UNIVERSITY OF MUMBAI

No. UG/66 of 2018-19

CIRCULAR:-

Attention of the Principals of the affiliated Colleges and Directors of the recognized Institutions in Science & Technology Faculty is invited to this office Circular Nos. UG/104 of 2010, dated 29th May, 2010 relating to syllabus of the Bachelor of Science (B.Sc.) degree course.

They are hereby informed that the recommendations made by the Board of Studies in Microbiology at its meeting held on 9th April, 2018 have been accepted by the Academic Council at its meeting held on 14th June, 2018 **vide** item No. 4.51 and that in accordance therewith, the revised syllabus as per the (CBCS) for the T.Y.B.Sc. in Microbiology (Sem – V & VI), has been brought into force with effect from the academic year 2018-19, accordingly. (The same is available on the University's website www.mu.ac.in).

(Dr. Dinesh Kamble)
I/c REGISTRAR

MUMBAI – 400 032
6th July, 2018

To

The Principals of the affiliated Colleges & Directors of the recognized Institutions in Science & Technology Faculty. (Circular No. UG/334 of 2017-18 dated 9th January, 2018.)

A.C./4.51/14/06/2018

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No. UG/ 66 -A of 2018 MUMBAI-400 032 6th July, 2018

Copy forwarded with Compliments for information to:-

1) The I/c Dean, Faculty of Science & Technology,
2) The Chairman, Board of Studies in Microbiology,
3) The Director, Board of Examinations and Evaluation,
4) The Director, Board of Students Development,
5) The Co-Ordinator, University Computerization Centre,

(Dr. Dinesh Kamble)
I/c REGISTRAR

AC Item No.

UNIVERSITY OF MUMBAI

Revised Syllabus for T.Y.B.Sc.
Program: B.Sc.
Course: Microbiology (USMB)

(Credit Based Semester and Grading System with effect from the academic year 2018 – 2019)

PREAMBLE

The Choice Based Credit system was introduced by Mumbai University from 2016 - 2017. The process was initiated by restructuring the F.Y.B.Sc. syllabus and the paper pattern according to the CBCS pattern and its implementation in the same year i.e. 2016 - 17.

This was followed by revision of S.Y.B.Sc. syllabus and paper pattern in the year 2017 - 2018.

The revised S.Y.B.Sc. syllabus gave an opportunity to the Microbiology students to opt for Paper III of any subject other than Microbiology. Likewise S.Y.B.Sc. students of other subjects could opt for Microbiology Paper III. This gave them the option to choose from diversity of applied sciences.

In continuation with this, the T.Y.B.Sc. syllabus is being revised in the year 2018 - 2019. The existing paper pattern will also be accordingly revised.

Keeping in tune with the revised syllabus, the committee has ensured that there is a continuous flow of information and latest advances in the subject imparted to the students. Hence some of the modules of the earlier syllabus have been upgraded, while some new modules have been added to the syllabus in order to bridge the knowledge gap of the learner from S.Y.B.Sc. to T.Y.B.Sc.

The syllabus is aimed at equipping the students with basic knowledge in various branches of Microbiology such as Microbial Genetics, Molecular Biology, Virology, Medical Microbiology, Immunology, Microbial Biochemistry and Industrial Microbiology. Additionally, it also makes students aware of interdisciplinary sciences such as Bioinformatics and Bioinstrumentation.

In all, the students offering Microbiology as a single major subject that is Six units pattern, will study eight courses of theory and practicals compulsory during Semester V and Semester VI together, while students opting for double major subject that is Three units pattern, will have four courses of theory and practicals compulsory during Semester V and Semester VI together.

The courses for six units will comprise of the following:

1) USMB 501 and USMB 601
2) USMB 502 and USMB 602
3) USMB 503 and USMB 603
4) USMB 504 and USMB 604

The courses for three units will comprise of the following:

1) USMB 501 and USMB 601
2) USMB 502 and USMB 602

The approach towards designing this syllabus has been to retain the classic concepts of Microbiology as well as keeping abreast with the latest discoveries in Microbiology and other interdisciplinary fields.

In conclusion, the revised syllabus aims at inculcating a spirit of learning and kindling curiosity towards the subject in the minds of learners, resulting in their pursuit of higher education in Microbiology.

T.Y.B.Sc. MICROBIOLOGY THEORY

(SEMESTER V)

COURSE CODE	TITLE	CREDITS AND LECTURES / SEM
USMB501	**Microbial Genetics**	**2.5 Credits (60 Lectures)**
Unit I	DNA Replication	15 Lectures
Unit II	Transcription, Genetic Code & Translation	15 Lectures
Unit III	Mutation and Repair	15 Lectures
Unit IV	Genetic Exchange & Homologous Recombination	15 Lectures
USMB502	**Medical Microbiology & Immunology: Part - I**	**2.5 Credits (60 Lectures)**
Unit I	Bacterial Strategies for Evasion and Study of a Few Diseases	15 Lectures
Unit II	Study of a Few Diseases with Emphasis on Cultural Characteristics of the Etiological agent, Pathogenesis, Laboratory Diagnosis and Prevention.	15 Lectures
Unit III	General Immunology - I	15 Lectures
Unit IV	General Immunology - II	15 Lectures
USMB503	**Microbial Biochemistry: Part - I**	**2.5 Credits (60 Lectures)**
Unit I	Biological Membranes & Transport	15 Lectures
Unit II	Bioenergetics & Bioluminescence	15 Lectures
Unit III	Methods of Studying Metabolism & Catabolism of Carbohydrates	15 Lectures
Unit IV	Fermentative Pathway & Anabolism of Carbohydrates	15 Lectures

USMB504	**Bioprocess Technology: Part - I**	**2.5 Credits (60 Lectures)**
Unit I	Upstream Processing - I	15 Lectures
Unit II	Upstream Processing - II	15 Lectures
Unit III	Fermentation Modes, Equipments and Instruments	15 Lectures
Unit IV	Traditional Industrial Fermentations	15 Lectures

N.B.

I. Each theory period shall be of 48 minutes duration. Theory component shall have 240 instructional periods plus 240 notional periods per semester which is equal to 384 learning hours. For theory component the value of One Credit is equal to 38.40 learning hours.

II. Each practical period shall be of 48 minutes duration. Practical component shall have 240 instructional periods plus 60 notional periods per semester which is equal to 240 learning hours. For practical component the value of One Credit is equal to 40 learning hours.

T.Y.B.SC. MICROBIOLOGY THEORY (SEMESTER V)

MICROBIAL GENETICS (USMB-501)

LEARNING OBJECTIVES

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:

1. **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.
2. **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.
3. **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.
4. **Genetic exchange:** This module includes the study of various mechanisms of gene transfer in bacteria. It also provides insight into the mechanisms of genetic recombination. The module deals with the Genetics of bacteria and bacteriophages, development of new strains and genetic mapping.
5. **Practicals**
   The laboratory techniques and experiments based on these topics will give students hands on competence in fundamental molecular biology experiments.

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.
- **Genetic exchange**: The student shall understand the various mechanisms of gene transfer in bacteria and genetic recombination.
- **Practicals**: The students will acquire skill to perform the laboratory techniques and experiments based on the above topics.

MICROBIAL GENETICS (USMB-501): DETAIL SYLLABUS

Title	Lectures / Semester	Notional Periods
Unit I: DNA Replication	**15 L**	**15**
1.1. Historical perspective - Conservative, dispersive, semi-conservative, bidirectional and semi-discontinuous, Theta model of replication.	**3 L**	
1.2. Prokaryotic DNA replication - Details of molecular mechanisms involved in Initiation, Elongation and Termination	**4 L**	
1.3. Enzymes and proteins associated with DNA replication- Primase, Helicase, Topoisomerase, SSB, DNA polymerases, Ligases, Ter and Tus proteins.	**3 L**	
1.4. Eukaryotic DNA replication - Molecular details of DNA synthesis, replicating the ends of the chromosomes assembling newly replicated DNA into nulcleosomes**.**	**4 L**	
1.5. Rolling circle mode of DNA replication	**1 L**	
Unit II: Transcription, Genetic Code and Translation	**15 L**	**15**
2.1 Central Dogma: An Overview, Transcription process, Transcription in bacteria - Initiation of transcription at promoters, elongation of an RNA chain, termination of an RNA chain	**3 L**	
2.2 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	**5 L**	
2.3 Genetic code - Nature of genetic code and characteristics of genetic code.	**2 L**	
2.4 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.	**5 L**	
Unit III: Transcription, Genetic Code and Translation	**15 L**	**15**
3.1 Mutation 3.1.1 **Terminology:** alleles, homozygous, heterozygous, genotype, phenotype, Somatic mutation, Germline mutation, Gene mutation, Chromosome mutation, phenotypic lag, hotspots and mutator genes	**1 L**	

3.1.2 **Fluctuation test.**	**1 L**	
3.1.3 **Types of mutations:** Point mutation, reverse mutation, suppressor mutation, frameshift mutation, conditional lethal mutation, base pair substitution, transition, transversion, missense mutation, nonsense mutation, silent mutation, neutral mutation, pleiotropic mutations.	**3 L**	
3.1.4 **Causes of mutation:** Natural/spontaneous mutation--replication error, depurination, deamination. Induced mutation: principle and mechanism with illustrative diagrams for: 3.1.4.1 Chemical mutagens - base analogues, nitrous acid, hydroxyl amine, intercalating agents and alkylating agents. 3.1.4.2 Physical mutagen 3.1.4.3 Biological mutagen (only examples)	**4 L**	
3.1.5 **Ames test**	**1 L**	
3.1.6 **Detection of mutants**	**1 L**	
3.2 DNA Repair 3.2.1 Mismatch repair, 3.2.2 Light repair 3.2.3 Repair of alkylation damage 3.2.4 Base excision repair 3.2.5 Nucleotide excision repair 3.2.6 SOS repair	**4 L**	
Unit IV: Genetic Exchange & Homologous Recombination	**15 L**	**15**
4.1 Genetic analysis of Bacteria	**1 L**	
4.2 Gene transfer mechanisms in bacteria 4.2.1 Transformation 4.2.1.1 Introduction and History 4.2.1.2 Types of transformation in prokaryotes--Natural transformation in *Streptococcus pneumoniae, Haemophilus influenzae,* and *Bacillus subtilis*. 4.2.1.3 Mapping of bacterial genes using transformation. 4.2.1.4 Problems based on transformation.	**3 L**	
4.2.2 Conjugation 4.2.2.1 Discovery of conjugation in bacteria 4.2.2.2 Properties of F plasmid/Sex factor 4.2.2.3 The conjugation machinery 4.2.2.4 Hfr strains, their formation and mechanism of conjugation 4.2.2.5 F' factor, origin and behavior of F' strains,	**5 L**	

	Sexduction. 4.2.2.6 Mapping of bacterial genes using conjugation (Wolman and Jacob experiment). 4.2.2.7 Problems based on conjugation		
4.2.3	Transduction 4.2.3.1 Introduction and discovery 4.2.3.2 Generalized transduction 4.2.3.3 Use of Generalized transduction for mapping genes 4.2.3.4 Specialized transduction 4.2.3.5 Problems based on transduction	**3 L**	
4.3	**Recombination in bacteria** 4.3.1 General/Homologous recombination 4.3.2 Molecular basis of recombination 4.3.3 Holliday model of recombination (Single strand DNA break model only) 4.3.4 Enzymes required for recombination 4.3.5 Site –specific recombination	**3 L**	

MEDICAL MICROBIOLOGY & IMMUNOLOGY: PART-I (USMB-502)

LEARNING OBJECTIVES

The course in medical microbiology has been designed to help students to build on the basic information regarding host defence mechanisms that they have gained in S.Y.B.Sc. It has been designed to highlight the most important areas of medical microbiology i.e. etiology, transmission, pathogenesis, clinical manifestations, laboratory diagnosis, prophylaxis, and treatment of various diseases The students have achieved a basic understanding of Innate Immunity and Host defence mechanisms in their lower classes and Immunology that forms an integral part of Medical Microbiology has been designed to help understand the ability of our immune system to defend against invading pathogens in a logical fashion. This includes our ability to defend against microorganisms by understanding the concepts of Humoral and Cellular Immunity (innate immunity) the tissues and organs of the immune system types of antigens we encounter and very importantly, the different types of antigen-antibody reactions.

LEARNING OUTCOMES: The students should be able to

- Give details of the virulence factors and other features of the pathogen
- Correlate these virulence factors with the pathogenesis and clinical features of the disease
- Comment on the mode of transmission, and therefore modes of prophylaxis of these diseases

- Comment on the methods of diagnosis of the disease.
- Conceptualize how the adaptive immune responses coordinate to fight invading pathogens and the organs and tissue involved
- Discuss the role of antigen in initiating the immune response
- Correlate the structure & functions of immunoglobulin
- Understand the importance of cytokines, MHC, APCs, Cytokines, and the role in adaptive immunity.
- Understand the various antigen –antibody reactions

MEDICAL MICROBIOLOGY AND IMMUNOLOGY: PART I

(USMB-502): DETAIL SYLLABUS

Title	Lectures / Semester	Notional Periods
Unit I: Bacterial Strategies for Evasion and Study of a Few Diseases	**15 L**	**15**
1.1. Study of virulence mechanisms in bacteria 1.1.1. Pathogenicity islands 1.1.2. Bacterial virulence factors 1.1.2.1. Adherence factors 1.1.2.2. Invasion of host cells and tissues 1.1.3. Toxins 1.1.3.1. Exotoxins 1.1.3.2. Exotoxins associated with diarrhoeal diseases and food poisoning 1.1.3.3. LPS of gram negative bacteria 1.1.4. Enzymes 1.1.4.1. Tissue degrading enzymes 1.1.4.2. IgA1 proteases 1.1.5. Antiphagocytic factors 1.1.6. Intracellular pathogenicity 1.1.7. Antigenic heterogeneity 1.1.8. The requirement for iron	**5 L**	
1.2. Study of A Few Infectious Diseases of the Respiratory Tract (wrt. Cultural Characteristics of the etiological agent, pathogenesis & clinical features, laboratory diagnosis, treatment and prevention only) 1.2.1. *S. pyogenes* infections 1.2.2. Influenza 1.2.3. Tuberculosis 1.2.4. Pneumonia caused by *K .pneumoniae*	**8 L**	
1.3. Study of urinary tract infections	**2L**	

Unit II: Study of few diseases (wrt. Cultural characteristics of the etiological agent, pathogenesis & clinical features, laboratory diagnosis, treatment and prevention only)		**15 L**	**15**
2.1	**Study of skin infections**	**7 L**	
2.1.1	Pyogenic skin infections caused by *Pseudomonas* and *S. aureus*		
2.1.2	Leprosy		
2.1.3	Fungal infections- Candidiasis		
2.1.4	Viral Infections- Herpes simplex		
2.2	**Study of gastrointestinal tract infections**	**8 L**	
2.2.1	Infections due to Enteropathogenic *E.coli* strains		
2.2.2	Enteric fever- *Salmonella*		
2.2.3	Shigellosis		
2.2.4	Rotavirus diarrhoea		
2.2.5	Dysentery due to *Entamoeba histolytica*		
Unit III: General Immunology – I		**15 L**	**15**
3.1.	**Organs and tissues of the immune system:**	**4 L**	
3.1.1	Primary lymphoid organs - structure and function of Thymus and Bone marrow		
3.1.2	Secondary lymphoid organs – structure and function of Spleen**,** Lymph node**,** Mucosa associated lymphoid tissues, Bronchus associated lymphoid tissue, Gut associated lymphoid tissue, Cutaneous associated lymphoid tissue		
3.2	**Antigens**	**5 L**	
3.2.1	Immunogenicity versus antigenicity: Concepts - Immunogenicity, Immunogen, Antigencity, Antigen, Haptens. Haptens as valuable research and diagnostic tools		
3.2.2	Factors that influence immunogenicity - Foreignness, Molecular size, Chemical composition, Heterogeneity, Susceptibility of antigen to be processed and presented, Contribution of the biological system to immunogenicity Genotype of the recipient, Immunogen dosage, Route of administration		
3.2.3	Adjuvants		
3.2.4	Epitopes / antigen determinants - General concept, Characteristic properties of B - cell epitopes, concepts of sequential and non-sequential epitopes (with only one example each). Properties of B - cell and T - cell epitopes. Comparison of antigen recognition by T cells and B cells		
3.2.5	Types of antigens – heterophile antigens, isophile antigens, sequestered antigens, super antigens, bacterial and viral antigens		
3.3	**Immunoglobulins**	**6 L**	
3.3.1	Immunoglobulins – basic structure of Immunoglobulins, heterodimer; types of heavy and light chains; constant and		

		variable regions, Immunoblobulin domains-hinge region. Basic concepts - hypervariable region, complementarity - determining regions (CDRs), framework regions (FRs) and their importance.		
	3.3.2	Immunoglobulin classes and biological activities - Immunogloublin G, Immunogloublin M, Immunogloublin A, Immunogloublin E, Immunogloublin D, (including diagrams)		
	3.3.3	Antigenic determinants on immunoglobulins – isotypes, allotypes, idiotypes**.**		
	3.3.4	Immunoglobulin Superfamily		
		Unit IV: General Immunology – II	**15 L**	**15**
4.1	**Cytokines**		**2 L**	
	4.1.1	Concepts - cytokines, lymphokines, monokines, interleukines, chemokines.		
	4.1.2	Properties of cytokines		
	4.1.3	Attributes of cytokines		
	4.1.4	Biological functions of cytokines		
4.2	**Major histocompatibility complex**		**3 L**	
	4.2.1	Introduction		
	4.2.2	Three major classes of MHC encoded molecules		
	4.2.3	The basic structure and functions of Class I and Class II MHC Molecules		
	4.2.4	Peptide binding by Class I and Class II MHC molecule		
4.3	**Antigen presenting cells**		**3 L**	
	4.3.1	Types of APC's		
	4.3.2	Endogenous antigens: The cytosolic pathway		
	4.3.3	Exogenous antigens: The endocytic pathway		
4.4	**Antigen Antibody reactions**		**7 L**	
	4.4.1	Precipitation reaction - Immunoelectrophoresis		
	4.4.2	Agglutination reactions - haeme-agglutination, bacterial agglutination, passive agglutination, agglutination inhibition.		
	4.4.3	Radioimmunoassay (RIA),		
	4.4.4	Enzyme Linked Immunosorbent Assay - indirect, competitive and sandwich ELISA		
	4.4.5	Immunofluorescence- Direct and indirect.		
	4.4.6	Western blotting.		

MICROBIAL BIOCHEMISTRY: PART-I (USMB-503)

LEARNING OBJECTIVES

This course is designed for T.Y.B.Sc. students who choose to major in Microbiology. 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 anabolic processes through concepts of biosynthesis, and polymerization namely glycogen and peptidoglycan biosynthesis.

LEARNING OUTCOMES: The students should be able to

- Understand the architecture of the membrane and how solute is transported inside the cell.
- Describe and explain the electron transport chains in prokaryotes and mitochondria and understand the mechanism of ATP synthesis.
- Explain bioluminescence mechanism and its significance
- Discuss the experimental aspect of studying catabolism and anabolism and the various pathways for the breakdown of carbohydrates along with reactions in amphibolic pathways.
- Describe various other pathways which produce different end products.
- Describe anabolic reactions in carbohydrate synthesis.
- Apply the concepts of energetics and catabolism in biodegradation of various substrates.

MICROBIAL BIOCHEMISTRY: PART-I

(USMB-503): DETAIL SYLLABUS

Title	Lectures / Semester	Notional Periods
Unit I: Biological Membranes & Transport	**15 L**	**15**
1.1 Composition and architecture of membrane 1.1.1 Lipids and properties of phospholipid membranes 1.1.2 Integral & peripheral proteins & interactions with lipids 1.1.3 Permeability	**2 L**	

	1.1.4 Aquaporins 1.1.5 Mechanosensitive channels		
1.2	**Methods of studying solute transport** 1.2.1 Use of whole cells 1.2.2 Liposomes 1.2.3 Proteoliposomes	**2 L**	
1.3	**Solute transport across membrane** 1.3.1 Passive transport and facilitated diffusion by membrane proteins 1.3.2 Co-transport across plasma membrane - (Uniport, Antiport, Symport) 1.3.3 Active transport & electrochemical gradient 1.3.4 Ion gradient provides energy for secondary active transport 1.3.4.1 Lactose transport 1.3.5 ATPases and transport (only Na-K ATPase) 1.3.6 Shock sensitive system – Role of binding proteins 1.3.6.1 Maltose uptake (Diagram and description) 1.3.6.2 Histidine uptake (Diagram and description) 1.3.7 Phosphotransferase system 1.3.8 Schematic representation of various membrane transport systems in bacteria.	**8 L**	
1.4	**Other examples of solute transport:** 1.4.1 Iron transport: A special problem 1.4.2 Assembly of proteins into membranes and protein export 1.4.3 Bacterial membrane fusion central to many biological processes	**3 L**	
	Unit II: Bioenergetics & Bioluminescence	**15 L**	**15**
2.1	**Biochemical mechanism of generating ATP:** Substrate-Level-Phosphorylation, Oxidative Phosphorylation & Photophosphorylation	**1 L**	
2.2	**Electron transport chain** 2.2.1 Universal Electron acceptors that transfer electrons to E.T.C. 2.2.2 Carriers in E.T.C. 2.2.2.1 Hydrogen carriers – Flavoproteins, Quinones 2.2.2.2 Electron carriers – Iron Sulphur proteins, Cytochromes. 2.2.3 Mitochondrial ETC 2.2.3.1 Biochemical anatomy of mitochondria 2.2.3.2 Complexes in Mitochondrial ETC 2.2.3.3 Schematic representation of Mitochondrial ETC**.**	**3 L**	
2.3	**Prokaryotic ETC** 2.3.1 Organization of electron carriers in bacteria	**3 L**	

2.3.1.1 Generalized electron transport pathway in bacteria 2.3.1.2 Different terminal oxidases 2.3.2 Branched bacterial ETC 2.3.3 Pattern of electron flow in *E. coli* - aerobic and anaerobic 2.3.4 Pattern of electron flow in *Azotobacter vinelandii*		
2.4 ATP synthesis 2.4.1 Explanation of terms – Proton motive force, Proton pump, Coupling sites, P:O ratio, Redox potential (definition of Standard reduction potential) 2.4.2 Free energy released during electron transfer from NADH to O_2 2.4.3 Chemiosmotic theory (only explanation) 2.4.4 Structure & function of Mitochondrial ATP synthase 2.4.5 Structure of bacterial ATP synthase 2.4.6 Mechanism by Rotational catalysis 2.4.7 Inhibitors of ETC, ATPase and uncouplers	**3 L**	
2.5 Other modes of generation of electrochemical energy 2.5.1 ATP hydrolysis 2.5.2 Oxalate formate exchange 2.5.3 End product efflux, Definition**,** Lactate efflux 2.5.4 Bacteriorhodopsin: - Definition, function as proton pump and significance	**2 L**	
2.6 Bioluminescence 2.6.1 Brief survey of bioluminescent systems 2.6.2 Biochemistry of light emission 2.6.3 Schematic diagram 2.6.4 Significance / Application	**3 L**	
Unit III: Studying Metabolism & Catabolism of Carbohydrates	**15 L**	**15**
3.1 Experimental Analysis of metabolism 3.1.1 Goals of the study 3.1.2 Levels of organization at which metabolism is studied 3.1.3 Metabolic probes. 3.1.4 Use of radioisotopes in biochemistry 3.1.4.1 Pulse labeling 3.1.4.2 Assay and study of radiorespirometry to differentiate EMP & ED 3.1.5 Use of biochemical mutants 3.1.6 Sequential induction	**3 L**	
3.2 Catabolism of Carbohydrates 3.2.1 Breakdown of polysaccharides – Glycogen, Starch, Cellulose 3.2.2 Breakdown of oligosaccharides - Lactose, Maltose, Sucrose, Cellobiose. 3.2.3 Utilization of monosaccharides - Fructose, Galactose	**10 L**	

3.2.4 Major pathways – (with structure and enzymes) 3.2.4.1 Glycolysis (EMP) 3.2.4.2 HMP Pathway - Significance of the pathway 3.2.4.3 ED pathway 3.2.4.4 TCA cycle - Action of PDH, Significance of TCA 3.2.4.5 Incomplete TCA in anaerobic bacteria 3.2.4.6 Anaplerotic reactions 3.2.4.7 Glyoxylate bypass		
3.3 Amphibolic role of EMP; Amphibolic role of TCA cycle	**1 L**	
3.4 Energetics of Glycolysis, TCA and ED pathway – Balance sheet only. Format as in Lehninger (2.5 ATP/NADH and 1.5 ATP / $FADH_2$) (Based on this format make balance sheet for Glycolysis - Lactic acid and Alcohol fermentation and for ED pathway)	**1 L**	
Unit IV: Fermentative Pathways & Anabolism of Carbohydrates	**15 L**	**15**
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 L**	
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)	**5 L**	
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	**6 L**	

BIOPROCESS TECHNOLOGY: PART-I (USMB-504)

LEARNING OBJECTIVES

Bioprocess Technology I course is designed to develop the learner's ability to study the techniques used in the different phases of industrial microbiology such as strain improvement, basic fermentation equipment & its sterilization aspects. 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 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 wine, beer, vinegar and enzymes.

Thus, this paper readies 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 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
- Describe the design of bioreactors for different applications and its process parameters
- Design media, growth conditions and techniques for producing and recovering different types of products of commercial value.
- Learner will be well –versed with the containment and levels of containment.

BIOPROCESS TECHNOLOGY: PART-I

(USMB-504): DETAIL SYLLABUS

Title	Lectures / Semester	Notional Periods
Unit I: Upstream Processing – I	**15 L**	**15**
1.1 Introduction 1.1.1 An introduction to fermentation processes 1.1.2 The range of fermentation processes 1.1.3 The Component parts of a fermentation process	**3 L**	
1.2 Screening methods 1.2.1 Primary and secondary screening	**3 L**	

	1.2.2 High throughput screening methods		
1.3	**Strain improvement** 1.3.1 The improvement of industrial microorganisms 1.3.2 The selection of induced mutants synthesizing improved levels of primary metabolites 1.3.3 The isolation of induced mutants producing improved yields of secondary metabolites. 1.3.4 The improvement of strains by modifying properties other than the yield of product	**6 L**	
1.4	**Preservation of cultures** 1.4.1 Preservation of industrially important organisms 1.4.2 Quality control of preserved stock 1.4.2.1. Key Criteria's 1.4.2.2. Development of a master culture bank (MCB) 1.4.2.3. Variability test to ensure reproducibility of the MCB	**3 L**	
	Unit II: Upstream Processing – II	**15 L**	**15**
2.1	**Fermentation media formulation and raw materials** 2.1.1 Media formulation 2.1.2 Raw materials for fermentation media	**4 L**	
2.3	**The development of inocula for industrial fermentations** 2.2.1 Introduction 2.2.2 Development of inocula for unicellular bacterial process 2.2.3 Development of inocula for mycelial process	**3 L**	
2.3	**Sterilization and achievement of aseptic conditions** 2.3.1 Introduction 2.3.2 Medium sterilization (concept of nabla factor) 2.3.3 Methods of batch sterilization 2.3.4 The design of continuous sterilization process 2.3.5 Sterilization of the Fermenter 2.3.6 Sterilization of the Feeds 2.3.7 Sterilization of the liquid wastes 2.3.8 Filter Sterilization 2.3.8.1 Filter sterilization of fermentation media, 2.3.8.2 Filter sterilization of air 2.3.8.3 Filter sterilization of fermenter exhaust air 2.3.9 Achievement of aseptic conditions	**6 L**	
2.4	**Scale up and scale down of fermentation**	**2 L**	
	Unit III: Fermentation Modes, Equipments and Instruments	**15 L**	**15**
3.1	**Modes of fermentation** 3.1.1 Batch, continuous and fed batch fermentation 3.1.2 Solid substrate fermentation	**3 L**	

3.2	**Design of fermenter** 3.2.1 Basic functions 3.2.2 Aseptic operation & Containment 3.2.3 Body construction 3.2.4 Agitator (impeller) – function, types, mechanical seal and magnetic drive 3.2.5 Baffles 3.2.6 The aeration system (sparger) - function and types 3.2.7 Valves (Globe, piston & needle) 3.2.8 Steam traps 3.2.9 Examples of fermenters - Stirred Tank Reactor, Air Lift, Deep Jet, Photobioreactor	**7 L**	
3.3	**Instrumentation and control** 3.3.1 Introduction to sensors and its types 3.3.2 Measurement and control of: pH, temperature, pressure, foam sensing, dissolved oxygen, inlet and exit gas analysis.	**5 L**	
	Unit IV: Traditional Fermentations	**15 L**	**15**
4.1	**Wine – Red, White, Champagne and Sherry:** Alcoholic fermentation, composition of grape juice, Sulphur dioxide addition, factors affecting wine fermentation, examples and role of yeasts involved in fermentation, malolactic fermentation, technological aspects of wine making- red, white, champagne, sherry, examples of aroma compounds of wine, types and examples of wine	**3 L**	
4.2	**Beer – Ale and Lager:** Elements of brewing process, process details, use of cylindro-conical vessel, primary fermentation, continuous fermentation, aging and finishing, yeasts involved in fermentation.	**3 L**	
4.3	**Alcohol from Molasses:** Introduction, biosynthesis of ethanol, production process- preparation of nutrient solution, fermentation, recovery by distillation**.**	**2 L**	
4.4	**Vinegar (acetic acid):** Introduction, biosynthesis, production using generator, production using submerged fermenter, recovery**.**	**3 L**	
4.5	**Baker's yeast:** Outline of production, yeast strains and their properties, factors important in production-oxygen requirement and aeration, concentration of sugar, pH, temperature, preparation of substrate, fermentation, harvesting of yeast cells, production of compressed and active dry yeast.	**2 L**	
4.6	**Fungal amylase production:** ∝ amylase- production from bacteria and fungi, β amylase and glucoamylase, concentration and purification.	**2 L**	

T.Y.B.Sc. MICROBIOLOGY PRACTICALS (SEMESTER-V)

Course Code: USMBP05

[Practicals Based on USMB501, Credits -1.5, Lectures- 60, Notional Periods-15]

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 mutant)
4. Replica plate technique for selection & characterization of mutants – auxotroph & antibiotic resistant
5. Isolation and detection of plasmid DNA.

Course Code: USMBP05

[Practicals Based on USMB502, Credits -1.5, Lectures-60, Notional Periods-15]

1. Acid fast staining.
2. Identification of *Candida* species using the germ tube test and growth on Chrom agar
3. To determine SLO and SLS activity of *S .pyogenes*
4. 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*
5. Identification of isolates obtained from pus, sputum, stool and urine by morphological, cultural and biochemical properties.
6. Antigen Preparation: O & H antigen preparation of Salmonella. Confirmation by slide agglutination

Course Code: USMBP06

[Practicals Based on USMB503; Credits-1.5, Lectures- 60, Notional Periods-15]

1. Isolation and study of Bioluminescent organisms
2. Study of oxidative and fermentative metabolism
3. Qualitative and Quantitative assay of Phosphatase
4. Study of Homo - Heterofermentations
5. Isolation and detection of Mitochondria
6. Glucose detection by GOD/POD

Course Code: USMBP06

[Practicals Based on USMB504, Credits -1.5, Lectures- 60, Notional Periods-15]

1. Alcohol Fermentation
   - 1.1. Preparation and standardization of yeast inoculums for alcohol fermentation
   - 1.2. Laboratory Alcohol fermentation using jaggery medium, calculation of efficiency of fermentation.

2. Determine the alcohol tolerance for yeast.
3. Determine the sugar tolerance for yeast.
4. Chemical estimation of sugar by Cole's ferricyanide method
5. Chemical estimation of alcohol
6. Production of amylase- detection, shake flask or solid substrate cultivation and detection (Qualitative).
7. Primary screening for antibiotic producers using Wilkin's agar overlay method.
8. Determination of antibiotic spectrum using agar strip / streak method.
9. Industrial Visit

TEXT BOOKS AND REFERENCE BOOKS

(SEMESTER V)

Course Code: USMB501

Text 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. D. Nelson and M. Cox, (2005), "Lehninger's Principles of biochemistry", 4th edition, Macmillan worth Publishers.
5. M. Madigan, J. Martinko, J. Parkar, (2009), "Brock Biology of microorganisms", 12th edition, Pearson Education International.
6. Fairbanks and Anderson, (1999), "Genetics", Wadsworth Publishing Company.
7. Prescott, Harley and Klein, "Microbiology", 7th edition Mc Graw Hill international edition.
8. Robert Weaver, "Molecular biology", 3rd edition. Mc Graw Hill international edition.
9. Nancy Trun and Janine Trempy, (2004), "Fundamental bacterial genetics", Blackwell Publishing
10. Snustad, Simmons, "Principles of genetics", 3rd edition. John Wiley & sons, Inc.

Reference books:

1. Benjamin Lewin, "Genes IX", Jones and Bartlett publishers.
2. JD Watson, "Molecular biology of the gene", 5th edition.

Course Code: USMB502

Text books:

1. Jawetz, Melnick and Adelberg's Medical Microbiology, 26th Edition, Lange publication
2. Ananthanarayan and Panicker's, Textbook of Microbiology, 10th edition
3. Ananthanarayan and Panicker's, Textbook of Microbiology, 9th edition
4. Ananthanarayan and Panicker's, Textbook of Microbiology, 8th edition
5. Kuby Immunology, 6th Edition, W H Freeman and Company
6. Pathak & Palan, Immunology: Essential & Fundamental, 1st& 3rd edition, Capital Publishing Company
7. Fahim Khan, Elements of Immunology, Pearson Education

Reference books / Internet references:

1. Kuby Immunology, 7th edition, W H Freeman and Company
2. Ananthanarayan and Panicker's, Textbook of Microbiology, 8th edition
3. Baron Samuel , Medical Microbiology, 4th edition
4. http://www.ncbi.nlm.nih.gov/books/NBK7627/
5. http://www.macmillanlearning.com/catalog/static/whf/kuby/

Course Code: USMB503

Text books:

1. Stanier, R. Y., M. Doudoroff and E. A. Adelberg. General Microbiology, 5th edition, The Macmillan press Ltd
2. Conn, E.E., P. K .Stumpf, G. Bruening and R. Y. Doi. 1987. Outlines of Biochemistry, 5th edition, 1987. John Wiley &Sons. New York.
3. Gottschalk,G., (1985), Bacterial Metabolism, 2nd edition, Springer Verlag
4. White, D., (1995), The Physiology and Biochemistry of Prokaryotes, 3rd edition, Oxford University Press
5. Nelson, D. L. and M.M. Cox (2005), Lehninger, Principles of biochemistry. 4th edition, W. H. Freeman and Company
6. Rose, A.H. (1976) Chemical Microbiology, 3rd edition. Butterworth-Heinemann
7. Zubay, G. L (1996), Biochemistry, 4th edition, Wm. C. Brown publishers
8. Mathews, C.K., K.E. van Holde, D.R. Appling, S, J, Anthony-Cahill (2012) Biochemistry, 4th edition. Pearson
9. Wilson and Walker, 4th edition Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University press.

Reference books:

1. Zubay, G. L (1996), Principles of Biochemistry, Wm. C. Brown publishers
2. Cohen, G.N. (2011). Microbial Biochemistry. 2nd edition, Springer

Course Code: USMB504

Text 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. H. A. Modi, (2009). ''Fermentation Technology'' Vol. 1 & 2, Pointer Publications, India.
6. Okafor Nduka (2007) ''Modern Industrial Microbiology and Biotechnology'', Science Publications Enfield, NH, USA.
7. Crueger W. and Crueger A. (2000) "Biotechnology -"A Textbook of Industrial
8. Microbiology", 2nd edition, Panima Publishing Corporation, New Delhi.
9. Prescott and Dunn's ''Industrial Microbiology''(1982) 4th edition, McMillan Publishers

Reference books

1. R. C. Dubey, 2005 A Textbook of ''Biotechnology'' S. Chand and Company, New Delhi.
2. H. A. Modi, 2009. ''Fermentation Technology'' Vol: 1 & 2, Pointer Publications, India
3. Practical Fermentation Technology by Brian Mcneil & Linda M. Harvey (2008).

T.Y.B.Sc. MICROBIOLOGY THEORY

(SEMESTER VI)

COURSE CODE	TITLE	CREDITS AND LECTURES / SEM
USMB601	**rDNA Technology, Bioinformatics & Virology**	**2.5 Credits (60 Lectures)**
Unit I	Recombinant DNA Technology	15 Lectures
Unit II	Applications of rDNA Technology & Bioinformatics	15 Lectures
Unit III	Regulation & Basic Virology	15 Lectures
Unit IV	Advanced Virology	15 Lectures
USMB602	**Medical Microbiology & Immunology: Part - II**	**2.5 Credits (60 Lectures)**
Unit I	Study of a Few Diseases with Emphasis on Cultural Characteristics of the Etiological Agent, Pathogenesis, Laboratory Diagnosis and Prevention.	15 Lectures
Unit II	Chemotherapy of Infectious Agents	15 Lectures
Unit III	Immunology - I	15 Lectures
Unit IV	Immunology – II	15 Lectures
USMB603	**Microbial Biochemistry: Part - II**	**2.5 Credits (60 Lectures)**
Unit I	Lipid Metabolism & Catabolism of Hydrocarbons	15 Lectures
Unit II	Metabolism of Proteins and Nucleic Acids.	15 Lectures
Unit III	Metabolic Regulation	15 Lectures
Unit IV	Prokaryotic Photosynthesis & Inorganic Metabolism	15 Lectures
USMB604	**Bioprocess Technology: Part - II**	**2.5 Credits (60 Lectures)**
Unit I	Downstream Processing	15 Lectures
Unit II	Advances in Bioprocess Technology	15 Lectures
Unit III	Quality Assurance, Quality Control, Instrumentation and Bioassay	15 Lectures
Unit IV	Industrial Fermentations	15 Lectures

T.Y.B.SC. MICROBIOLOGY THEORY (SEMESTER V)

rDNA TECHNOLOGY, BIOINFORMATICS & VIROLOGY (USMB-601)

LEARNING OBJECTIVES

rDNA technology, Bioinformatics and Virology, USMB 601 is a course for T.Y.B.Sc. in Semester VI Microbiology students which deal with the following:

1. **The rDNA technology:** This module deals with the basic steps in gene cloning, vectors, model organisms, methods of transformation and screening and identification of recombinant cells.
2. **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.
3. **Gene Regulation and Basic Virology:** This module will make the students understand the genetic basis of regulation and operon control through the involvement of regulatory proteins. The study of Basic Virology will emphasise on the structure, classification and general modes of replication of viruses.
4. **Advanced Virology:** This module deals with basic structure and life cycle of different viruses and cultivation of viruses. It also comprises of basic study on Prions, Viriods and viruses causing cancer.

LEARNING OUTCOMES:

- **r DNA technology:** This module will make the student understand the methods to construct recombinant DNA molecules, also know the tools required like vectors, restriction enzymes etc.
- **Application of rDNA technology and Bioinformatics**: The learner will know about applications of r DNA technology, through bioinformatics the student will understand the use of databases and software tools for understanding biological data.
- **Gene Regulation and Basic Virology:** The student will know about gene expression in prokaryotes, operon as a unit of gene regulation, regulation of gene expression in prokaryotes and bacteriophages. The student will also understand about general structure, life cycle and classification of viruses.
- **Advanced 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, Viriods and viruses causing cancer.
- **Practicals**: The students will acquire skill to perform the laboratory techniques and experiments based on the above topics. The students will understand computational biology and insilico analytical techniques.

rDNA TECHNOLOGY, BIOINFORMATICS & VIROLOGY

(USMB-601): DETAIL SYLLABUS

Title	Lectures / Semester	Notional Periods
Unit I: Recombinant DNA Technology	**15 L**	**15**
1.1 Branches of Genetics 1.1.1 Transmission genetics 1.1.2 Molecular genetics 1.1.3 Population genetics 1.1.4 Quantitative genetics	**1 L**	
1.2 Model Organisms 1.2.1 Characteristics of a model organism 1.2.2 Examples of model organisms used in study 1.2.3 Examples of studies undertaken using prokaryotic and eukaryotic model organisms	**2 L**	
1.3 Plasmids 1.3.1 Physical nature 1.3.2 Detection and isolation of plasmids 1.3.3 Plasmid incompatibility and Plasmid curing 1.3.4 Cell to cell transfer of plasmids 1.3.5 Types of plasmids 1.3.6 Resistance Plasmids, Plasmids encoding Toxins and other Virulence characteristics, Colfactor, Degradative plasmids	**2 L**	
1.4 Transposable Elements in Prokaryotes 1.4.1 Insertion sequences 1.4.2 Transposons: Types, Structure and properties, Mechanism of transposition, Integrons	**2 L**	
1.5 Basic steps in Gene Cloning.	**1 L**	
1.6 Cutting and joining DNA molecules - Restriction and modification systems, restriction endonucleases, DNA ligases	**3 L**	
1.7 Vectors 1.7.1 Plasmids as cloning vectors. plasmid vectors, pBR322 vector 1.7.2 Cloning genes into pBR322 1.7.3 Phage as cloning vectors, cloning genes into phage vector 1.7.4 Cosmids 1.7.5 Shuttle vectors 1.7.6 YAC 1.7.7 BAC	**3 L**	
1.8 Methods of transformation	**1 L**	

	Unit II: Applications of rDNA Technology & Bioinformatics	**15 L**	**15**
2.1	**PCR**- basic PCR and different types of PCR (Reverse transcriptase PCR, Real time quantitative PCR)	**2 L**	
2.2	**Basic techniques** 2.2.1 Southern, Northern and Western blotting. 2.2.2 Autoradiography (explain the term	**2 L**	
2.3	**Screening and selection methods for identification and isolation of recombinant cells**	**2 L**	
2.4	**Applications of recombinant DNA technology:** Site specific mutagenesis of DNA, Uses of DNA polymorphism, STRS and VNTRS, DNA molecular testing for human genetic diseases (Only RFLP), DNA typing, gene therapy, Genetic engineering of plants and animals.	**4 L**	
2.5	**Bioinformatics** 2.5.1 Introduction 2.5.2 Definition, aims, tasks and applications of Bioinformatics. 2.5.3 Database, tools and their uses – 2.5.3.1 Importance, Types and classification of databases 2.5.3.2 Nucleic acid sequence databases- EMBL, DDBJ, GenBank, GSDB, Ensembl and specialized Genomic resources. 2.5.3.3 Protein sequence databases-PIR, SWISS-PROT, TrEMBL NRL-3D.Protein structure databases-SCOP, CATH, PROSITE, PRINTS and BLOCKS. KEGG. 2.5.4 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)	**5 L**	
	Unit III: Regulation & Basic Virology	**15 L**	**15**
3.1	**A) Lac operon and problems on Lac operon** **B) Trp operon**	**7 L**	
3.2	**Regulation of lytic and lysogenic pathway of lambda phage**	**3 L**	
3.3	**Viral architecture -** Capsid, viral genome and envelope	**2 L**	
3.4	**Viral classification (Baltimore classification)**	**1 L**	
3.5	**Viral replication cycle** - Attachment, penetration, uncoating, types of viral genome, their replication, assembly, maturation & release.	**2 L**	

	Unit IV: Advanced Virology	**15 L**	**15**
4.1	Structure of TMV, T4, Influenza virus, HIV. Life cycle of T4 phage, TMV, Influenza Virus and HIV in detail**.**	**5 L**	
4.2	**Cultivation of viruses**- cell culture techniques, embryonated egg, laboratory animals, Cell culture methods: Equipment required for animal cell culture, Isolation of animal tissue	**3 L**	
4.3	**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.	**3 L**	
4.4	**Role of viruses in cancer:** Important definitions, characteristics of cancer cell, Human DNA tumor viruses- EBV, Kaposis sarcoma virus, Hepatitis B and C virus, Papiloma Virus.	**2 L**	
4.5	**Prions:** Defination, Examples of diseases caused by prions, Kuru, PrP protein and protein only hypothesis	**1 L**	
4.6	**Viroids**	**1 L**	

MEDICAL MICROBIOLOGY & IMMUNOLOGY: PART - II

(USMB-602)

LEARNING OBJECTIVES

Medical microbiology encompasses the etiology, transmission, pathogenesis, clinical manifestations, laboratory diagnosis, prophylaxis, and treatment of various diseases that are most common to humans through which the students build on the basic information regarding host defence mechanisms that they have gained in S.Y.B.Sc. A separate unit is based on chemotherapy that is available for infectious agent and the misuse of antibiotic in generation of multiple resistance strains. 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. The course has been designed to help understand the ability of our immune system to defend against invading pathogens in a logical fashion. This includes the role of T and B cells and their role in obtaining acquired immunity. It also includes the role of immunoheamatology in blood transfusion and very importantly, can we prevent pathogens from infecting us (vaccination) and the production and use of monoclonal antibodies.

LEARNING OUTCOMES:

- Give details of the virulence factors and morphological and cultural features of the pathogen
- Correlate these virulence factors with the pathogenesis and clinical features of the disease
- Comment on the mode of transmission, and modes of prophylaxis of these diseases
- Given a few key clinical features, identify the likely causative agent.
- Comment on the methods of diagnosis of the disease.
- 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 Acquire an understanding of the role of immune system in disease:
- Understand the activation of complement system
- Apply the concept of immunity to prevention of disease by development of vaccines

MEDICAL MICROBIOLOGY & IMMUNOLOGY: PART - II

(USMB-602): DETAIL SYLLABUS

Title	Lectures / Semester	Notional Periods
Unit I: Study of a Few Diseases with Emphasis on Cultural Characteristics of the Etiological Agent, Pathogenesis, Laboratory Diagnosis and Prevention.	**15 L**	**15**
1.1 Study of vector-borne infections - Malaria	**2 L**	
1.2 Study of sexually transmitted infectious diseases 1.2.1 Syphilis 1.2.2 AIDS 1.2.3 Gonorrhoea	**8 L**	
1.3 Study of central nervous system infectious diseases 1.3.1 Tetanus 1.3.2 Polio 1.3.3 Meningococcal meningitis	**5 L**	

	Unit II: Chemotherapy of Infectious Agents	**15 L**	**15**
2.1	**Attributes of an ideal chemotherapeutic agent** - Selective toxicity, Bioavailability of drug, routes of drug administration, LD50, MBC, etc.	**2 L**	
2.2	**Mode of action of antibiotics on-** 2.2.1 Cell wall (Beta-lactams- Penicillin and Cephalosporins, Carbapenems) 2.2.2 Cell Membrane (Polymyxin and Imidazole) 2.2.3 Protein Synthesis (Streptomycin, Tetracycline and Chloramphenicol) 2.2.4 Nucleic acid (Quinolones, Nalidixic acid, Rifamyicn) 2.2.5 Enzyme inhibitors (Sulfa drugs, Trimethoprim)	**8 L**	
2.3	**List of common antibiotics** - used for treating viral, fungal and parasitic diseases.	**1 L**	
2.4	**Mechanisms of drug resistance** - Its evolution, pathways and origin for ESBL, VRE, MRSA	**3 L**	
2.5	(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	**2 L**	
	Unit III: Immunology – I	**15 L**	**15**
3.1	**T cells** 3.1.1 T Cell Receptor-structure (alpha-beta, gamma-delta TCR) 3.1.2 TCR-CD_3 complex - structure and functions. Accessory molecules 3.1.3 T cell activation 3.1.3.1 TCR mediated signaling – Overview 3.1.3.2 Costimulatory signals 3.1.3.3 Superantigens induced T cell activation 3.1.4 T cell differentiation (Memory and Effector cells)	**4 L**	
3.2	**Cell mediated effector response** 3.2.1 General properties of effector T cells 3.2.2 Cytotoxic T cells and destruction of target cell by perforin/granzyme pathway and Fas pathway 3.2.3 Killing mechanism of NK cells 3.2.4 Antibody mediated cell cytotoxicity (ADCC)	**3 L**	
3.3	**B cells** 3.3.1 B cell receptor and co-receptor-structure and function 3.3.2 B cell activation and Differentiation 3.3.2.1 Thymus dependant and independent antigens	**4 L**	

	3.3.2.2 Signal transduction pathway activated by BCR-overview 3.3.2.3 Role T_H cell in B cell response-Formation of T-B conjugates, CD40/CD40L interaction, T_H cells cytokine signals		
3.4	**Humoral Response** 3.4.1 Primary and secondary responses 3.4.2 In vivo sites for induction of Humoral response 3.4.3 Germinal centers and antigen induced B cell Differentiation 3.4.3.1 Cellular events within germinal centers- Overview 3.4.3.2 Affinity maturation, somatic hyper-mutation and class switching 3.4.3.3 Generation of plasma cells and memory cells	**4 L**	
	Unit IV: Immunology – II	**15 L**	**15**
4.1	**Vaccines** 4.1.1 Active and passive immunization 4.1.2 Types of vaccines - Killed and attenuated vaccines, Whole organism vaccines, Purified macromolecules as vaccines, recombinant viral vector vaccines, DNA vaccines 4.1.3 Use of adjuvants in vaccine 4.1.4 New vaccine strategies 4.1.5 Ideal vaccine 4.1.6 Route of vaccine administration, Vaccination schedule	**7 L**	
4.2	**Immunohaematology** 4.2.1 Human blood group systems, ABO, secretors and non secretors, Bombay Blood group. Rhesus system and list of other blood group systems 4.2.2 Haemolytic disease of new born, Coombs test.	**3 L**	
4.3	**Complement System** 4.3.1 Functions and components of complement 4.3.2 Complement Activation—classical, alternative and lectin pathway 4.3.3 Biological consequences of complement activation	**3 L**	
4.4	**Monoclonal Antibodies** 4.4.1 Production and clinical uses	**2 L**	

MICROBIAL BIOCHEMISTRY: PART-II

(USMB-603)

LEARNING OBJECTIVES

Having studied many aspects of microbial physiology in the earlier semester, contents of this semester is designed to understand how myriad organic compounds such as lipids, carbohydrates, proteins and nucleic acids can be utilized by the living cells. These life mechanisms also reveal how biomolecules are synthesized. 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. Photosynthesis is studied to understand the diversity in mechanism of its electron transfer, pigments and localization of photosynthetic apparatus, although the energy conservation mechanism is not different. Microorganisms are diverse with respect to their metabolism and the field of lithotrophy explains how some universal inorganic compounds can be used to make constituents of cell biomass yet others use them as electron acceptors or reduced compounds as source of energy.

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 their significance.

- Metabolism of Lipids, Fatty acids, Nucleotides and Amino acids
- Catabolism of Protein and aliphatic hydrocarbons
- Regulation of metabolic process at various levels
- Photosynthesis
- Metabolism of inorganic molecules with special reference to nitrate and sulfate
- Biological Nitrogen fixation
- Lithotrophy

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

- Screening of microorganisms producing lipase, PHB and protease
- Detection of activity of enzymes which play an important role in amino acid and nitrate metabolism
- Quantitative detection of important metabolic products such as protein and uric acid.
- Quantitative detection of an important metabolic enzymes- protease

MICROBIAL BIOCHEMISTRY: PART-II

(USMB-603): DETAIL SYLLABUS

Title	Lectures / Semester	Notional Periods
Unit I: Lipid Metabolism & Catabolism of Hydrocarbons	**15 L**	**15**
1.1 Introduction to Lipids 1.1.1 Lipids –Definition, classification & functions 1.1.2 Types and role of fatty acids found in bacteria 1.1.3 Common phosphoglycerides in bacteria 1.1.4 Action of lipases on triglycerides /tripalmitate	**2 L**	
1.2 Catabolism of Fatty Acids and PHB 1.2.1 Oxidation of saturated fatty acid by β oxidation pathway 1.2.2 Energetics of β oxidation of Palmitic acid 1.2.3 Oxidation of propionyl CoA by acrylyl- CoA pathway and methylcitrate pathway 1.2.4 PHB as a food reserve and its degradation	**5 L**	
1.3 Anabolism of Fatty Acids & Lipids 1.3.1 Biosynthesis of straight chain even carbon saturated fatty acid (palmitic acid) 1.3.2 Biosynthesis of phosphoglycerides in bacteria 1.3.3 Biosynthesis of PHB	**6 L**	
1.4 Catabolism of aliphatic hydrocarbons 1.4.1 Organisms degrading aliphatic hydrocarbons 1.4.2 Hydrocarbon uptake mechanisms 1.4.3 Omega oxidation pathway- 1.4.3.1 Pathway in *Corynebacterium* and yeast 1.4.3.2 Pathway in *Pseudomonas*	**2 L**	
Unit II: Metabolism of Proteins and Nucleic Acids	**15 L**	**15**
2.1 Protein / amino acid catabolism 2.1.1 Enzymatic degradation of proteins 2.1.2 General reactions of amino acids catalyzed 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)	**6 L**	

2.2 Anabolism of amino acids 2.2.1 Schematic representation of amino acid families 2.2.2 Biosynthesis of amino acids of Serine family (Serine, Glycine and Cysteine)	**2 L**	
2.3 Catabolism of Nucleotides 2.3.1 Degradation of purine nucleotides up to uric acid formation 2.3.2 Salvage pathway for purine and pyrimidine nucleotides	**3 L**	
2.4 Biosynthesis of nucleotides 2.4.1 Nomenclature and structure of nucleotides 2.4.2 Role of nucleotides (high energy triphosphates) 2.4.3 Biosynthesis of pyrimidine nucleotides 2.4.4 Biosynthesis of purine nucleotides 2.4.5 Biosynthesis of deoxyribonucleotides	**4 L**	
Unit III: Metabolic Regulation	**15 L**	**15**
3.1 Definition of terms and major modes of regulation	**2 L**	
3.2 Regulation of enzyme activity 3.2.1 Noncovalent enzyme inhibition 3.2.1.1 Allosteric enzymes and feedback inhibition 3.2.1.2 Patterns of FBI, combined activation and inhibition 3.2.2 Covalent modification of enzymes 3.2.2.1 Monocyclic cascades 3.2.2.2 Examples of covalent modification(without structures) 3.2.2.3 Regulation of Glutamine synthetase	**5 L**	
3.3 DNA binding proteins and regulation of transcription by positive & negative control 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*	**4 L**	
3.4 Global regulatory mechanisms 3.4.1 Global control & catabolite repression 3.4.2 Stringent response	**2 L**	
3.5 Regulation of EMP and TCA cycle - (Schematic and Regulation of Pryruvate dehydrogenase Complex)	**2 L**	
Unit IV: Prokaryotic Photosynthesis & Inorganic Metabolism	**15 L**	**15**
4.1 Photosynthesis 4.1.1 Definition of terms in photosynthesis (light and dark reactions, Hill reaction & reagent, Photophosphorylation) 4.1.2 Photosynthetic pigments 4.1.3 Location of photochemical apparatus 4.1.4 Photochemical generation of reductant	**4 L**	

4.2 Light reactions in: 4.2.1 Purple photosynthetic bacteria 4.2.2 Green sulphur bacteria 4.2.3 Cyanobacteria (with details)	**3 L**	
4.3 Dark reaction 4.3.1 Calvin Benson cycle 4.3.2 Reductive TCA cycle	**2 L**	
4.4 Inorganic Metabolism 4.4.1 Assimilatory pathways: 4.4.1.1 Assimilation of nitrate, 4.4.1.2 Ammonia fixation – Glutamate dehydrogenase, Glutamine synthetase, GS-GOGAT, Carbamoyl phosphate synthetase 4.4.1.3 Biological nitrogen fixation (Mechanism for N_2 fixation and protection of nitrogenase) 4.4.1.4 Assimilation of sulphate 4.4.2 Dissimilatory pathways: 4.4.2.1 Nitrate as an electron acceptor (Denitrification in *Paracoccus denitrificans*) 4.4.2.2 Sulphate as an electron acceptor	**5 L**	
4.5 Lithotrophy–Enlist organisms and products formed during oxidation of Hydrogen, carbon monoxide, Ammonia, Nitrite, Sulphur, Iron.	**1 L**	

BIOPROCESS TECHNOLOGY: PART-II (USMB-604)

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. Thus, it becomes a laboratory to market scenario where the entire products reach. 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 fulfill these requirements. Thus, this paper readies 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:

- Understand the actual process involved in fermentations of important products.
- 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.

BIOPROCESS TECHNOLOGY: PART-II

(USMB-504): DETAIL SYLLABUS

Title	Lectures / Semester	Notional Periods
Unit I: Downstream Processing	**15 L**	**15**
1.1 Recovery and purification 1.1.1 Introduction 1.1.2 Methods of DSP: Precipitation, Filtration, Centrifugation, Cell Disruption, Liquid-Liquid Extraction, Solvent Recovery, Chromatography, Membrane Processes, Drying, Crystallization, Whole Broth Processing	**10 L**	
1.2 Effluent treatment – Introduction, Dissolved oxygen concentration as indicator of water quality, The strength of fermentation effluents, Treatment process (Physical, chemical and biological)	**5 L**	
Unit II: Advances in Bioprocess Technology	**15 L**	**15**
2.1 Animal biotechnology 2.1.1 Primary cell culture and established cell lines 2.1.2 Basic principles 2.1.3 Growth media 2.1.4 Cell viability 2.1.5 Scale up of cultured cells and tissue 2.1.6 Applications of cell culture: Vaccines, somatic cell fusion, valuable products.	**5 L**	
2.2 Plant tissue culture 2.2.1 Introduction	**5 L**	

2.2.2 Requirements for in vitro culture, Methods of plant cell and tissue culture 2.2.3 Types of cultures of plant materials: explants, callus, organogenesis, root culture, shoot culture, micropropogation, suspension culture, protoplast culture, protoplast fusion and somatic hybridization**.** 2.2.4 Applications: production of disease resistant plants, production of virus free plant, 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** 2.3.1 Introduction and Definitions 2.3.2 Methods 2.3.3 Immobilized Enzyme Reactors 2.3.4 Applications	**5 L**	
Unit III: Quality Assurance, Quality Control, Instrumentation and Bioassay **3.1 Quality assurance and quality control** 3.1.1 Definitions, Chemical and pharmaceutical products 3.1.2 Variables of batch process 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** **3.3 Instrumentation: Principles, working and application of** 3.3.1 Spectrophotometry: UV, Visible & IR 3.3.2 AAS & AES (Flame photometry) **3.4 Bioassay** 3.4.1 Introduction 3.4.2 Types: Diffusion, End Point, Turbidometric, Metabolic Response, Enzymatic **3.5 Intellectual property rights** 3.5.1 Genesis, Role of WTO and TRIPS 3.5.2 Overview of patent system 3.5.3 Requirements for patentability 3.5.4 Patent Categories 3.5.5 Preliminary steps for patent applications 3.5.6 Patent Procedures 3.5.7 For biotech and microbiological products	**15 L** **4 L** **2 L** **3 L** **3 L** **3 L**	**15**

	Unit IV: Industrial Fermentations	**15 L**	**15**
4.1	**Penicillin and semisynthetic penicillins:** Introduction, biosynthesis and regulation, strain development, production methods. Semisynthetic penicillins: Examples, production, advantages	**3 L**	
4.2	**Aminoglycoside: Streptomycin:** Aminoglycoside antibiotics, biosynthesis, regulation of biosynthesis, strain development, production method, recovery.	**3 L**	
4.3	**Vitamin B $_{12}$:** Occurrence and economic significance,structure, biosynthesis, production based on media containing carbohydrates by- *Propionibacteria* and *Pseudomonas,* recovery.	**2 L**	
4.4	**Citric acid:** Introduction, strains used for production, biosynthesis, nutrient media, production processes- surface and submerged, product recovery.	**3 L**	
4.5	**Glutamic acid:** Production strains, biosynthesis, effect of permeability on production, conditions of manufacturing, production process and recovery.	**2 L**	
4.6	**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	**2 L**	

T.Y.B.Sc. MICROBIOLOGY PRACTICALS (SEMESTER-VI)

Course Code: USMBP07

[Practicals Based on USMB601, Credits -1.5, Lectures- 60, Notional Periods-15]

1. Isolation of genomic DNA of *E. coli* and measurement of its concentration by UV-VIS.
2. Enrichment of coliphages, phage assay (pilot & proper).
3. Restriction digestion of lambda phage /any plasmid DNA (Demo)
4. Beta galactosidase assay
5. Bioinformatics practicals

   On Line Practical
   i. Visiting NCBI and EMBL websites & list services available, software tools available and databases maintained
   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

6. Animal cell culture (Demo)

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

1. Demonstration of malarial parasite in blood films (Demo)
2. Selection and testing of antibiotics using the Kirby-Bauer method
3. Determination of MBC of an antibiotic.
4. Blood grouping – Direct & Reverse typing
5. Coomb's Direct test
6. Determination of Isoagglutinin titer
7. Demonstration experiments - Widal, VDRL

Course Code: USMBP08
[Practicals Based on USMB603; Credits-1.5, Lectures- 60, Notional Periods-15]

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. Study of breakdown of amino acids – Lysine decarboxylase and Deaminase activity
8. Study of Lithotrophs – Nitrosification and Nitrification

Course Code: USMBP08
[Practicals Based on USMB604, 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
7. Estimation of phenol.
8. Industrial Visit

TEXT BOOKS AND REFERENCE BOOKS

(SEMESTER VI)

Course Code: USMB601

Text 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. Prescott, Harley and Klein, "Microbiology",. 7th edition Mc Graw Hill international edition.
7. Edward Wagner and Martinez Hewlett, (2005) "Basic Virology", 2nd edition, Blackwell Publishing
8. Teri Shors,.(2009), "Understanding viruses", Jones and Bartlett publishers.
9. S.Ignacimuthu, (2005), "Basic Bioinformatics", Narosa publishing house.
10. Robert Weaver, (2008), "Molecular biology", 3rd edition, Mc Graw Hill international edition.
11. Primrose and Twyman, (2001), "Principles of gene manipulation and genomics", 6th edition, Blackwell Publishing
12. Arthur Lesk, (2009), "Introduction to Bioinformatics", 3rd edition, Oxford University Press
13. Snustad, Simmons, "Principles of genetics", 3rd edition. John Wiley & sons, Inc.
14. A textbook of biotechnology R. C. Dubey 4 th edition. S. Chand.

Reference books:

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

Course Code: USMB602

Text books:

1. Jawetz, Melnick and Adelberg's Medical Microbiology, 26th edition, Lange publication
2. Ananthanarayan and Panicker's, Textbook of Microbiology, 10th edition 2017

3. Ananthanarayan and Panicker's, Textbook of Microbiology, 9th edition
4. Ananthanarayan and Panicker's, Textbook of Microbiology, 8th edition
5. Introduction to diagnostic microbiology for lab Science Maria Dannessa Delost 2015
6. Prescott's microbiology 10th edition 2017
7. Kuby Immunology,4th and 6th edition, W H Freeman and Company
8. Pathak & Palan, Immunology: Essential & Fundamental, 1st& 3rd edition, Capital Publishing Company
9. Fahim Khan, Elements of Immunology, Pearson Education

Reference books / Internet references:

1. Baron Samuel , Medical Microbiology, 4th edition
http://www.ncbi.nlm.nih.gov/books/NBK7627/
2. Kuby Immunology, 7th edition, W H Freeman and Company
http://www.macmillanlearning.com/catalog/static/whf/kuby/

Course Code: USMB603

Text books:

1. Stanier, R. Y., M. Doudoroff and E. A. Adelberg. General Microbiology, 5th edition, The Macmillan press Ltd.
2. Conn, E.E., P. K. Stumpf, G. Bruening and R. Y. Doi. 1987. Outlines of Biochemistry, 5th edition, 1987. John Wiley & Sons. New York.
3. Gottschalk, G., (1985), Bacterial Metabolism, 2nd edition, Springer Verlag
4. White, D., (1995), The Physiology and Biochemistry of Prokaryotes, 3rd edition, Oxford University Press
5. Nelson, D. L. and M.M. Cox (2005), Lehninger, Principles of biochemistry, 4th edition, W. H. Freeman and Company.
6. G. Moat, J.W. Foster, M, P. Spector. (2002), Microbial Physiology, 4th edition, WILEY-LISS
7. Madigan, M.T. and J.M. Martinko2006. 11th edition, Brock Biology of Microorganisms. Pearson Prentice Hall.

Reference books:

1. Zubay, G. L (1996), Biochemistry, 4th edition, Wm. C. Brown publishers
2. Zubay, G. L (1996), Principles of Biochemistry, Wm. C. Brown publishers
3. Principles of Biochemistry, Lehninger, 5th edition, W. H. Freeman and Company

Course Code: USMB604

Text 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. H. K. Das., "Text book of Biotechnology", 2nd and 3rd edition.
5. A textbook of biotechnology R. C. Dubey 4th edition. S. Chand.
6. H. A. Modi, (2009). ''Fermentation Technology'' Vol. 1 & 2, Pointer Publications, India
7. Okafor Nduka (2007) ''Modern Industrial Microbiology and Biotechnology'', Science Publications Enfield, NH, USA.
8. Crueger W. and Crueger A. (2000) "Biotechnology -"A Textbook of Industrial
9. Microbiology", 2nd edition, Panima Publishing Corporation, New Delhi.
10. Prescott and Dunn's ''Industrial Microbiology'' (1982) 4th edition, McMillan Publishers.
11. Veerakumari L. "Bioinstrumentation", MJP Publisher
12. Pharmaceutical Microbiology, Hugo and Russell, 7th edition, Blackwell Science.

Reference books

1. Peppler, H. J. and Perlman, D. (1979), "Microbial Technology''. Vol 1 & 2, Academic Press.
2. Williams, Bryan L; Wilson, 2nd edition." A Biologist's guide to principles and techniques of practical biochemistry" Baltimore: University Park Press, 1981.
3. Wilson, Keith, 1936-; Goulding, Kenneth H, 3rd edition., A Biologist's guide to principles and techniques of practical biochemistry" London ; Baltimore : E. Arnold, 1986.
4. Wilson and Walker, "Principles and techniques of practical biochemistry" 5th edition.

Modality of Assessment
Assessment pattern for theory

Scheme of Examination

The learner's Performance shall be assessed by conducting the Semester End Examinations with 100% marks

Semester End Theory Assessment - 100% **100 marks**

1. Duration - These examinations shall be of **3 hours** duration.
2. Theory question paper pattern :-
   i. There shall be **five questions** each of **20** marks (with internal options)
   ii. Question one will be based on unit one, question two on unit two, question three on unit three and question four on unit four. Question five will have questions from all four units of the syllabus.
   iii. Each of the main questions one to four will be subdivided into two sub-questions "A" and "B". Sub-question "A" will have four questions (of 6 marks each) out of which any two will be attempted. Total marks allotted to sub-question "A" will be 12 marks. Sub-question "B" will be 'Do as directed (attempt eight out of twelve)'. Each question in Sub-question "B" will be of one mark each. Total marks allotted to "B" sub-question will be 8 marks. Main question five will have six questions (of 5 marks each) out of which any four will be attempted, total 20 marks.
   iv. All questions shall be **compulsory** with internal choice within the questions.
   v. The allocation of marks will depend on the weightage of the topic.

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
USMBP05	Based on USMB501 and USMB502 of Semester V	Credits 3 (8 periods/week) = 120 periods/semester
USMBP06	Based on USMB503 and USMB504 of Semester V	Credits 3 (8 periods/week) = 120 periods/semester

Semester V

Course	USMB-501	USMB-502	USMB-503	USMB-504	Grand Total
Theory	**100**	**100**	**100**	**100**	**400**
Practicals	**50**	**50**	**50**	**50**	**200**

Semester VI

Course	USMB-601	USMB-602	USMB-603	USMB-604	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
USMBP05	Based on USMB501 and USMB502 of Semester V	Credits 3 (8 periods/week) = 120 periods/semester
USMBP06	Based on USMB503 and USMB504 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
USMBP07	Based on USMB601 and USMB602 of Semester VI	Credits 3 (8 periods/week) = 120 periods/semester
USMBP08	Based on USMB603 and USMB604 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 Courses)**		**Second Year (Credit x No. of Courses)**		**Third Year (Credit x No. of Courses)**		**Total Credit Value**
	First Semester	**Second Semester**	**Third Semester**	**Fourth Semester**	**Fifth Semester**	**Sixth Semester**	
Core Courses (Theory)	04x03	04x03	06x02	06x02	2.5x04	2.5x04	68
Core Courses (Practicals)	02x03	02x03	03x02	03x02	1.5x04	1.5x04	36
Foundation course	02x01	02x01	02x01	02x01			08
Applied Component Courses (Theory)					02x01	02x01	04
Applied Component Courses (Practical)					02x01	02x01	04
Total	**20**	**20**	**20**	**20**	**20**	**20**	**120**