b. Basic concepts of mammalian immune response c. Immune dysfunction and its consequences	3L	
		3.2	**Hematopoiesis** a. Basic Concept of stem cell, progenitor cell and lineages b. Regulation at genetic level c. Hematopoietic homeostasis and role of apoptosis	3L	
		3.3	**Antigens** 1. Types of antigens – heterophile, isophile, sequestered and superantigens 2. Epitopes a. General Concept b. Properties of B cell epitopes c. Properties of T cell epitopes	4L	
		3.4	**Immunoglobulins** a. Fine structure of antibody – concept of domains, heavy chains, light chains, CDRs, hypervariable regions b. Five major classes of antibody heavy chains c. Two major classes of antibody light chains d. Specific functions of domains of antibody heavy and light chain e. Effector functions of IgM, IgG, IgA, IgE isotypes	5L	
	IV		**GENERAL IMMUNOLOGY II**	**15**	

		4.1	**Cytokines and chemokines** a. General properties of cytokines and chemokines b. Six families of cytokines and their receptors • Cytokines of IL-1 family & its receptors • Cytokines of hematopoietin class I family & its receptors • Interferons cytokine family and its receptors • Cytokines of TNF family and its receptors • Cytokines of IL-17 family and its receptors • Chemokines – structure and receptors	3L	
		4.2	**Immunological techniques – Principle & applications** a. Concepts of immunogen, antigen, affinity, avidity, cross reactivity b. Agglutination reactions c. Precipitation reactions – Mancini's & Ouchterlony method d. Radioimmunoassay e. ELISA – indirect and sandwich f. Western blotting g. Immunoelectron microscopy Alternatives to antigen antibody reactions	5L	
		4.3	**Immunohematology** a. Concept of whole blood unit, anticoagulants, additive solutions, blood collection sets, components of blood, washing and storage of RBCs b. ABO blood group system – Inheritance, Antigen development, Antibodies of ABO system, Secretor status, subgroups of A and B c. Testing methods - Forward typing, microplate & gel testing, reverse typing, molecular testing d. Rh blood group system – Genes, Nomenclature, D antigen & clinical significance of weak D and partial D antigen e. Hemolytic disease of the fetus & newborn – maternal alloimmunization, pathophysiology, assessing risk for HDN, cord blood testing, serologic testing, prevention of HDN	7L	

Course Code: BHUSMBP05
[Practicals Based on BH. USMB502, Credits -1.5, Lectures- 60, Notional Periods-15]

1. Immunodiffusion by Mancini and Ouchterlony's method
2. Study of human blood groups and their grouping by Direct & Reverse typing
3. Determination of Isoagglutinin titer
4. Blood compatibility test.
5. Coomb's Direct test
6. Antibiotic sensitivity testing by Stoke's method & Kirby Bauer method
7. Determination of MIC and MBC of antibiotic.
8. Determination of antibacterial spectrum by Ditch plate technique

TEXTBOOKS AND REFERENCE BOOKS

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2. Ananthanarayan and Panicker's, Textbook of Microbiology, 8th edition
3. Ananthanarayan and Panicker's, Textbook of Microbiology, 10th edition
4. Owen Judith, J. Punt, S. Stranford, Kuby Immunology, 7th Edition, W.H. Freeman and Company, New York, 2013
5. Pathak & Palan, Immunology: Essential & Fundamental, 1st& 3rd edition, Capital Publishing Company
6. Quinley E, Immunohematology – Principles and Practice, 3rd Edition, Lippincott Williams & Wilkins, 2011
7. Fahim Khan, Elements of Immunology, Pearson Education, 2009
8. Maria Delost, Introduction to Diagnostic Microbiology for Laboratory Sciences, 2015, Jones & Bartlett Learning Publications
9. Abigail Slayers and Dixie Whitt, Bacterial Pathogenesis, A Molecular Approach, 2002, 2nd Edition, ASM Press

MICROBIAL BIOCHEMISTRY – PART I [BH. USMB503]

LEARNING OBJECTIVES

Biochemistry is the branch of science that explores the chemical processes that take place inside all living things, from bacteria to plants and animals. It is a laboratory-based science that brings together biology and chemistry, by using chemical knowledge and techniques to help understand and solve biological problems. Microbial physiology is best understood with knowledge of biochemistry. The course thus focuses on the need to study uptake, various intermediary metabolic processes and methods to study metabolism both invitro as well as invivo. The course is designed to expose students to carbohydrate metabolism as also understand the principles of energy generation by different physiological groups of organisms. The advanced area of bioenergetics unfolds the universal mechanisms of energy generation by using electron transport systems and gaining knowledge of energy conservation. The student is also learning alternative pathways like HMP, ED, TCA cycle.

LEARNING OUTCOMES: The students should be able to

1. Understand the architecture of the membrane and how solute is transported inside the cell.
2. Describe and explain the electron transport chains in prokaryotes and mitochondria and understand the mechanism of ATP synthesis.
3. Discuss the experimental aspect of studying catabolism and anabolism and the various pathways for the breakdown of carbohydrates along with reactions in amphibolic pathways.
4. Describe the photosynthetic apparatus, photochemical centers, ETC and mechanism of ATP synthesis.
5. Understand the origin and dual mechanism in cyanobacteria
6. Describe various other pathways which produce different end products.
7. Describe alternate pathways & reactions in carbohydrate synthesis.

DETAILED SYLLABUS

Course Code	Unit	Sub unit	Title	No of lectures	Credit
BHUSMB 503			**MICROBIAL BIOCHEMISTRY – PART I**	**60**	**2.5**
	I		**BIOLOGICAL MEMBRANES AND TRANSPORT**	**15**	
		1.1	**Composition and architecture of membrane** 1.1.1 Lipid bilayer is stable in water 1.1.2 Bilayer Architecture & function of membranes 1.1.3 Membrane proteins are receptors, transporters & enzymes 1.1.4 Major types of Membrane proteins 1.1.5 Porins 1.1.6 Aquaporins and passage of water 1.1.7 Mechanosensitive channels 1.1.8 Crypticity	**3L**	
		1.2	**Methods of studying solute transport** a. Use of whole cells b. Liposomes **c.** Proteoliposomes	**2L**	
		1.3	**Solute transport across membrane** a. Passive transport and facilitated diffusion, Ion channels b. Active transport – PMF energizes active transport c. Co-transport across the membrane (uniport, symport, antiport) d. Ion gradient provides energy for secondary active transport : Lactose transport in *E.coli* , Glucose transport in epithelial cells e. P-type ATPase and transport (only Na-K ATPase)	**5L**	
		1.4	Shock sensitive systems-role of binding proteins, ABC transporters, Histidine uptake	**2L**	
		1.5	Phosphotransferase system, Schematic representation of various membrane transport systems in bacteria	**1L**	
		1.6	**Other Examples of solute transport** a. Iron transport – A special problem b. Protein export c. Bacterial membrane fusion central to many biological processes Study: defective ion channel in cystic fibrosis	**2L**	
	II		**BIOENERGETICS - OXIDATIVE PHOSPHORYLATION**		
		2.1	Mechanisms of metabolism (Concept, examples): Respiration (aerobic & anaerobic), fermentation, Chemolithotrophy, phototrophy	**3L**	

		2.2	Biochemical mechanisms of generating ATP: a. Substrate level Phosphorylation b. Electron transport mediated: Oxidative Phosphorylation & Photophosphorylation c. Mitochondria – Role in cellular respiration and Structure		
		2.3	**Electron transport chain** a. Oxidation-Reduction reactions, electron donors & acceptors, Reduction potential, redox couples, electron tower b. NAD+ as a redox carrier c. Carriers in E.T.C. Hydrogen carriers – Flavoproteins, Quinones Electron carriers – Iron Sulphur proteins, Cytochromes 1. Complexes in respiratory chains(mitochondrial) 2. Association of complexes in Respirasomes 3. Production of reactive oxygen species during OP 4. Conservation of energy of electron transfer in a proton gradient d. Proton-motive force: Chemiosmosis, ATP synthase (Structure), Rotational catalysis, Respiratory Inhibitors, uncouplers of OP, ionophores of OP, ATP yield & P:O ratio, Coupling sites, Roles of electron transport energy.	**7L**	
		2.4	**Prokaryotic ETC** Difference between bacterial & mitochondrial respiration Oxidases and reductases – types and significance Pattern of electron flow in *E. coli* - anaerobic and aerobic Anaerobic respiration – concept and examples Electron flow in *Azotobacter vinelandii* – significance	3L	
		2.5	**Other modes of generating electrochemical energy: Concept, mechanism and significance** a. ATP hydrolysis b. Oxalate- formate exchange c. Bacteriorhodopsin	2L	
		2.6	Bioluminescence: Bypass of respiratory electron flow		
		Self Study: Hot, stinking plants & alternative Respiratory pathways.			
	III		**BIOENERGETICS - PHOTOPHOSPHORYLATION & CHEMOLITHOROPHY**	**15**	
		4.1	Introduction to photosynthesis	1L	
		4.2	Phototrophic bacteria: Oxygenic & anoxygenic	2L	
		4.3	Cyanobacteria & chloroplast	2L	
		4.4	Photosynthetic apparatus, photochemical centers & pigments	2L	

		4.5	Photosynthetic ETC- Procaryotes, Cyanobacteria & Chloroplast	3L	
		4.6	Mechanism of ATP synthesis, mechanism of energy transfer.	2L	
		4.7	Evolutionary origin of dual mechanism in cyanobacteria	1L	
		4.8	Inorganic metabolism & energetics of chemolithotroph Physiological Groups of chemolithotrophs, inorganic electron donors & energetics	2L	
	IV		**ANALYSIS OF METABOLISM & CATABOLISM OF CARBOHYDRATES**	15 L	
			Metabolic concepts: Central metabolic pathways, Secondary metabolic pathways, amphibolic pathways		
		3.1	**Experimental Approaches to study metabolism** a. Metabolic inhibitors b. Growth studies c. Biochemical mutants d. Isotopes in biochemical studies, omics (Definition & example)	3L	
		3.2	**Catabolism of Carbohydrates** a. Glycolysis & overview of glycolysis (Structure & enzymes) b. Feeder pathways for Glycolysis c. Breakdown of polysaccharides – glycogen, starch, cellulose d. Breakdown of oligosaccharides – lactose, maltose, sucrose, cellobiose e. Utilization of monosaccharides – fructose, galactose **Alternative pathways (with structure & enzymes)** f. HMP pathway and ED pathway g. TCA cycle – action of PDH, pathway, incomplete TCA, Anaplerotic reactions, Amphibolic role of TCA, fate of pyruvate (fermentations- Schematic), Glyoxylate bypass	4L 7L	
		3.3	Study of glycolysis in tumors – targets for chemotherapy & diagnostics	1L	
			Study of Glucose catabolism at limiting concentration of oxygen		

Course Code: BHUSMBP06
[Practicals Based on BH. USMB503, Credits -1.5, Lectures- 60, Notional Periods-15]

1. Isolation and detection of chloroplast [Hill reaction]
2. Study of oxidative and fermentative metabolism
3. Qualitative and Quantitative assay of Phosphatase
4. Isolation and detection of Mitochondria
5. Glucose detection by GOD/POD .
6. Galactose transport by yeast

TEXTBOOKS AND REFERENCE BOOKS

Text books:

1. Madigan M.T., Martinko JM., Parker J. 2003. Brock Biology of Microorganisms-International Edition. Pearson Education, Inc-NJ.
2. Jain JL., Jain S., Jain N. 2005. Fundamentals of Biochemistry. S.Chand & Company Ltd.
3. Nelson DL, Cox MM., Hoskins AA. 2021 Lehninger Principles of Biochemistry 8th ed., Macmillan international. W.H. Freeman & Company
4. Stanier, R. Y., M. Doudoroff and E. A. Adelberg. General Microbiology, 5th edition,The Macmillan press Ltd
5. Conn, E.E., P. K. Stumpf, G. Bruening and R. Y. Doi. 1987. Outlines of Biochemistry,5th edition. John Wiley &Sons. New York.
6. Voet Donald, Voet Judith G. 2021 (Adapted edition). Voet's Biochemistry. John Wiley & Sons.
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8. Rose, A.H. (1976) Chemical Microbiology, 3rd edition. Butterworth-Heinemann
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Reference books:

1. Zubay, G. L (1996), Principles of Biochemistry, Wm. C. Brown publishers
2. Cohen, G.N. (2011). Microbial Biochemistry. 2nd edition, Springer.
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4. Mathews, C.K., K.E. van Holde, D.R. Appling, S, J, Anthony-Cahill (2012)Biochemistry, 4th edition. Pearson.
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BIOPROCESS TECHNOLOGY – PART I [BH. USMB504]

LEARNING OBJECTIVES

Bioprocess Technology I course is designed to expose the student to different aspects if Industrial microbiology such as strain improvement, basic fermentation equipment & its sterilization aspects, Instruments associated with fermentation process etc. It gives an in depth focus of the different types of fermenters used in industry for production of different products, and also emphasizes its process parameters. It includes the principles and describes the main steps and processes in the industrial production of beverages and enzymes.

Industrial microbiology becomes an important application-based paper covering various microbial fermentations. Thus, it becomes a laboratory to market scenario where the entire products reach. The learner is provided with the details of productions of important traditional fermentation products like alcohol, vinegar, baker's yeast and enzymes.

Thus, this paper readies the learner to understand and apply the knowledge of fermentation technology and related products. The revised course of this paper also consists of basic

concepts behind biofertilizers, role of microbes as biocontrol agents, concepts of biopesticides and bioherbicides.
This course aims to enable graduates to enter industry with an appropriate level of understanding of the need for both the science and business aspects to be achievable to make a viable product and enhance their entrepreneur skills.

LEARNING OUTCOMES: The students should be able to

- Describe the applications of microbes and its strain improvement in Industrial Microbiology.
- Apply kinetic formula to determine growth and productivity parameters of batch continuous, fed batch and solid substrate fermentations
- Understand the process of inoculum development for various fermentation processes
- Explain various ingredients of fermentation media and also the concept of sterilization, Del factor
- Describe the design of bioreactors for different applications and its process control parameters & principle and working of some advanced instruments frequently used in fermentation studies
- Design media, growth conditions and techniques for producing and recovering different types of products of commercial value.
- Understand the importance of microbes as industrial inoculants, microbes as biocontrol agents, microbes as biopesticides.
- Learner will be well –versed with the containment and levels of containment

DETAILED SYLLABUS

Course Code	Unit	Sub unit	Title	No of lectures	Credit
BHUSMB 504			**BIOPROCESS TECHNOLOGY – PART I**	**60**	**2.5**
	I		**UPSTREAM PROCESSING – I**	**15**	
		1.1	**Strain improvement** a. The improvement of industrial microorganisms b. The selection of induced mutants synthesizing improved levels of primary metabolites c. The isolation of induced mutants producing improved yields of secondary metabolites. d. The improvement of strains by modifying properties other than the yield of product e. High throughput screening methods	**9L**	
		1.2	**The development of inocula for industrial fermentations** a. Introduction b. Criteria for ideal inoculum c. Inoculum preparation procedure :- d. Development of inocula for unicellular bacterial process e. Development of inocula for yeast process. f. Development of inocula for mycelial process	**6L**	

	II		**UPSTREAM PROCESSING – II**	**15**	
		2.1	**Fermentation media formulation and raw materials** a. Criteria for ideal fermentation media b. Media formulation :- only criteria c. Raw materials for fermentation media	**7L**	
		2.2	a. **Sterilization and achievement of aseptic conditions** b. Introduction c. Achievement of aseptic conditions d. Aseptic operation & Containment e. Medium sterilization (concept of Nabla factor) f. Methods of batch sterilization g. The design of continuous sterilization process h. Sterilization of the Fermenter i. Sterilization of the Feeds j. Sterilization of the liquid wastes **Filter Sterilization :-** 1. Filter sterilization of fermentation media, 2. Filter sterilization of air 3. Filter sterilization of fermenter exhaust air	**8L**	
	III		**FERMENTATION EQUIPMENT'S, INSTRUMENTS & INSTRUMENTATION**	**15**	
		3.1	**Design of fermenter** a. Basic functions b. Body construction c. Agitator (impeller) – function, types, d. Baffles e. The aeration system (sparger) - function and types f. Valves (Examples of all valves) g. Steam traps [function only] h. Examples of fermenters - Stirred Tank Reactor, Air Lift, Tower fermenter, Deep Jet, Photobioreactor	**8L**	
		3.2	**Instrumentation and control** a. Introduction to sensors and its types b. Measurement and control of: - pH, temperature, pressure, foam sensing, dissolved oxygen, inlet and exit gas analysis	**4L**	
		3.3	**Instrumentation: Principles, working and application of** a. Spectrophotometry: UV, Visible & IR b. AAS & AES (Flame photometry)	**3L**	
	IV		**TRADITIONAL FERMENTATIONS**	**15**	
		4.1	**Alcohol from Molasses** Introduction, biosynthesis of ethanol production process - preparation of nutrient solution, fermentation, recovery by distillation	3L	
		4.2	**Vinegar (Apple cider):** a. Introduction, biosynthesis, b. Production using generator, c. Production using submerged fermenter, & recovery	3L	

		4.3	**Baker's yeast:** a. Outline of production, yeast strains and their properties, b. factors important in production-oxygen requirement and aeration, concentration of sugar, pH, temperature, c. preparation of substrate, fermentation, harvesting of yeast cells, d. Production of compressed and active dry yeast.	3L	
		4.4	**Fungal amylase production:** a. Amylase- production from bacteria and fungi, b. Amylase and glucoamylase, concentration and purification.	2L	
		4.5	**Agricultural Microbial inoculants industrial aspects:** a. Bio fertilizer: - *Rhizobium, Azotobacter, Azospirillum, PSB, BGA, Azolla*. *b.* Biocontrol agents: *Pseudomonas fluorescens, Trichoderma* c. Biopesticides: - *Bacillus thuringenesis*, NPV d. Bioherbicides e. Inoculant formulations	4L	

Course Code: BHUSMBP06
[Practicals Based on BHUSMB504, Credits -1.5, Lectures- 60, Notional Periods-15]

1. Alcohol Fermentation
   a. Preparation and standardization of yeast inoculums for alcohol fermentation
   b. Laboratory Alcohol fermentation using jaggery medium, calculation of efficiency of fermentation.
   c. Determine the alcohol tolerance for yeast.
   d. Determine the sugar tolerance for yeast.

5. Chemical estimation of sugar by Cole's ferricyanide method

6. Chemical estimation of alcohol

7. Production of amylase- detection, shake flask or solid substrate cultivation and detection (Quantitative).

8. Isolation of bacterial biofertilizers :- *Rhizobium, Azotobacter , Azospirillum* and phosphate solubilising bacteria.

TEXTBOOKS AND REFERENCE BOOKS

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2. Stanbury P. F., Whitaker A. & Hall S. J., (1997), "Principles of Fermentation Technology", 2nd edition, Aditya Books Pvt. Ltd, New Delhi.
3. Stanbury P. F., Whitaker A. & Hall S. J 3rd edition (2017) "Principles of Fermentation Technology"
4. Peppler, H. J. and Perlman, D. (1979), "Microbial Technology''. Vol. 1 & 2, Academic Press
5. Wulf Crueger & Anneliese Crueger, (2017), Biotechnology – A textbook of Industrial Microbiology, 3rd Edition, Medtech Scientific International Pvt Ltd

6. Dr. P.K. Shivkumar, M.M. Joe. K. Sukesh (2010), An Introduction to Industrial Microbiology, 1st Edition, S. Chand & Company
7. H. A. Modi, (2009). ‘’Fermentation Technology’’ Vol. 1 & 2, Pointer Publications, India.
8. Okafor Nduka (2007) ‘’Modern Industrial Microbiology and Biotechnology’’, Science Publications Enfield, NH, USA.
9. Crueger W. and Crueger A. (2000) "Biotechnology -"A Textbook of Industrial Microbiology", 2nd edition, Panima Publishing Corporation, New Delhi.
10. Prescott and Dunn's ‘’Industrial Microbiology’’(1982) 4th edition, McMillan Publishers

T.Y.B.Sc – MICROBIOLOGY [THEORY]
(SEMESTER VI)

Course Code	Title	Credits & Lectures/ Semester
BH. USMB601	**Microbial Genetics, rDNA Technology & Bioinformatics**	**2.5 Credits [60 Lectures]**
Unit I	Extra chromosomal elements & Regulation of gene expression	**15L**
Unit II	Genetic Exchange & Homologous Recombination	**15L**
Unit III	Recombinant DNA Technology	**15L**
Unit IV	Applications Of rDNA Technology & Bioinformatics	**15L**
BH. USMB602	**MEDICAL MICROBIOLOGY AND IMMUNOLOGY - PART I**	**2.5 Credits [60 Lectures]**
Unit I	Pathogenesis of Emerging Infectious Diseases	**15L**
Unit II	Bacterial strategies for evading host defences & Vaccination	**15L**
Unit III	B cell Immunology	**15L**
Unit IV	T cell Immunology	**15L**
BH. USMB603	**MICROBIAL BIOCHEMISTRY – PART II**	**2.5 Credits [60 Lectures]**
Unit I	Carbon Anabolism	**15L**
Unit II	Metabolism of Lipids & aliphatic compounds	**15L**
Unit III	Metabolism of Nitrogenous compounds	**15L**
Unit IV	Metabolic Regulation	**15L**
BH. USMB604	**BIOPROCESS TECHNOLOGY – PART II**	**2.5 Credits [60 Lectures]**
Unit I	Post fermentation production techniques	**15L**
Unit II	Advances in Bioprocess Technology	**15L**
Unit III	Quality Assurance, Quality Control, IPR and Bioassay	**15L**
Unit IV	Industrial Fermentations	**15L**

MICROBIAL GENETICS AND VIROLOGY – PART I [BH. USMB601]

LEARNING OBJECTIVES

USMB 601 is a course for T.Y.B.Sc. In Semester VI Microbiology students which deal with the following:

1. **Extrachromosomal genetic elements & gene regulation:** This module deals with the basic concepts of plasmids and its characteristics. It also covers different types of plasmids and different methods for detection and isolation of plasmids. Additionally, this module will make the students understand the genetic basis of regulation and operon control through the involvement of regulatory proteins and regulation of lytic and lysogeny in lambda phage.
2. **Genetic Exchange & Homologous recombination -** The student shall study the various mechanisms of gene transfer in bacteria and genetic recombination.
3. **Recombinant DNA technology**: This module deals with the basic steps in gene cloning, vectors, model organisms, methods of transformation and screening and identification of recombinant cells.
4. **Application of rDNA technology and Bioinformatics:** This module will empower the student to understand the basic techniques in Recombinant DNA technology along with their applications. Bioinformatics is the basic tool in understanding Cells at the genomic and proteomic levels. Inclusion of Bioinformatics in this module will empower the learner with insilico analytical techniques.

LEARNING OUTCOMES

1. **Extrachromosomal genetic elements & gene regulation:** The student will be able to understand the basic concepts of plasmids, its characteristics & detection methods. The learner will also understand the genetic basis of regulation and operon control & mechanism of regulation of lytic and lysogeny in lambda phage.
2. **Genetic Exchange & Homologous recombination -** The student shall understand various mechanisms of gene transfer in bacteria i.e transformation, transduction & conjugation and various models in genetic recombination in bacteria.
3. **Recombinant DNA technology**: The learner will understand the basic steps in gene cloning, significance and use of vectors, role of model organisms in generics & methods of transformation and screening and identification of recombinant cells.
4. **Application of rDNA technology and Bioinformatics:** The student will be able to understand the basic techniques in Recombinant DNA technology along with their applications. Study of bioinformatics will help the student to understand the various insilico analytical techniques.

DETAILED SYLLABUS

Course Code	Unit	Sub unit	Title	No of lectures	Credit
BH.USMB 601			**MICROBIAL GENETICS, rDNA TECHNOLOGY & BIOINFORMATICS**	**60**	**2.5**
	I		**EXTRA CHROMOSOMAL ELEMENTS & REGULATION OF GENE EXPRESSION**	**15**	
		1.1	**Plasmids** a. Physical nature b. Plasmid incompatibility, copy number and Plasmid curing c. Cell to cell transfer of plasmids d. Classification of plasmids e. Host range plasmids f. Types of plasmids: - Resistance Plasmids, Plasmids encoding Toxins and other Virulence characteristics, Col factor, Degradative plasmids g. Isolation & Detection of plasmids.	**7L**	
		1.2	**Regulation of gene expression** a. Types regulation of gene expression b. Lac operon and problems on Lac operon c. Regulation of lytic and lysogenic pathway of lambda phage	**8L**	
	II		**GENETIC EXCHANGE & HOMOLOGOUS RECOMBINATION**	**15**	
		2.1	**Genetic analysis of bacteria**	1L	
		2.2	**Gene transfer mechanisms in bacteria** **Transformation** a. Introduction and History b. Types of transformation in prokaryotes--Natural transformation in *Streptococcus pneumoniae, Haemophilus influenzae,* and *Bacillus subtilis*. c. Artificial transformation d. Mapping of bacterial genes using transformation. e. Problems based on transformation.	3L	
		2.3	**Conjugation** a. Discovery of conjugation in bacteria b. Properties of F plasmid/Sex factor c. The conjugation machinery d. F+, F prime & Hfr strains, their formation and mechanism of conjugation e. F' factor, origin and behavior of F' strains, Sexduction. f. Mapping of bacterial genes using conjugation (Wolman and Jacob experiment). g. Problems based on conjugation	**5L**	
		2.4	**Transduction** a. Introduction and discovery	3L	

			b. Generalized transduction c. Use of Generalized transduction for mapping genes d. Specialized transduction e. Problems based on transduction		
		2.5	**Recombination in bacteria** 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	3L	
	III		**RECOMBINANT DNA TECHNOLOGY**	**15**	
		3.1	**Branches of genetics** a. Transmission genetics b. Molecular genetics c. Population genetics d. Quantitative genetics	**1L**	
		3.2	**Model organisms** a. Characteristics of a model organism b. Examples of model organisms used in study c. Examples of studies undertaken using prokaryotic and eukaryotic model organisms	**4L**	
		3.3	**Gene cloning** a. **Basic step of gene cloning** b. **Cutting and joining DNA molecules** - Restriction and modification systems, restriction endonucleases, DNA ligases -3 **Vectors** a. Plasmids as cloning vectors. plasmid vectors, pBR322 vector, Cloning genes into pBR322 b. Phage as cloning vectors, cloning genes into phage vector c. YAC d. Cosmids [examples] e. Shuttle vectors [examples] f. BAC [examples]	**10L**	
		3.4	**Methods of transformation**	**2L**	
	IV		**APPLICATIONS OF rDNA TECHNOLOGY & BIOINFORMATICS**	**15**	
		4.1	**PCR** a. Basic PCR and different types of PCR b. (Reverse transcriptase PCR, Real time quantitative PCR)	2L	
		4.2	**Basic Techniques** a. Southern, Northern and Western blotting. b. Autoradiography (explain the term)	3L	
		4.3	**Screening and selection methods for identification and isolation of recombinant cells**	2L	
		4.4	**Applications of recombinant DNA technology** a. Site specific mutagenesis of DNA,	3L	

			b. Uses of DNA polymorphism, c. STRS and VNTRS, d. DNA molecular testing for human genetic diseases (Only RFLP), DNA typing, gene therapy, e. Genetic engineering of plants and animals.		
		4.5	**Bioinformatics** a. Introduction b. Definition, aims, tasks and applications of Bioinformatics. c. Database, tools and their uses – d. Importance, Types and classification of databases e. Nucleic acid sequence databases- EMBL, DDBJ, GenBank, GSDB, Ensembl and specialized Genomic resources. f. Protein sequence databases-PIR, SWISS-PROT, TrEMBL NRL-3D. Protein structure databases-SCOP, CATH, PROSITE, PRINTS and BLOCKS. KEGG. g. Explain the terms: Transcriptome, Metabolomics, Pharmacogenomics, Phylogenetic analysis, Phylogenetic tree, Annotation, Genomics- structural, functional and comparative genomics, Proteomics - structural and functional proteomics, Sequence alignment - global v/s local alignment, FASTA, BLAST (Different types of BLAST)	5L	

Course Code: BHUSMBP07
[Practicals Based on BHUSMB601, Credits -1.5, Lectures- 60, Notional Periods-15]

1. Isolation of plasmid DNA & detection by electrophoresis & spectrophotometric.
2. Transformation of *E. coli*
3. Beta galactosidase assay
4. Restriction digestion of lambda phage /any plasmid DNA (Demo)
5. Bioinformatics Practicals

On Line Practical

1. Visiting NCBI and EMBL websites & list services available, software tools available and databases maintained
2. ii. Visiting & exploring various databases mentioned in syllabus and
    a. Using BLAST and FASTA for sequence analysis
    b. Fish out homologs for given specific sequences (by teacher – decide sequence of some relevance to their syllabus and related to some biological problem e.g. evolution of a specific protein in bacteria, predicting function of unknown protein from a new organism based on its homology)
    c. Six frame translation of given nucleotide sequence
    d. Restriction analysis of given nucleotide sequence
    e. Pair-wise alignment and multiple alignment of a given protein sequences
    f. Formation of phylogenetic tree

TEXTBOOKS AND REFERENCE BOOKS

1. Peter J. Russell (2006), "I Genetics-A molecular approach", 2nd edition.
2. Benjamin A. Pierce (2008), "Genetics a conceptual approach", 3rd edition, W. H. Freeman and company.
3. R. H. Tamarin, (2004), "Principles of genetics", Tata McGraw Hill.
4. M. Madigan, J. Martinko, J. Parkar, (2009), "Brock Biology of microorganisms", 12th edition, Pearson Education International.
5. Fairbanks and Anderson, (1999), "Genetics", Wadsworth Publishing Company.
6. S.Ignacimuthu, (2005), "Basic Bioinformatics", Narosa publishing house.
7. Robert Weaver, (2008), "Molecular biology", 3rd edition, Mc Graw Hill international edition.
8. Primrose and Twyman, (2001), "Principles of gene manipulation and genomics", 6th edition, Blackwell Publishing
9. Arthur Lesk, (2009), "Introduction to Bioinformatics", 3rd edition, Oxford University Press
10. Snustad, Simmons, "Principles of genetics", 3rd edition. John Wiley & sons, Inc.
11. A textbook of biotechnology R. C. Dubey 4 th edition. S. Chand.
12. David Freifelder, Microbial Genetics (1999), Narosa Publishing House
13. D. Nelson and M. Cox, (2005), "Lehninger's Principles of biochemistry", 4th edition, Macmillan worth Publishers.

Reference books:

1. T. K. Attwood & D. J. Parry-Smith, (2003), "Introduction to bioinformatics", Pearson education
2. Benjamin Lewin, (9th edition), "Genes IX", Jones and Bartlett publishers.
3. JD Watson, "Molecular biology of the gene", 5th edition.

MEDICAL MICROBIOLOGY & IMMUNOLOGY – PART II [BH. USMB602]

LEARNING OBJECTIVES

This course is designed to highlight various emerging infectious diseases and the mechanisms used by pathogens to evade immune response. It covers characteristics, virulence factors, prevention and treatment regimen related with a number of infectious diseases in humans. The course will provide the conceptual basis for understanding various emerging infectious diseases and the strategies used by pathogens to circumvent the immune system of the host. The students have achieved a basic understanding of Innate Immunity and innate defence mechanisms in their lower classes and Immunology that forms an integral part of this course has been designed to help understand the concepts of humoral and cellular immune response which forms the second arm of the immune system i.e Acquired Immune response. Furthermore, it will also provide opportunities for a student to develop diagnostic skillset in microbiology, including the practical application and interpretation of basic laboratory tests conducted in analysis laboratories in the field of medical microbiology and immunology.

LEARNING OUTCOMES

After completing this course, the student should be able to

1. Give details of the virulence factors and other features of the pathogen

2. Correlate these virulence factors with the pathogenesis and clinical features of the disease
3. Explain the prevention and treatment of infectious diseases
4. Understand various mechanisms used by pathogens to evade immune response
5. Understand the concept of vaccination and explain the various types of vaccines
6. Understand the structure and role of T and B cells in generating adaptive immunity and thereby study effector responses in both Humoral & Cell Mediated Immunity
7. Conceptualize how the adaptive immune responses coordinate to fight invading pathogens.

DETAILED SYLLABUS

Course Code	Unit	Sub unit	Title	No of lectures	Credit
BHUSMB 602			**MEDICAL MICROBIOLOGY & IMMUNOLOGY – PART II**	**60**	**2.5**
	I		**PATHOGENESIS OF EMERGING INFECTIOUS DISEASES**		
			Emerging and re-emerging infectious diseases a. Overview & types of emerging infectious diseases **[**Characteristics, Virulence factors, Prevention and Treatment to be studied of the following diseases] b. Food-Borne and Water-Borne Bacterial Infections • *Diarrheagenic E.coli, Salmonella, Shigella, Vibrio* c. Opportunistic infections • *Pseudomonas aeruginosa, Candia albicans* d. Antibiotic resistant pathogens • *Streptococcus pneumoniae* • *Staphylococcus aureus* e. Microbiota shift diseases – Bacterial vaginosis *f.* Emerging human pathogens – *Group B Streptococci and Enterococci* g. New diseases caused by newly discovered bacteria – Lyme disease, Legionnaires h. Bioterrorism agents • *Bacillus anthracis* • *Yersina pestis*	**15L**	
	II		**BACTERIAL STRATEGIES OF EVADING HOST DEFENCES & VACCINATION**		
			Overview of bacterial defense strategies **Colonization and Invasion of Host surface** a. Penetrating intact skin b. Penetrating mucin layer c. Resisting antibacterial peptides d. Adherance e. sIgA proteases	**6L**	

			f. Iron acquisition mechanisms g. Invasion and intracellular residence		
			Evading Complement, Phagocytosis & Antibody response a. Capsules b. Resistance to NO c. Surviving phagocytosis **d.** Evading host antibody response	**5L**	
			Vaccination a. Principles and effects of vaccination b. Types of vaccines and their characteristics • Attenuated whole agent vaccines • Inactivated whole agent vaccines • Toxoids • Subunit vaccines • Conjugated vaccines • Nucleic acid vaccines c. Concept of adjuvants d. Safety of vaccines e. Recommended immunization schedule for 0 to 6 years	**4L**	
	III		**B CELL IMMUNOLOGY**	**15**	
			B cells a. B cell development in bone marrow. b. B cell receptor and co-receptor-structure and function c. B cell activation and Differentiation d. Thymus dependant and independent antigens e. Signal transduction pathway activated by BCR f. Role TH cell in B cell response-Formation of T-B conjugates, CD40/CD40L interaction, TH cells cytokine signals	**7L**	
			Humoral Response a. Primary and secondary responses b. In vivo sites for induction of Humoral response c. Germinal centres and antigen induced B cell Differentiation d. Multigene organization of Ig genes e. Mechanism of VDJ recombination f. Affinity maturation, somatic hyper-mutation, Ig diversity & class switching g. Generation of plasma cells and memory cells	**8L**	
	IV		**T CELL IMMUNOLOGY**	**15**	
			T cells a. Early thymocyte development b. Positive and negative selection c. Exit from thymus and final maturation d. T Cell Receptor - structure (alpha-beta, gamma-delta TCR)		

			e. TCR-CD3 complex - structure and functions. Accessory molecules f. T cell activation & TCR mediated signalling g. Costimulatory signals h. Superantigens induced T cell activation i. T cell differentiation j. T cell memory (signals inducing memory cell, difference in CD4+ & CD8+ memory cells)	**8L**	
			Cell mediated effector response a. General properties of effector T cells b. Recognition of infected cell and generation of CTL c. Cytotoxic T cells and destruction of target cell by perforin/Granzyme pathway and Fas pathway d. NK cells – surface markers, receptors and killing mechanism e. Antibody mediated cell cytotoxicity (ADCC)	**7L**	

Course Code: BH.USMBP07
[Practicals Based on BH. USMB602, Credits -1.5, Lectures- 60, Notional Periods-15]

1. To determine SLO and SLS activity of *S .pyogenes*
2. Study of standard [pure] cultures of *E. coli, Klebsiella spp., Proteus spp., Pseudomonas spp., Salmonalla typhi, S. paratyphi A, S. paratyphi B, Shigella spp.,Vibrio spp., S .pyogenes, S. aureus*
3. Identification of isolates obtained from pus, sputum, stool and urine by morphological, cultural, biochemical properties and determination of antibiotic sensitivity.
4. *Candida albicans* – Isolation on Chrome Agar and Germ tube formation
5. Separation and detection of lymphocytes.

TEXTBOOKS AND REFERENCE BOOKS

1. Goering Richard, H. Dockrell, M. Zuckerman, P. Chiodini, Mims Medical Microbiology and Immunology, 6th Edition, Elsevier, 2019.
2. Ananthanarayan and Panicker's, Textbook of Microbiology, 8th edition
3. Ananthanarayan and Panicker's, Textbook of Microbiology, 10th edition
4. Owen Judith, J. Punt, S. Stranford, Kuby Immunology, 7th Edition, W.H. Freeman and Company, New York, 2013
5. Pathak & Palan, Immunology: Essential & Fundamental, 1st& 3rd edition, Capital Publishing Company
6. Quinley E, Immunohematology – Principles and Practice, 3rd Edition, Lippincott Williams & Wilkins, 2011
7. Fahim Khan, Elements of Immunology, Pearson Education, 2009
8. Maria Delost, Introduction to Diagnostic Microbiology for Laboratory Sciences, 2015, Jones & Bartlett Learning Publications
9. Abigail Slayers and Dixie Whitt, Bacterial Pathogenesis, A Molecular Approach, 2002, 2nd Edition, ASM Press

MICROBIAL BIOCHEMISTRY-PART II (BH.USMB 603)

LEARNING OBJECTIVES

Having studied many aspects of microbial physiology in the earlier semester, contents of this semester is designed to understand anabolism of carbon, dark reaction, metabolism of lipid and aliphatic compounds. Since all biosynthetic pathways are denovo or salvage, the vital regulatory role played by enzymes is understood. Various levels and mechanisms of regulation are dealt to make the learner aware of coordinated mechanisms of metabolism in the living cell. The students will also be exposed to basic concepts of operons with examples, riboswitches and global regulatory mechanisms. Also genetic regulation mechanisms in eukaryotic cells will be covered in this module.

LEARNING OUTCOMES: At the end of the course in Microbial Biochemistry; USMB 603, the learner will have an understanding of the following metabolic process and mechanisms and their significance.

1. Anabolism of carbon
2. Dark reaction
3. Biosynthesis of starch, cellulose and sucrose
4. Metabolism of lipids and aliphatic compounds
5. Metabolism of nitrogenous compounds
6. Catabolism of nucleotides
7. Major modes of regulation of gene expression

DETALED SYLLABUS

Course Code	Unit	Sub unit	Title	No of lectures	Credit
BHUSMB 603			**MICROBIAL BIOCHEMISTRY – PART II**	**60**	**2.5**
	I		**Anabolism of carbon**	**15**	
			The strategy of biosynthesis, Composition of *E. coli* cells, general pattern of metabolism leading to synthesis of a cell from glucose	**1L**	
		1.1	**CO2 fixation (Dark reactions)-Phototrophs** Calvin Benson cycle Reductive TCA cycle	**2L**	
		1.2	**Biosynthesis of Starch, Cellulose & Sucrose**	**2L**	
		1.3	**Importance of Sugar nucleotides**	**1L**	
		1.4	Gluconeogenesis		
		1.5	Biosynthesis of periodic macromolecules: Glycogen, cell wall-peptidoglycan, outer membrane layer	**4L**	
		1.6	Synthesis of PHB		
	II		**Metabolism of lipids & aliphatic compounds**		
		2.1	Introduction to Lipids	**4L**	

			Lipids –Definition, classification & functions		
			Types and role of fatty acids found in bacteria		
			Common phosphoglycerides in bacteria		
			Action of lipases on triglycerides /tripalmitate		
			Oxidases, Oxygenases, CytP450 enzymes		
		2.2	**Catabolism of Fatty Acids and PHB**	**3L**	
			Oxidation of saturated fatty acid by β oxidation & energetics		
			PHB as a food reserve and its degradation		
		2.3	**Anabolism of Fatty Acids & Lipids** Biosynthesis of straight chain even carbon saturated fatty acid(palmitic acid) Biosynthesis of phosphoglycerides in bacteria	**4L**	
		2.4	**Catabolism of aliphatic hydrocarbons** Organisms degrading aliphatic hydrocarbons Hydrocarbon uptake mechanisms Omega oxidation pathway- Pathway in *Corynebacterium* and yeast Pathway in *Pseudomonas*	**4L**	
	III		**Metabolism of nitrogenous compounds**	**15**	
		3.1	**Protein / amino acid catabolism** Enzymatic degradation of proteins, putrefaction General reactions of amino acids catalyzed by Amino acid decarboxylases Amino acid deaminases Amino acid transaminases Amino acid racemases Metabolic fate of amino acids - Glucogenic and ketogenicamino acids	**4L**	
		3.2	Fermentation of pair of amino acids -Stickland reaction	**1L**	
		3.3	**Anabolism of amino acids** Schematic representation of amino acid families		
			Biosynthesis of amino acids of Serine family (Serine, Glycine, cysteine)	**2L**	
		3.4	**Nitrogen cycle**, Nitrogen fixation, Denitrification, Ammonia fluxes & nitrification Nitrogen excretion & Urea cycle	**3L**	
		3.4	**Catabolism of Nucleotides**	**3L**	
			Degradation of purine nucleotides up to uric acid formation		
			Salvage pathway for purine and pyrimidine nucleotides		
		3.5	Biosynthesis of nucleotides (ribonucleotides & deoxyribonucleotides) & role of nucleotides	**2L**	

	IV		**Metabolic Regulation**	**15L**	
		4.1	**Overview of regulation: Major modes of regulation** **Regulation of enzyme activity** Allosteric proteins & Feedback inhibition	**3L**	
			Covalent modification of enzymes Monocyclic cascades, examples of covalent modification Regulation of Glutamine synthetase		
		4.2	Principles of gene regulation	**3L**	
			Proteins & RNAs of Gene Regulation		
			Concept of an operon, Common patterns of regulation of transcription: Repression & Induction. Regulation by: DNA-binding proteins, protein-protein interaction		
		4.3	Maltose operon, Attenuation & Trp operon	**3L**	
			Riboswitches: Enzyme cofactor TPP, amino acid-Lysine, Purine, Nucleotide base group	**2L**	
		4.4	Global regulatory mechanisms: catabolite repression, Stringent response, alarmones	**2L**	
		4.5	Regulation of gene expression in Eucaryotes: chromatin structure, histone modification, gene silencing	**2L**	

Course Code: BHUSMBP08
[Practicals Based on BH.USMB603; Credits-1.5, Lectures- 60, Notional Periods-15]

1. To study catabolite repression by diauxic growth curve.
2. Protein estimation by Lowry's method
3. Estimation of uric acid from serum and urine sample.
4. Qualitative and Quantitative assay of Protease
5. Qualitative detection of Lipase
6. Study of breakdown of amino acids – Lysine decarboxylase.
7. Study of Lithotrophs – Nitrosification and Nitrification.

TEXTBOOKS AND REFERENCE BOOKS

Text books:

1. Madigan M.T., Martinko JM., Parker J. 2003. Brock Biology of Microorganisms-International Edition. Pearson Education, Inc-NJ.
2. Jain JL., Jain S., Jain N. 2005. Fundamentals of Biochemistry. S.Chand & Company Ltd.
3. Nelson DL, Cox MM., Hoskins AA. 2021 Lehninger Principles of Biochemistry 8th ed., Macmillan international. W.H. Freeman & Company
4. Stanier, R. Y., M. Doudoroff and E. A. Adelberg. General Microbiology, 5th edition,

The Macmillan press Ltd
5. Conn, E.E., P. K. Stumpf, G. Bruening and R. Y. Doi. 1987. Outlines of Biochemistry, 5th edition. John Wiley &Sons. New York.
6. Voet Donald, Voet Judith G. 2021 (Adapted edition). Voet's Biochemistry. John Wiley & Sons.
7. Nelson, D. L. and M.M. Cox (2005), Lehninger, Principles of biochemistry. 4th edition, W. H. Freeman and Company

Reference books:

1. Zubay, G. L (1996), Principles of Biochemistry, Wm. C. Brown publishers
2. Cohen, G.N. (2011). Microbial Biochemistry. 2nd edition, Springer.
3. Wilson and Walker, 4th edition Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University press.
4. Mathews, C.K., K.E. van Holde, D.R. Appling, S, J, Anthony-Cahill (2012) Biochemistry, 4th edition. Pearson.
5. Gottschalk,G., (1985), Bacterial Metabolism, 2nd edition, Springer Verlag
6. White, D., (1995), The Physiology and Biochemistry of Prokaryotes, 3rd edition, Oxford University Press

BIOPROCESS TECHNOLOGY – PART II [BH. USMB604]

LEARNING OBJECTIVES

Bioprocess Technology II is designed to develop the learner's ability to study the techniques use in the downstream process used for the final product and industrial effluent treatment.
Bioprocess technology II becomes an important application-based paper covering microbial fermentations as well as applying the techniques of molecular biology to enzyme technology, animal tissue culture as well as plant tissue culture. The learner is provided with the details of productions of important products like antibiotics, vitamins, organic acid, amino acids and mushrooms along with the analysis techniques using various instruments and bioassays.
The learner is expected to learn the need of Quality management and regulatory bodies as the products need to fulfil these requirements. Thus, this paper prepares the learner to understand and apply the knowledge of fermentation technology and related products. This course aims to enable graduates to enter industry with an appropriate level of understanding of the need for both the science and business aspects to be achievable to make a viable product and enhance their enterpreunial skills.

LEARNING OUTCOMES: The student will be able to

- Understand the actual process involved in downstream processing of important products.
- Understand the importance of effluent treatment and explain the newer methods of sewage treatment
- To apply the knowledge of applications of animal and plant tissue culture techniques.
- Learn the applications of immobilized enzymes in various fields.
- Understand the working of important instruments used in biochemical analysis and bioassay.
- Learn the salient features of quality management and regulatory procedures.

At the end of the course the learner will also acquire the following practical skills

- Techniques involved in running a bioassay, immobilization of cells & sterility testing
- Preliminary techniques in animal & plant tissue culture

DETAILED SYLLABUS

Course Code	Unit	Sub unit	Title	No of lectures	Credit
BHUSMB 604			**BIOPROCESS TECHNOLOGY – PART II**	**60**	**2.5**
	I		**POST FERMENTATION PRODUCTION TECHNIQUES**	**15**	
		1.1	**Post Fermentation Production Techniques** a. Introduction b. Downstream processing c. Disintegration of cells, Extraction, Concentration, purification, drying, Whole Broth Processing	**10L**	
		1.2	**Effluent treatment** a. Introduction, b. Dissolved oxygen concentration as indicator of water quality c. The strength of fermentation effluents d. Newer approaches to sewage treatment	**5L**	
	II		**ADVANCES IN BIOPROCESS TECHNOLOGY**	**15**	
		2.1	**Animal biotechnology** a. Primary cell culture and established cell lines b. Basic principles c. Growth media d. Cell viability e. Scale up of cultured cells and tissue f. Applications of cell culture: Monoclonal antibody, somatic cell fusion, valuable products.	**5L**	
		2.2	**Plant tissue culture** a. Introduction b. Requirements for in vitro culture, Methods of plant cell and tissue culture c. Types of cultures of plant materials: explants, callus, organogenesis, root culture, shoot culture, micropropogation, suspension culture, protoplast culture, protoplast fusion and somatic hybridization d. **Applications**:- production of disease resistant plants, production of virus free plant,	**5L**	

			In vitro selection of cell lines for disease resistance, micropropogation, secondary metabolites from cell culture, transgenic plants for crop improvement		
		2.3	**Immobilized enzyme and cells** a. Introduction and Definitions b. Methods c. Immobilized Enzyme Reactors d. Applications	**5L**	
	III		**QUALITY ASSURANCE, IPR AND BIOASSAY**	**15**	
		3.1	**Quality assurance and quality control** a. Definitions, Chemical and pharmaceutical products b. Variables of batch process c. Q.A and Q.C wrt.- Raw materials, method of manufacturing, in process items, finished products, label and labeling, packaging materials d. Control of microbial contamination during manufacturing	7L	
		3.2	**Sterilization control and assurance**	2L	
		3.3	**Bioassay** a. Introduction b. Types: Diffusion, End Point, Turbidometric, Metabolic Response, Enzymatic assay.	3L	
		3.4	**Intellectual property rights** a. IPR – Introduction b. Overview of patent system c. Patent Categories d. For biotech and microbiological products	3L	
	IV		**INDUSTRIAL FERMENTATIONS**	**15**	
		4.1	**Penicillin and semisynthetic penicillins:** a. Introduction, biosynthesis and regulation, strain development, production methods. b. Semisynthetic penicillins: Examples, production, advantages	3L	
		4.2	**Aminoglycoside: Streptomycin:** a. Aminoglycoside antibiotics, biosynthesis, regulation of biosynthesis, strain development, production method, recovery.	3L	
		4.3	**Vitamin B 12:** a. Occurrence and economic significance, structure, biosynthesis, b. Production based on media containing carbohydrates by- *Propionibacteri*a and *Pseudomonas*, recovery.	2L	
		4.4	**Citric acid:** a. Introduction, b. Strains used for production, biosynthesis, nutrient media c. Production processes- surface and submerged, product recovery.	3L	
		4.5	**Glutamic acid**	2L	

			a. Production strains, biosynthesis, effect of permeability on production. b. Conditions of manufacturing, production process and recovery. c. Introduction to dual fermentation.		
		4.6	**Mushroom cultivation (Agaricus):** a. Edible mushroom species, b. preparation of substrate- composting- phase I and phase II, Factors affecting composting, c. preparation of spawn, casing, induction of fruiting body formation, harvesting	2L	

Course Code: BHUSMBP08
[Practicals Based on BHUSMB604, Credits -1.5, Lectures- 60, Notional Periods-15]

1. Bioassay of an antibiotic (Ampicillin / Penicillin)
2. Bioassay of Cyanocobalamin.
3. Perform immobilization of yeast cells for invertase activity - making of beads, Determination of activity and count by haemocytometer and viable count.
4. Plant tissue culture – Callus culture (Demo).
5. Sterility testing of injectable.
6. Chemical estimation of Penicillin /Ampicillin
7. Industrial Visit

TEXTBOOKS AND REFERENCE BOOKS

1. Casida L. E., "Industrial Microbiology" (2009) Reprint, New Age International (P) Ltd, Publishers, New Delhi.
2. Stanbury P. F., Whitaker A. & Hall S. J., (1997), "Principles of Fermentation Technology", 2nd edition, Aditya Books Pvt. Ltd, New Delhi.
3. Stanbury P. F., Whitaker A. & Hall S. J 3rd edition (2017) "Principles of Fermentation Technology"
4. Peppler, H. J. and Perlman, D. (1979), "Microbial Technology''. Vol. 1 & 2, Academic Press
5. Wulf Crueger & Anneliese Crueger, (2017), Biotechnology – A textbook of Industrial Microbiology, 3rd Edition, Medtech Scientific International Pvt Ltd
6. Dr. P.K. Shivkumar, M.M. Joe. K. Sukesh (2010), An Introduction to Industrial Microbiology, 1st Edition, S. Chand & Company
7. H. A. Modi, (2009). ''Fermentation Technology'' Vol. 1 & 2, Pointer Publications, India.
8. Okafor Nduka (2007) ''Modern Industrial Microbiology and Biotechnology'', Science Publications Enfield, NH, USA.
9. Crueger W. and Crueger A. (2000) "Biotechnology -"A Textbook of Industrial Microbiology", 2nd edition, Panima Publishing Corporation, New Delhi.
10. Prescott and Dunn's ''Industrial Microbiology''(1982) 4th edition, McMillan Publishers

Modality of Assessment
Assessment pattern for Theory

Theory Examination Pattern:

A) Internal Assessment- 40%- 40 Marks

Sr. No.	Evaluation type	Marks
1	Internal Class Test with Objective type questions and Short Notes (CIA-I) (5 mark test on every unit of each paper)	20
2	(CIA-II) Assignment, Model making, Poster making of syllabus related topic, Internship , Project work	20
	TOTAL	40

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

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

Paper Pattern:

1. There shall be **05** questions of **12** marks each.
2. The first question will be a mixed bag objective and remaining four questions will be unitized subjective.
3. Each of the main questions two to five will be subdivided into two sub-questions "A" and "B". Sub-question "A" will have four questions (of 5 marks each) out of which any two will be attempted. Total marks allotted to sub-question "A" will be 10 marks. Sub-question "B" will be 'Do as directed (attempt two out of four)'. Each question in Sub-question "B" will be of one mark each. Total marks allotted to "B" sub-question will be 2 marks.
4. All questions [Q.2 to Q.5] shall be compulsory with internal choice within questions except first question [Q.1].
5. The unitized questions would have subjective and objective type of questions.

Overall Examination & Marks Distribution Pattern

Semester V & VI

Course BH. USMB	501 , 502 ,503 & 504			601 , 602 ,603 & 604			Grand total
	Internal	External	Total	Internal	External	Total	
Theory	160	240	400	160	240	400	800
Practical	-	200	200	-	200	200	400
Total							1200

Rubrics of evaluation for ESE

Unit	Knowledge	Understanding	Analysis & critical thinking	Total marks/unit
From all units	04	04	04	12
1	04	04	04	12
2	04	04	04	12
3	04	04	04	12
4	04	04	04	12
Total	**20**	**20**	**24**	**60**
% Weightage	**33.33**	**33.33**	**33.34**	**100**

Passing Standard:

The learners to pass a course shall have to obtain a minimum of 40% marks in aggregate for each course and 40% marks in **Semester End Examination (i.e. 40 out of 100) separately**, to pass the course and **minimum of Grade E** in each project, wherever applicable, to pass a particular semester.

Practical Examination Pattern:

External (Semester end practical examination):-

Sr.No.	Particulars/ paper	Marks
1.	**Laboratory work**	**40**
2.	**Journal**	**05**
3.	**Viva**	**05**

Semester V:

The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

In case of loss of Journal and / or Report, a Lost Certificate should be obtained from the Head of the Department / Co-ordinator of the department; failing which the student will not be allowed to appear for the practical examination.

Semester VI

The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

In case of loss of Journal and/ or Report, a Lost Certificate should be obtained from the Head of the Department/ Co-ordinator of the department; failing which the student will not be allowed to appear for the practical examination.

Overall Examination and Marks Distribution Pattern

Course code	**Practical Syllabus**	**Credits & lectures**
BHUSMBP05	Based on BHUSMB501 and BHUSMB502 of Semester V	Credits 3 (8 periods/week) = 120 periods/semester
BHUSMBP06	Based on BHUSMB503 and BHUSMB504 of Semester V	Credits 3 (8 periods/week) = 120 periods/semester

SEMESTER V

Course	**BHUSMB501**	**BHUSMB502**	**BHUSMB503**	**BHUSMB504**	**Grand Total**
Theory	**100**	**100**	**100**	**100**	**400**
Practicals	**50**	**50**	**50**	**50**	**200**

SEMESTER VI

Course	**BHUSMB601**	**BHUSMB602**	**BHUSMB603**	**BHUSMB604**	**Grand Total**
Theory	**100**	**100**	**100**	**100**	**400**
Practicals	**50**	**50**	**50**	**50**	**200**

T.Y.B.Sc. Microbiology Practicals: Semester-V

Course code	**Practical Syllabus**	**Credits & lectures**
BHUSMBP05	Based on BHUSMB501 and BHUSMB502 of Semester V	Credits 3 (8 periods/week) = 120 periods/semester
BHUSMBP06	Based on USMB503 and BHUSMB504 of Semester V	Credits 3 (8 periods/week) = 120 periods/semester

T.Y.B.Sc. Microbiology Practicals: Semester-VI

Course code	Practical Syllabus	Credits & lectures
BHUSMBP07	Based on BHUSMB601 and BHUSMB602 of Semester VI	Credits 3 (8 periods/week) = 120 periods/semester
BHUSMBP08	Based on BHUSMB603 and BHUSMB604 of Semester VI	Credits 3 (8 periods/week) = 120 periods/semester

COURSE WISE CREDIT ASSIGNMENT UNDER THE FACULTY OF SCIENCE
Program: B.Sc.

Course: Microbiology (USMB)

Course wise credit assignments under the faculty of science Type of Courses / Credits Assigned	First Year (Credit X No of Credits)		Second Year (Credit X No of Credits)		Third Year (Credit X No of Credits)		Total Credit Value
	First Semester	Second Semester	Third Semester	Fourth Semester	Fifth Semester	Sixth Semester	
Core Courses (Theory)	4 X 3	4 X 3	6 X 2	6 X 2	2.5 X 4	2.5 X 4	68
Core Courses (Practicals)	2 X 3	2 X 3	3 X 2	3 X 2	1.5 X 4	1.5 X 4	36
Foundation course	2 X 1	2 X 1	2 X 1	2 X 1			08
Applied Component Courses (Theory)					2 X 1	2 X 1	04
Applied Component Courses (Practical)					2 X 1	2 X 1	04
Total	**20**	**20**	**20**	**20**	**20**	**20**	**120**

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