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 2016–2017)

PREAMBLE

With the introduction of Credit Based Semester & Grading System (CBSGS) and continuous evaluation consisting of components of Internal Assessment & External Assessment by the esteemed University from the academic year 2011-12 at F.Y.B.Sc.level,the earlier existing syllabus of F.Y.B.Sc.Microbiology was restructured according to the CBSGS pattern for implementation from 2011-12.Likewise the existing syllabi of S.Y.B.Sc.and T.Y. B.Sc. Microbiology were restructured as per the CBSGS pattern for their implementation from 2012-13 and 2013-14 respectively.

The existing syllabi of F.Y.B.Sc.and S.Y.B.Sc. Microbiology were due for revision and for it's implementation from the academic year 2014-15 and 2015-16 respectively. Now it is the existing syllabus of T.Y.B.Sc. Microbiology which was due for revision as per the CBSGS pattern and for it's implementation from the academic year 2016-17.

Keeping in tune with the revised syllabi of F.Y.B.Sc. and S.Y.B.Sc., the sub-committee has taken utmost care to maintain the continuity in the flow of information of higher level at T.Y.B.Sc.Hence some of the modules of the earlier syllabus of T.Y.B.Sc.have been upgraded with the new modules in order to make the learners aware about the recent developments in various branches of Microbiology (like Microbial Genetics, Molecular Biology, Virology, Medical Microbiology, Immunology, Microbial Biochemistry, Industrial Microbiology, Microbial Biotechnology) with an objective to raise the students awareness in interdisciplinary courses such as Biostatistics, Biophysics, Bioinformatics , Computational Biochemistry, Bioinstrumentation, Nanoscience and Astrobiology.
All the 08 courses of theory and practicals (Semester-V & Semester-VI together) are compulsory to the students offering microbiology as a single major subject (6 units pattern of the old course).These courses are :-

1. USMB501and USMB601
2. USMB502 and USMB602
3. USMB503 and USMB603
4. USMB504 and USMB604

However,students opting for double major subject (3 units pattern of old course) shall have following 04 courses of theory and practicals (Semester-V & Semester-VI together) compulsory:-

1. USMB501 and USMB601
2. USMB502 and USMB602

I am thankful to co-conveners and all the members of our sub-committees for their great efforts and for timely submission of the draft syllabus.

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	MUTATION AND REPAIR	15 lectures
Unit III	HOMOLOGOUS RECOMBINATION &GENETIC EXCHANGE	15 lectures
Unit IV	PLASMIDS, TRANSPOSONS & OPERONS	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 AETIOLOGICAL 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	15 Lectures

	&CATABOLISM OF CARBOHYDRATES	
Unit IV	FERMENTATIVE PATHWAY& ANABOLISM OF CARBOHYDRATES	15 Lectures
USMB504	**BIOPROCESS TECHNOLOGY & ENVIRONMENTAL MICROBIOLOGY.**	**2.5 credits (60 Lectures)**
Unit I	UPSTREAM PROCESSING	15 lectures
Unit II	FERMENTER EQUIPMENT AND CONTROL:	15 lectures
Unit III	DOWNSTREAM PROCESSING & ENVIRONMENTAL ASPECTS	15 lectures
Unit IV	TRADITIONAL INDUSTRIAL FERMENTATIONS : PART-I	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 : USMB-501(Microbial Genetics)

Learning Objectives:

Microbial Genetics isan undergraduate T.Y. B.Sc. Microbiology coursethat deals with both conceptual and practicaltools for generating, processing and understanding biological genetic information. It develops knowledge of the underlying theories of genetics which exhibits a broad understanding of genetic exchange among prokaryotes.It also gives students hands-on competence in fundamental molecular biology theories and laboratory techniques.It gives an overview of recombinant DNA technology and biotechnology applications utilising genetic manipulation.It also provides practical experience of the major analytical techniques used in bioinformatics.It also deals with basic structure and life cycle of different types of viruses and explains different terminologies like cancer, prions, viriods and their mechanism.This course will help students to build on the basic information regarding DNA structure transcription, translation and genetic code that they have gained in S. Y. B.Sc.

Learning Outcomes: Students should be able to-

- Understand the molecular mechanism involved in DNA replication
- Understand how to identify and classify mutations in DNA followed bymechanism of DNA repair
- Understand basic concepts of homologous recombination and genetic exchange among prokaryotes
- Understand natural plasmids and transposons present in prokaryotes
- Understand an account of prokaryotic gene structure and the mechanisms controlling gene expression

USMB-501: DETAIL SYLLABUS

Course Code	Title	Lectures/ Semester	Notional Periods
USMB501	**MICROBIAL GENETICS**	**2.5 Credits (60 Lectures)**	**Self Study (60)**
	UNIT I **DNA REPLICATION** 1.1. **Historical perspective**— conservative, dispersive, semi-conservative, Bidirectional and semi-discontinuous 1.2. **Prokaryotic DNA replication** – Details of molecular mechanism involved in Initiation, Elongation nd Termination 1.3. **Enzymes and proteins associated with DNA replication-** primase, helicase, topoisomerase, SSB, DNA polymerases, ligases, Ter and Tus proteins 1.4. **Eukaryotic DNA replication--** Molecular details of DNA synthesis, replicating the ends of the chromosomes 1.5. **Rolling circle mode of replication**	**15 Lectures** **4 Lectures** **4 Lectures** **4 Lecture** **2 Lecture** **1 Lectures**	**15**
	UNIT II **MUTATION AND REPAIR** **2.1. Mutation** 2.1.a.**Terminology:** alleles, homozygous, heterozygous, genotype, phenotype, Somatic mutation, Germline mutation, Gene mutation, Chromosome mutation, phenotypic lag, hotspots and mutator genes 2.1.b. Fluctuation test. 2.1.c. **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.	**15 Lectures** **1 Lectures** **1 Lecture** **1 Lectures**	**15**

	2.1.d. **Causes of mutation:** Natural/spontaneous mutation--replication error, depurination, deamination. Induced mutation: principle and mechanism with illustrative diagrams for – i. Chemical mutagens- base analogues, nitrous acid, hydroxyl amine, intercalating agents and alkylating agents. ii. Physical mutagen iii. Biological mutagen(only examples) 2.1.e. Ames test 2.1.f. Detection of mutants **2.2. DNA Repair** a. Mismatch repair, b. Light repair c. Repair of alkylation damage d. Base excision repair e. Nucleotide excision repair f. SOS repair	**5 Lectures** **1 Lectures** **1 Lectures** **5 Lectures**	
	UNIT III **GENETIC EXCHANGE** **3.1. Gene transfer mechanisms in bacteria& homologous recombination** 3.1.a. Transformation i. Introduction and History ii. Types of transformation in prokaryotes--Natural transformation in *Streptococcus pneumoniae, Haemophilus influenzae,* and *Bacillus subtilis* iii. Mapping of bacterial genes using transformation. iv. Problems based on transformation. 3.2.b. Conjugation i. Discovery of conjugation in bacteria ii. Properties of F plasmid/Sex factor iii. The conjugation machinery iv. Hfr strains, their formation and mechanism of conjugation v. F' factor, origin and behavior of F' strains, Sexduction. vi. Mapping of bacterial genes using conjugation	**15 Lectures** **4 Lectures** **5 Lectures**	**15**

	(Wolman and Jacob experiment). vii. Problems based on conjugation 3.3.c.Transduction i. Introduction and discovery ii. Generalised transduction iii. Use of Generalised transduction for mapping genes iv. Specialised transduction v. Problems based on transduction **3.4. Recombination in bacteria** 3.4.a. General/Homologous recombination i. Molecular mechanism ii. Holliday model of recombination b. Site –specific recombination	**3 Lectures** **3 Lectures**	
	UNIT IV **PLASMIDS, TRANSPOSONS & OPERONS (REGULATION)** **4.1.Plasmids** a. Physical nature b.Detection and isolation of plasmids c. Plasmid incompatibility and Plasmid curing d. Cell to cell transfer of plasmids e. Types of plasmids i. Resistance Plasmids, ii. Plasmids encoding Toxins and other Virulence characteristics iii. col factor iv. Degradative plasmids **4.2.Transposable Elements in Prokaryotes** a. Insertion sequences b. Transposons i. Types ii. Structure and properties iii. Mechanism of transposition iv. Transposon mutagenesis c. Integrons **4.3. Lac operon and problems on Lac operon Trp operon**	**15 Lectures** **4 Lecture** **4 Lectures** **7 Lectures**	**15**

T. Y. B. Sc. Microbiology Theory:

USMB-502 (Medical Microbiology &Immunology: Part-I)

Learning objectives:

One of the most important areas of microbiology, medical microbiology encompasses the aetiology, transmission, pathogenesis, clinical manifestations, laboratory diagnosis, prophylaxis, and treatment of various diseases that are enlisted in the syllabus. This course will help students to build on the basic information regarding host defence mechanisms that they have gained in S. Y. B.Sc.Immunology is an integral part of Medical Microbiology and this course is designed for T.Y.B.Sc. Microbiology students and it is assumed 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 our innate ability to defend against microorganisms (innate immunity); should this first line of defence fail, how we can fight infections (acquired immunity); if we react excessively, what price we pay (hypersesitivity); and very importantly, how we can prevent pathogens from infecting us (vaccinantion).

Learning Outcomes: (Medical Microbiology) 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, epidemiology and therefore 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.

Learning Outcomes: (Immunology) Should be able to-

- Conceptualize how the innate and adaptive immune responses coordinate to fight invading pathogens
- Discuss the role of antigen in initiating the immune response
- Correlate the structure & functions of immunoglobulin
- Understand the importance of all the other entities involved ie T cells, B cells, NK cells, APCs, Cytokines, MHC, TcR, BcR, Co-receptors, Signalling pathways etc

USMB-502: DETAIL SYLLABUS

Course Code	Title	Lectures/ Semester	Notional Periods
USMB502	**MEDICAL MICROBIOLOGY AND IMMUNOLOGY**	**2.5 Credits (60 lectures)**	**Self Study (60)**
	UNIT I **BACTERIAL STRATEGIES FOR EVASION AND STUDY OF A FEW DISEASES**	**15**	**15**
	1A. Study of virulence mechanisms in bacteria	**01**	
	1.1. Identifying bacteria that cause disease		
	1.2. Genomics and bacterial pathogenicity	**01**	
	1.2.1. The clonal nature of bacterial pathogens		
	1.2.2. Mobile genetic elements		
	1.2.3. Pathogenicity islands		
	1.3. Bacterial virulence factors	**03**	
	1.3.1. Adherence factors		
	1.3.2. Invasion of host cells and tissues		
	1.3.3. Toxins		
	1.3.3.1. Exotoxins		
	1.3.3.2. Exotoxins associated with diarrhoeal diseases and food poisoning		
	1.3.3.3. LPS of gram negative bacteria		
	1.3.4. Enzymes		
	1.3.4.1. Tissue degrading enzymes		
	1.3.4.2. IgA1 proteases		
	1.3.5. Antiphagocytic factors		
	1.3.6. Intracellular pathogenicity		
	1.3.7. Antigenic heterogeneity		
	1.3.8. The requirement for iron		
	1.3.9. The role of biofilms		
	1B. Study of A Few Infectious Diseases of the Respiratory Tract with Emphasis on Cultural Characteristics of the Aetiological Agent, Pathogenesis & clinical features, Laboratory Diagnosis And Prevention	**10**	
	1.1. *S. pyogenes* infections		
	1.2. Diphtheria		
	1.3. Common cold		
	1.4. Tuberculosis		
	1.5. Pneumonia caused by *K .pneumoniae*		

	UNIT II **STUDY OF A FEW DISEASES WITH EMPHASIS ON CULTURAL CHARACTERISTICS OF THE AETIOLOGICAL AGENT, PATHOGENESIS & CLINICAL FEATURES, LABORATORY DIAGNOSIS AND PREVENTION.** **2.1 Study of skin infections** 2.1.1 Leprosy 2.1.2 Fungal infections- Oral Thrush 2.1.3 Pyogenic skin infections caused by *Pseudomonas* and *S. aureus.* **2.2 Study of gastrointestinal tract infections** 2.2.1 Enteric fever- *Salmonella* 2.2.2 Shigellosis 2.2.3 Rotavirus diarrhoea 2.2.4 Dysentery due to *Entamoebahistolytica* 2.2.5 Infections due to Enteropathogenic *E.coli* strains **2.3 Study of urinary tract infections**	**15** **05** **08** **02**	**15**
	UNIT III : GENERAL IMMUNOLOGY-I **3.1. Antigens** 3.1.1.Immunogenicity versus antigenicity 3.1.2.Factors that influence immunogenicity – foreignness, molecular size, chemical composition, heterogenicity, ability to be processed and presented, contribution of the biological system to immunogenicity – genotype of the recipient, animal, immunogen dosage, route of administration and adjuvants 3.1.3.Epitopes / antigen determinants (only concepts) 3.1.4.Haptens and antigenicity 3.1.5.Immunogenicity of some natural substances – native globular proteins, polysaccharides, lipids, nucleic acids Types of antigens – heterophile antigens, isophile antigens, sequestered antigens, super antigens, bacterial and viral antigens **3.2. Immunoglobulins** 3.2.1. Immunoglobulins – basic and fine structure 3.2.2.Immunoglobulin classes and biological activities 3.2.3.Antigenic determinants on immunoglobulins – isotypes, allotypes, idiotypes 3.2.4.Immunoglobulin Superfamily	**15** **05** **07**	**15**

	3.2.5.Monoclonal antibodies, Production (Diagrammatically) & applications **3.3. T Cells, B cells and NK Cells** **3.4. Antigen presenting cells** Antigen presentation- professional and non-professional cells and processing pathways, (Cytosolic and Endocytic pathway)	**01** **02**	
	UNIT IV : GENERAL IMMUNOLOGY- II **4.1. Cytokines** 4.1.1. Properties and functions 4.1.2. Cytokines secreted by Th1 and Th2 cells **4.2. MHC complex and MHC molecules** 4.2.1. Structure of class I, and class II molecules; class III molecules 4.2.2. Peptide – MHC interaction **4.3. T cells** 4.3.1. Receptors, structure (alpha-beta, gamma-delta TcR) 4.3.2. TcR-CD3 complex structure & functions. Accessory molecules. 4.3.3. Subsets of T cells (Th1, Th2, T reg) 4.3.4. T cell activation, Costimulatory molecules, T cell differentiation (memory & effector cell) **4.4. B cells** 4.4.1. Receptors----structure & organization 4.4.2. B cell activation and differentiation – i)Thymus dependent and independent antigens, ii) B cell activating signals, iii) Role of Th cells in Humoral response, formation of T – B conjugates, CD40 / CD40L interaction, Th cell cytokine signals.	**15** **02** **03** **05** **05**	**15**

T.Y.B.Sc.Microbiology Theory :

USMB-503 (Microbial Biochemistry : Part-I)

Learning objectives:

This course is designed for T.Y.B.Sc. Microbiology students in order that the students achieve a basic understanding of solute transport and metabolism. The course has been designed to expose students to methods of studying energy generation, fermentative metabolism as well as anabolism.

There has been a lot of importance attached to biochemical reactions in living cells. The student must be exposed to the mechanism of solute transport and methods to study the same. The students are already exposed to laws of thermodynamics in the lower level,however, they should be made aware of the electron transport chain in Procaryotes and Mitochondria. ATP synthesis and anabolic mechanisms need to be explained to the students to understand the breakdown of mono, di and oligosaccharides. The students will also be exposed to the fermentative pathways and anabolic reactions.

Learning Outcomes: 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.

USMB-503: DETAIL SYLLABUS

Course Code	Title	Lectures/ Semester	Notional Periods
USMB 503	**MICROBIAL BIOCHEMISTRY:(Part- I)**	**2.5 Credits (60 lectures)**	**Self Study (60)**
	UNIT I **BIOLOGICAL MEMBRANES & TRANSPORT**	**15**	**15**
	1.1 Composition and architecture of membrane 1.1.1. Lipids 1.1.2. Integral & peripheral proteins & interactions with lipids 1.1.3. Permeability and outer membrane- a barrier 1.1.4. Aquaporins 1.1.5. Mechanosensitive channels	**02**	
	1.2 Methods of studying solute transport 1.2.1. Using whole cells 1.2.2. Using Liposomes 1.2.3. Using Proteoliposome	**02**	
	1.3 Solute transport across membrane 1.3.1. Passive transport facilitated by membrane proteins. 1.3.2. Transporters grouped into Superfamilies 1.3.3. Co transport across plasma membrane (Uniport, Antiport, Symport) 1.3.4. Active transport & electrochemical gradient 1.3.5. Ion gradient provides energy for secondary activetransport eg. Lactose transport 1.3.6. ATPases and transport 1.3.7. ABC transporters e.g. Histidine transport 1.3.8. Shock sensitive system – Role of binding proteins e.g. Maltose uptake 1.3.9. Phosphotransferase system 1.3.10.Schematic representation of various Membrane transport mechanisms in *E. coli*	**08**	
	1.4 Other examples of solute transport- 1.4.1. Iron transport : A special problem 1.4.2. Bacterial protein export 1.4.3. Bacterial membrane fusion central to many biological processes	**03**	

	UNIT II **BIOENERGETICS AND BIOLUMINESCENCE.**	**15** **Revision**	**15**
	2.1. Biochemical mechanism of generating ATP- Substrate level, Oxidative, and Photo Phosphorylation	**04**	
	2.2 Electron transport chain 2.2.1. Universal Electron acceptors that transfer electrons to ETC. 2.2.2. Carriers in ETC i. Hydrogen carriers – Flavoproteins, Quinones ii. Electron carriers – Iron sulphur proteins, Cytochromes 2.2.3. Mitochondrial ETC i. Biochemical anatomy of mitochondria ii. Complexes in Mitochondrial ETC iii.Schematic representation of Mitochondrial ETC	**03**	
	2.3 Prokaryotic ETC 2.3.1. Organization of electron carriers in bacteria 2.3.2. Generalised electron transport pathway in bacteria 2.3.3. Different terminal oxidases 2.3.4. Branched bacterial ETC 2.3.5. Pattern of electron flow in ***E. coli*** - aerobic and anaerobic 2.3.6. Pattern of electron flow in***Azotobacter vinelandii***	**03**	
	2.4. ATP synthesis 2.4.1. Explanation of terms – Proton motive force, Proton pump, Coupling sites, P:O ratio, Redox potential 2.4.2. Free energy released during electron transfer from NADH to O_2. 2.4.3. Chemiosmotic theory 2.4.4. Structure & function of Mitochondrial ATP synthase (No Kinetics) 2.4.5. Mechanism by Rotational catalysis 2.4.6. Structure of bacterial ATP synthase 2.4.7. Inhibitors of ETC, Inhibitors of ATPase, Uncouplers, Ionophores	**03**	
	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, Significance, Function as proton pump, **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 **UNIT III** **METHODS OF STUDYING METABOLISM & CATABOLISM OF CARBOHYDRATES** **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 i. Pulse labeling ii. Assay & study of radiorespirometry – to differentiate EMP & ED 3.1.5. Use of biochemical mutants. 3.1.6. Sequential induction technique **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. 3.2.4. Major pathways- i. Glycolysis (EMP) ii.HMP Pathway & Significance of the pathway iii. ED pathway, iv. TCA cycle & Significance of the cycle v. Anaplerotic reactions vi. Glyoxylate bypass, vii. Incomplete TCA in anaerobic bacteria **3.3 Amphibolic role of EMP and TCA cycle**	**02** **15** **03** **10**	**15**

	3.4 Energetics of Glycolysis, ED and TCA pathway – Balance sheet only(No efficiency calculation)	**01** **01**	
	UNIT IV **FERMENTATIVE PATHWAY& ANABOLISM OF CARBOHYDRATES**	**15**	**15**
	4.1 Fermentative pathways (With structures and enzymes) 4.1.1. Lactic acid fermentation – i. Homofermentors ii. Heterofermentors iii. Bifidobacterium pathway (Schematic) 4.1.2. Alcohol fermentation i. by ED pathway in bacteria ii. by EMP in yeasts	**04**	
	4.2 Other modes of fermentations in microorganisms 4.2.1. Mixed acid, 4.2.2. Butanediol 4.2.3. Butyric acid 4.2.4. Butanol-acetone 4.2.5. Propionic acid (Acrylate pathway and succinate propionate pathway)	**05**	
	4.3 Anabolism of Carbohydrates 4.3.1. General pattern of metabolism leading to synthesis of a cell from Glucose 4.3.2. Gluconeogenesis (Mitochondrial aspect not included) 4.3.3. Biosynthesis of Glycogen 4.3.4. Biosynthesis of Peptidoglycan	**06**	

T.Y.B.Sc.Microbiology Theory : USMB-504 (Bioprocess Technology & Environmental Microbiology)

Learning Objectives

Bioprocess Technology & Environmental Microbiology 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.The downstream process and the environmental aspects of the final product are also included.

Industrial and Environmental Microbiology 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 and enzymes along with the analysis techniques using various instruments and statistical tools.

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: 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 and continuous 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
- Design an industrial process by keeping in view the strict guidelines for its recovery & disposal
- Learner will be well –versed with the environmental aspects such as carbon credits & containment levels.
- Learn to develop the corrective measures for dealing with the environmental pollution and its consequences.

USMB-504: DETAIL SYLLABUS

Course Code	Title	Lectures/ Semester	Notional Periods
USMB 504	**BIOPROCESS TECHNOLOGY & ENVIRONMENTAL MICROBIOLOGY.**	**2.5 CREDITS (60 LECTURES)**	**Self Study (60)**
	UNIT I **UPSTREAM PROCESSING :** **1.1 Strain Improvement of industrial microorganisms** Selection of induced mutants Selection of mutants with altered permeabilility Isolation of mutants not producing Feed Back Inhibitors or Feed Back repressors (All Methods –Only one example) Use of auxotrophs for production of primary metabolites. Example aspartate family. Isolation of mutants that do not recognize the presence of inhibitors & repressors with example(Gradient plate –Lysine) Isolation of auxotrophic mutants example-(Penicillin-Davies technique &Minaturized tech) Isolation of induced mutants for secondary metabolites. Isolation of resistant mutants. Isolation of revertant mutants. **1.2 Sterilization** Introduction. Media sterilization (Concept of nabla factor), Design of batch sterilization. Methods of batch sterilization,- Design of continuous sterilization, Methods – Heat	**15L** **10** **5**	**15**
	UNIT II **FERMENTER EQUIPMENT AND CONTROL** **2.1.Design of fermenter** Scale Up, Basic functions of fermenter,- Aseptic operation & containment ,Body construction, Aeration and agitation:Agitators, Stirrer glands & bearing, Mechanical seals(Names & Functions ,no diagrams), Magnetic Drive, - Baffles, Sparger: porous, orifice; nozzle; combined. Achievement & maintenance of ascetic condition,	**15** **10**	**15**

	Valves / Steam traps - function in general & examples. Types of fermenters:Acetator, Cavitator, Tower fermenter, Cylindro conical, Air lift – outer loop / inner loop, Deep jet, Cyclone column, Packed tower (generator), Rotating disc, Bubble cap. **2.2 Instrumentation & Control of variables** Introduction, Types of sensors, Sensing & Control of- pH, temp, Dissolved oxygen, Flow measurement &control, Pressure, Inlet / Exit gas analysis, Foam sensing, Oxygen	**5**	
	UNIT III **DOWNSTREAM PROCESSING & ENVIRONMENTAL ASPECTS :** **3.1.Downstream processing** Recovery & Purification of fermentation products Introduction, Precipitation, Filtration - theory, filter-aids, batch filters(Plate and frame filters), continuous filters.(Rotary vaccum),Centrifugation : flocculating agent, range of centrifuges - Basket, tubular bowl. Cell disruption: Physico-chemical. Liquid – Liquid extraction, Solvent recovery, Chromatography –Ion exchange & Adsorption Membrane processes – Ultrafiltration, reverse osmosis, liquid membranes.Drying , Crystallization ,Whole broth processing. **3.2 .Environmental aspects** 3.2.1 Effluent treatment 3.2.2. Carbon Credits - Environmental Degradation issues and challenges	**15** **10** **5**	**15**

	UNIT IV **TRADITIONAL INDUSTRIAL FERMENTATIONS :PART-I** 4.1. Beer –Ale and Lager 4.2. Wine –Red and white & Champagne 4.3. Vinegar (acetator& Generator) 4.4. Alcohol from molasses 4.5. Baker's yeast 4.6. Fungal amylase by solid substrate fermentation	**15** **3** **3** **3** **2** **2** **2**	**15**

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. Replica plate technique for selection & characterization of mutants – auxotroph & antibiotic resistant
4. Isolation and detection of plasmid DNA.
5. Preparation of competent cells and transformation
6. Diauxic Growth and beta galactosidase assay

Course code : USMBP05

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

1. Illustration of the role of plasmids in antibiotic resistance through curing of the plasmid
2. Study of iron sequestration- siderophore production in *Pseudomonas* spp.
3. Determination of mannose resistant haemagglutination as an indication for presence of P fimbriae in uropathogenic *E.coli* strains.
4. Acid fast staining of M. tuberculosis.
5. To determine SLO and SLS activity of *S .pyogenes*
6. Serological identification of enteropathogenic *E.coli*
7. Identification of isolates obtained from nasal swabs, skin swab, pus, sputum, stool and urine by morphological, cultural and biochemical properties.
8. 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. Detection of organic acids by TLC
5. Study of Home and Heterofermentation
6. Isolation and detection of Mitochondria
7. Glucose detection by GOD/POD
8. Galactose transport in yeasts

Course code: USMBP06

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

1. Alcohol tolerance for yeast.
2. Sugar tolerance for yeast.
3. Alcohol fermentation.-Efficiency of fermentation
4. Chemical estimation –Sugar by Cole's
5. Chemical estimation –Alcohol
6. Gradient plate technique for analogue resistant mutants.
7. Production of amylase- detection, shake flask or solid substrate cultivation and stimation. (Qualitative)

Semester V:Text Books and Reference Books

USMB501: Text books

1. Peter J. Russell (2006), "Genetics-A molecular approach", 2nd ed.
2. Benjamin A. Pierce (2008), "Genetics a conceptual approach", 3rd ed., 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 ed., Macmillan worth Publishers.
5. M.Madigan, J.Martinko, J.Parkar, (2009), "Brock Biology of microorganisms", 12th ed., 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 edn. Mc Graw Hill international edition.
9. Nancy Trun and Janine Trempy, (2004), "Fundamental bacterial genetics", Blackwell Publishing
10. Snustad, Simmons, "Principles of genetics", 3rd edn. John Wiley & sons, Inc.

USMB501:Reference books:

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

USMB502:Text books:

1. Jawetz, Melnick and Adelberg's Medical Microbiology, 26th Edition, Lange publication
2. Bacterial Pathogenesis –A molecular approach Abigail Salyer And Dixie Whitt 2nd Ed ASM press
3. Ananthanarayan and Panicker's, Textbook of Microbiology, 9th edition
4. Kuby Immunology, 6th Edition, W H Freeman and Company
5. Pathak & Palan, Immunology: Essential & Fundamental, 1st& 3rd Edition, Capital Publishing Company
6. Fahim Khan, Elements of Immunology, Pearson Education

USMB502: Reference books / Internet references:

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

USMB503 :Text books:

1. Stanier, R. Y.,M. Doudoroff andE. 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, 3rdednButterworth-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, 4thedn. Pearson
9. Wilson and Walker , 4thedn

USMB503 : Reference books:

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

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. &HaII--S. J., (1997), "Principles of Fermentation Technology", 2nd Edition, Aditya Books Pvt. Ltd, New Delhi.
3. Peppler, H. J. and Perlman, D. (1979), "Microbial Technology’’. Vol 1 & 2, Academic Press
4. H. A. Modi, (2009). ‘’Fermentation Technology’’ Vols 1 & 2, Pointer Publications, India
5. OkaforNakuda (2007) ‘’Modern Industrial Microbiology and Biotechnology’’, Science Publications Enfield, NH, USA.
6. Environmental degradation : issues and challenges by Shitole and Sable, Global research publication (2012)

USMB504 : Reference books

1. Crueger W. and Crueger A. (2000) "Biotechnology -"A Textbook of Industrial Microbiology", 2nd Edition, Panima Publishing Corporation, New Delhi.
2. Prescott and Dunn's ‘’Industrial Microbiology’’(1982) 4th Edition, McMillan Publishers

T. Y. B. Sc. MICROBIOLOGY THEORY
SEMESTER-VI

COURSE CODE	TITLE	CREDITS AND LECTURES/SEM
USMB601	**RDNA TECHNOLOGY, BIOINFORMATICS & VIROLOGY**	**2.5 (60 LECTURES)**
Unit I	RECOMBINANT DNA TECHNOLOGY	15 lectures
Unit II	BASIC TECHNIQUES & BIOINFORMATICS	15 lectures
Unit III	BASIC VIROLOGY	15 lectures
Unit IV	ADVANCED VIROLOGY	15 lectures
USMB602	**MEDICAL MICROBIOLOGY & IMMUNOLOGY : PART II**	**2.5 (60 LECTURES)**
Unit I	STUDY OF A FEW DISEASES WITH EMPHASIS ON CULTURAL CHARACTERISTICS OF THE AETIOLOGICAL AGENT, PATHOGENESIS, LABORATORY DIAGNOSIS AND PREVENTION.	15 lectures
Unit II	CHEMOTHERAPY OF INFECTIOUS AGENTS	15 lectures
Unit III	HUMORAL RESPONSE,CELL MEDIATED EFFECTOR RESPONSE, ANTIGEN-ANTIBOBY REACTIONS	15 lectures
Unit IV	VACCINES, IMMUNOHAEMATO;OGY, HYPERSENSITIVITY	15 lectures
USMB603	**MICROBIAL BIOCHEMISTRY : PART II**	**2.5 (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	**APPLIED AND INDUSTRIAL MICROBIOLOGY**	**2.5 CREDITS (60 LECTURES)**
Unit I	TRADITIONAL INDUSTRIAL FERMENTATIONS – PART 2	15 lectures
Unit II	ADVANCES IN BIOPROCESSES TECHNOLOGY:	15 lectures
Unit III	BIOINSTRUMENTATION & BIOSTATISTICS	15 lectures
Unit IV	QUALITY ASSURANCE & REGULATORY PRACTICES	15 lectures

T.Y.B.Sc.Microbiology Theory : USMB-601(rDNA Technology,Bioinformatics & Virology)

Learning Objectives

Microbial Genetics isan undergraduate T.Y. B.Sc. Microbiology coursethat deals with both conceptual and practicaltools for generating, processing and understanding biological genetic information. It develops knowledge of the underlying theories of genetics which exhibits a broad understanding of genetic exchange among prokaryotes.It also gives students hands-on competence in fundamental molecular biology theories and laboratory techniques.It gives an overview of recombinant DNA technology and biotechnology applications utilizing genetic manipulation.It also provides practical experience of the major analytical techniques used in bioinformatics.It also deals with basic structure and life cycle of different types of viruses and explains different terminologies like cancer, prions, viriods and their mechanism.This course will help students to build on the basic information regarding DNA structure transcription, translation and genetic code that they have gained in S. Y. B.Sc.

Learning Outcomes: Students should be able to-

1. Understand the basic concepts and techniques of recombinant DNA technology
2. Understand the basic concepts of Bioinformatics.
3. Understand the basic structure, classification, , enumeration, cultivation and life cycle of viruses
4. Understand the terms like cancer, prions, viriods and their mechanis
5. Understand regulation of lambda phage

USMB-601 : DETAIL SYLLABUS

Course Code	Title	Lectures/ Semester	Notional Periods
USMB601	**RECOMBINANT DNA TECHNOLOGY, BIOINFORMATICS&VIROLOGY**	**2.5 Credits (60 Lectures)**	**Self Study (60)**
	UNIT I **RECOMBINANT DNA TECHNOLOGY** **1.1. Branches of Genetics** 1.1.a. Transmission genetics 1.1.1.b. Molecular genetics 1.1.c. Population genetics 1.1.d. Quantitative genetics **1.2. Model Organisms** 1.2.a. Characteristics of a model organism 1.2.b. Examples of model organisms used in study 1.2.c. Examples of studies undertaken using prokaryotic and eukaryotic model organisms **1.3. Basic steps in Gene Cloning.** **1.4. Cutting and joining DNA molecules**--Restriction and modification systems, restriction endonucleases, DNA ligases **1.5. Vectors** 1.5.a. Plasmids as cloning vectors. The plasmid vectors, pBR322 vector 1.5.b. Cloning genes into pBR322 1.5.c. Phage as cloning vectors, cloning genes into phage vector 1.5.d. Cosmids 1.5.e. Shuttle vectors 1.5.f. YAC 1.6.g.BAC **1.6. Methods of transformation** **1.7.Screening and selection methods for identification and isolation of recombinant cells**	**15** **1** **2** **1** **2** **4** **2** **3**	**15**

	UNIT II **BASIC TECHNIQUES & BIOINFORMATICS** **2.1. Basic techniques** 2.1.a. Southern, Northern and Western blotting. 2.1.b. Autoradiography (explain the term) **2.2.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. **2.3. PCR**- basic PCR and different types of PCR (Reverse transcriptase PCR, Real time quantitative PCR) **2.4. Bioinformatics** 2.4.a. Introduction i. Definition, aims, tasks and applications of Bioinformatics. ii. Database, tools and their uses - ➢ Importance, Types and classification of databases ➢ Nucleic acid sequence databases- EMBL, DDBJ, GenBank, GSDB, Ensembl and specialized Genomic resources. ➢ Protein sequence databases-PIR, SWISS-PROT, TrEMBL NRL-3D.Protein structure databases-SCOP, CATH, PROSITE, PRINTS and BLOCKS. KEGG. 2.4.b. Brief introduction to Transcriptome, Metabolomics, Pharmacogenomics, Phylogenetic analysis, Phylogenetic tree, Annotation, 2.4.c. Sequence alignment-- global v/s local alignment, FASTA, BLAST. 2.4.d. Genomics- structural, functional and comparative genomics. 2.4.e. Proteomics- structural and functional proteomics.	**15** **2** **4** **2** **7**	**15**
	UNIT III **BASIC VIROLOGY** **3.1. Viral architecture-** 3.1.a. Capsid, viral genome and envelope 3.1.b. Structure of TMV, T4, Influenza virus, HIV.	**15** **4**	**15**

	3.2. Viral classification **3.3. The viral replication cycle**- attachment, penetration, uncoating, types of viral genome and their replication, assembly, maturation and release. **3.4. Cultivation of viruses**- cell culture techniques, embryonated egg, laboratory animals, Cell culture methods:Equipment required for animal cell culture,Isolation of animal tissue	**2** **4** **5**	
	UNIT IV **ADVANCED VIROLOGY** **4.1.** Life cycle of T4 phage, TMV, Influenza Virus and HIV in detail **4.2. Visualization and enumeration of virus particles** 4.2.a. Measurement of infectious units i. Plaque assay ii. Fluorescent focus assay iii. Infectious center assay iv. Transformation assay v. Endpoint dilution assay. 4.2.b. Measurement of virus particles and their components i. Electron microscopy ii. Atomic force microscopy iii. Haemagglutination iv. Measurement of viral enzyme activity. **4.3. Regulation of lytic and lysogenic pathway of lambda phage** **4.4. Role of viruses in cancer:** Imp defination,charaeteristics of cancer cell,cancer multi step process,Homan DNA tumor viruses- EBV,Kaposis sarcoma virus,Hepatitis B and C virus,Papiloma Virus. **4.5. Prions and viroids**	**15** **5** **3** **3** **2** **2**	**15**

T.Y.B.Sc.Microbiology Theory : USMB-602 (Medical Microbiology & Immunology:Part-II)

Learning objectives:

One of the most important areas of microbiology, medical microbiology encompasses the aetiology, transmission, pathogenesis, clinical manifestations, laboratory diagnosis, prophylaxis, and treatment of various diseases that are enlisted in the syllabus. This course will help students to build on the basic information regarding host defence mechanisms that they have gained in S. Y. B.Sc.

Immunology is an integral part of Medical Microbiology and this course is designed for TYBSc Microbiology students and it is assumed 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 our innate ability to defend against microorganisms (innate immunity); should this first line of defence fail, how we can fight infections (acquired immunity); if we react excessively, what price we pay (hypersesitivity); and very importantly, can we prevent pathogens from infecting us (vaccinantion).

Learning Outcomes: (Medical Microbiology) 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, epidemiology and therefore 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.

Learning Outcomes: (Immunology): students should be able to-

- Understand the effector responses- Humoral Immunity & Cell Mediated Immunity and differentiate between them
- Acquire an understanding of the role of immune system in disease:
    - Unregulated response resulting in Hypersensitivity
- Understand the mechanism of Antigen-Antibody interaction & it's significance in diagnosis
- Apply the concept of immunity to prevention of disease by development of vaccines

USMB-602 : DETAIL SYLLABUS

Course Code	Title	Lectures/ Semester	Notional Periods
USMB 602	**MEDICAL MICROBIOLOGY AND IMMUNOLOGY**	**2.5 Credits (60 Lectures)**	**Self Study (60)**

	UNIT I **STUDY OF A FEW DISEASES WITH EMPHASIS ON CULTURAL CHARACTERISTICS OF THE AETIOLOGICAL AGENT, PATHOGENESIS, LABORATORY DIAGNOSIS AND PREVENTION.** 1.1 Study of vector-borne infections Malaria 1.2 Study of sexually transmitted infectious diseases 1.2.1 Syphilis 1.2.2 AIDS 1.2.3 Gonorrhoea 1.3 Study of central nervous system infectious diseases 1.3.1 Tetanus 1.3.2 Polio 1.3.3 Meningococcal meningitis	**15** **02** **08** **05**	**15**
	UNIT II **CHEMOTHERAPY OF INFECTIOUS AGENTS** 2.1.1 Attributes of an ideal chemotherapeutic agent and related definitions 2.1.2 Selection and testing of antibiotics for bacterial isolates by Kirby-Bauer method 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) 2.3.1 List of common antibiotics used for treating viral, fungal and parasitic diseases. 2.3.2 New antibiotics 2.4 Mechanisms of drug resistance- Its evolution, pathways and origin	**15** **02** **09** **01** **03**	**15**

	UNIT III **HUMORAL RESPONSE,CELL MEDIATED EFFECTOR RESPONSE, ANTIGEN-ANTIBOBY REACTIONS** **3.1. Humoral Response** 3.1.1. Induction of Humoral response, Primary and secondary responses 3.1.2. Germinal centers and antigen induced B cell differentiation 3.1.3. Affinity maturation and somatic hyper mutation, Ig diversity, class switching 3.1.4. Generation of plasma cells and memory cells **3.2. Cell mediated effector response** 3.2.1. Generation and target destruction by Cytotoxic T cells. 3.2.2. Killing mechanism of NK cells. 3.2.3. Antibody dependent cell cytotoxicity (ADCC) **3.3. Antigen-Antibody reactions** Precipitation, agglutination, passive agglutination, agglutination inhibition, Radioimmunoassay (RIA), Enzyme immunoassays (EIA), Immunofluorescence, western blot technique	**15** **05** **03** **07**	**15**

	UNIT IV VACCINES, IMMUNOHAEMATOLOGY, HYPERSENSITIVITY **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, Failures in vaccination 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. 4.3. Hypersensitivity 4.3.1. Coombs and Gells classification 4.3.2. Type I to Type IV hypersensitivity, Mechanism and manifestation.	**15** **08** **03**	**15**

T.Y.B.Sc.Microbiology Theory : USMB-603 (Microbial Biochemistry:Part-II)

Learning objectives:

There are a large number of macromolecules such as lipids, carbohydrates, proteins and nucleic acids which are catabolised by the living cells. Cells also bring about biosynthesis of these macromolecules. Various enzymes play a major role in these biochemical reactions. These enzymatic reactions are regulated. The learner must be made aware of the mechanisms of catabolism, anabolism as well as the regulation of this mechanism in the living cell. There are prokaryotic cells which bring about photosynthesis to generate energy. Prokaryotic cells are also involved in metabolism of inorganic compounds.

This course is designed for TYBSc Microbiology students and it is assumed that the students already have a basic understanding of macromolecules. The course will help students to understand the metabolism of macromolecules as well as the regulation of metabolic reactions. The students would also learn photosynthetic reactions in prokaryotic cells and metabolism of inorganic compounds.

Learning Outcomes: **Students should be able to-**

- Understand the reactions involved in metabolism of lipids and hydrocarbons.
- Describe and explain protein catabolism as well as anabolic processes in the cell.
- Explain nucleic acid metabolism and recycling of nucleotides.
- Discuss the mechanism of regulation with regards to allosteric proteins, gene expression as well as through other mechanisms like end product inhibition and covalent modification.
- Describe prokaryotic photosynthesis with respect to photosynthetic pigments, photochemical apparatus and light and dark reactions.
- Describe metabolism of inorganic compounds and Lithotrophy

USMB-603 : DETAIL SYLLABUS

Course Code	Title	Lectures/ Semester	Notional Periods
USMB603	**MICROBIAL BIOCHEMISTRY PART II**	**2.5 Credits (60lectures)**	**Self Study (60)**
	UNIT I **LIPID METABOLISM & CATABOLISM OF HYDROCARBONS**	**15**	**15**
	1.1 General introduction to Lipids 1.1.1. Lipids and their functions 1.1.2. Action of lipases on triglycerides /tripalmitate 1.1.3. Phospholipids and their properties 1.1.4. Common phosphoglycerides in bacteria	**02**	
	1.2 Catabolism of Lipids 1.2.1.Oxidation of saturated fatty acid - β oxidation pathway - Energetics of β oxidation of Palmitic acid 1.2.2. Oxidation of propionic acid. 1.2.3. Degradation of poly beta hydroxy butyrate	**05**	
	1.3 Anabolism of Lipids 1.3.1. Biosynthesis of straight chain even carbon saturated fatty acid (palmitic acid) 1.3.2. Biosynthesis ofphosphoglycerides in bacteria 1.3.3. Biosynthesis of PHB	**06**	
	1.4 **Catabolism of aliphatic hydrocarbons** 1.4.1. Oxidation of saturated aliphatic hydrocarbon (n-alkane) 1.4.2. Omega oxidation pathway- i) Pathway in***Corynebacterium***and yeast ii) Pathway in***Pseudomonas***	**02**	

	UNIT II **METABOLISM OF PROTEINS AND NUCLEIC ACIDS**	**15**	**15**
	2.1 Protein catabolism 2.1.1. Enzymatic degradation of proteins 2.1.2. Metabolic fate of amino acids (schematic only) 2.1.3. Metabolism of single amino acids – i. Deamination reactions ii. Decarboxylation iii. Transamination 2.1.4. Fermentation of single amino acid - Glutamic acid by ***Clostridium glutamicum*** 2.1.5**.**Fermentation of pair of amino acids - Stickland reaction	**05**	
	2.2 Anabolism of Proteins 2.2.1. Schematic representation of amino acid families 2.2.2. Synthesis of amino acids of Aspartate family	**04**	
	2.3 Nucleic acid Catabolism 2.3.1. Degradation of purine nucleotides up to uric acid formation 2.3.2. Recycling of purine and pyrimidine nucleotides by salvage pathway	**03**	
	2.4 Anabolism of Nucleic Acids 2.4.1. Metabolic origin of atoms in purine and pyrimidine ring. 2.4.2. Biosynthesis of pyrimidine nucleotides. 2.4.3. Biosynthesis of purine nucleotides. 2.4.4. Formation of deoxyribonucleotides. 2.4.5. Synthesis of nucleotide diphosphates and triphosphates. 2.4.6. Role of nucleotides (high energy triphosphates)	**03**	
	UNIT III **METABOLIC REGULATION**	**15**	**15**
	3.1Overview and major modes of regulation Examples of cellular control mechanism acting at various levels of metabolism (tabulation only)	**01**	
	3.2 **Allosteric proteins** 3.2.1. Definition 3.2.2. Allosteric enzymes - Role of allosteric	**03**	

	enzymes using ATCase as example (no kinetic study) 3.2.3.Regulatory allosteric proteins i. Interaction of proteins with DNA ii. Structure of DNA Binding proteins iii. Examples - Lac repressor, Trp repressor, CAP protein iv.Definition and examples of alarmones **3.3 Regulation of gene expression (Transcription)** 3.3.1. Introduction to operon model 3.3.2. Common patterns of regulation of transcription - General concept of positive and negative regulation of operons i. Lac operon - Mechanism of regulation - Induction - Catabolite repression ii. Trp operon - End Product Repression - Attenuation 3.3.3. Regulation of gene expression i. Multiple Sigma Factors ii. Riboswitches **3.4 Regulation of enzyme activity (Post translational regulation)** 3.4.1. End-Product Inhibition and Mechanism of End Product Inhibition in branched pathways with examples i. Isofunctional enzymes ii. Concerted feedback inhibition iii. Sequential feedback inhibition iv. Cumulative Feedback inhibition v. Combined activation and inhibition 3.4.2. Covalent modification of enzymes i. General examples without structures ii. Monocyclic cascade &interconvertable enzyme definition iii. Glutamine synthetase system of ***E.coli*** 3.4.3. Regulation by proteolytic cleavage **3.5 Regulation of EMP and TCA** (Schematic and Role of Pryruvate dehydrogenase Complex)	**06** **04** **01**	
	UNIT IV **PROKARYOTIC PHOTOSYNTHESIS & INORGANIC METABOLISM**	**15**	**15**

	4.1 Prokaryotic photosynthesis 4.1.1. Early studies on photosynthesis i. Light and dark reactions ii. Bacterial photosynthesis iii. Hill reaction 4.1.2. Phototrophic prokaryotes -Oxygenic, Anoxygenicphototrophs examples only 4.1.3. Photosynthetic pigments 4.1.4. Location of photochemical apparatus 4.1.5. Photophosphorylation 4.1.6. Light reactions in i. Purple photosynthetic bacteria ii. Green sulphur bacteria iii. Cyanobacteria (with details) 4.1.7. Dark reaction i. Calvin Benson cycle ii. Reductive TCA	**09**	
	4.2 Inorganic Metabolism 4.2.1. Assimilatory pathways- i. Assimilation of nitrate, ii. Ammonia fixation – Glutamate dehydrogenase, Glutamine synthetase, GS-GOGAT, Carbamoyl phosphate synthetase iii. Biological nitrogen fixation (Mechanism for N_2 fixation and protection of nitrogenase) iv. Assimilation of sulphate 4.2.2. Dissimilatory pathways- i. Nitrate as an electron acceptor (Denitrification in ***Paracoccusdenitrificans***) ii. Sulphate as an electron acceptor **4.2.3.** Lithotrophy– Enlist organisms and products formed during oxidation of Hydrogen, carbon monoxide, Ammonia, Nitrite, Sulphur, Iron..	**03** **02** **01**	

T.Y.B.Sc.Microbiology Theory : USMB-604 (Applied & Industrial Microbiology)

Learning Objectives

Bioprocess Technology & Environmental Microbiologycourse 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.The downstream process and the environmental aspects of the final product are also included.

Industrial and Environmental Microbiology 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 and enzymes along with the analysis techniques using various instruments and statistical tools.

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: Students should be able to-

- 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 enzymes in various fields.

- Understand the working of important instruments used in biochemical analysis and also learn to analyze the results using statistical tools.
- Learn the salient features of quality management and regulatory procedures.
- Understand the commercial and economic aspects of applied microbiology.

USMB-604 : DETAIL SYLLABUS

Course Code	Title	Lectures/ Semester	Notional Periods
USMB 604	**APPLIED AND ENVIRONMENTAL MICROBIOLOGY**	**2.5 Credits(60 Lectures)**	**Self Study (60)**
	UNIT I **TRADITIONAL INDUSTRIAL FERMENTATIONS : PART-2** 1.1. Penicillin& Semisynthetic Penicillin 1.2. Vitamin B12 from *Propionibacterium& Pseudomonas* 1.3. Glutamic Acid (direct) 1.4. Citric acid 1.5 Mushroom	**15** **04** **03** **02** **03** **03**	**15**
	UNIT II **ADVANCES IN BIOPROCESSES TECHNOLOGY:** **2.1 Animal Cell Cultivation and applications** Animal Cell Lines, Methods of cultivation and establishment of cell lines, Animal cell culture fermenters, Large scale cultivation procedures **2.2. Plant Tissue Culture** Methods of cultivation of organ culture, callus culture and cell suspension culture, Application in Agriculture (Disease resistant plants, virus free plants) Horticulture (Micropropagation) Industry (secondary metabolites production),Transgenic plant (Insect resistant plants) **2.3 Enzyme Technology** Enzyme Immobilization methods, Applications in therapeutic uses, Analytical uses and Industrial uses	**15** **05** **05** **05**	**15**

	UNIT III **BIOINSTRUMENTATION& BIOSTATISTICS** **3.1.Bioinstrumentation** – Principles, working and applications of**:** 3.1.1 Spectrophotometry (I. R) 3.1.2Atomic absorption (AAS) & Atomic Emission (Flame photometry) 3.1.3 Radioisotopes and autoradiography 3.1.4 Microbiological Assays **3.2Biostatistics** Introduction to Biostatistics Sample and Population Data presentation: Dot diagram, Bar diagram, Histogram, Frequency curve. Central Tendency: Mean, Median, Mode Summation, notations. Standard Deviation, Variance, Q-Test, t-test and F-test.	**15** **10** **05**	**15**
	UNIT IV **QUALITY ASSURANCE & REGULATORY PRACTICES :** **4.1** Intellectual Property Rights: Introduction to Intellectual Property Genesis of IPR - GATT, WTO, TRIPS, The World Intellectual Property Rights Organization (WIPO) Types of Intellectual Property – Patents, Copyright, Trademark, Trade secret Plant varieties protection act, Designs, Geographical Indications Indian Patent office site- http://www.ipindia.nic.in/ **4.2 QA,QC,GMP :** Definitions- Manufacture, Quality, Quality Control, In-Process Control, Quality Assurance, Good Manufacturing Practices.Chemicals,Pharmaceuticals, Chemicals &Pharmaceutical production The five variables, In process Items, Finished Products, Labels and Labeling, Packaging materials	**15** **07** **04**	**15**

	Documentation,Regulations,Control of Microbial contamination during manufacture, Premises and contamination control ,Manufacture of sterile products,Clean and Aseptic Area Important publications related to QA **4.3 Sterilization Control and Sterility Assurance:** Bio-burden determinations Environmental monitoring Sterilization Monitors – Physical, Chemical and Biological indicators Sterility Testing	**04**	

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
4. Amplification of DNA by PCR and confirmation of it by gel electrophoresis [Demo.]
5. Western Blot.(Demo)
6. Bioinformatics practical

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

7. Animal cell culture (demo)

Course Code : USMBP07

[Practicals Based on USMB602;Credits -1.5,Lectures- 60,Notional Periods-15]

1. Acid fast staining of *M.leprae*
2. Identification of *Candida* species using the germ tube test and growth on Chrom agar
3. Demonstration of malarial parasite in blood films
4. Selection and testing of antibiotics using the Kirby-Bauer method
5. Determination of MBC of an antibiotic.
6. Blood grouping – Direct & Reverse typing
7. Coomb's Direct test
8. Determination of Isoagglutinin titer
9. Demonstration experiments- Widal, VDRL

Course Code : USMBP08

[Practicals Based on 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
4. Qualitative and Quantitative assay of Protease
5. Qualitative and Quantitative assay of Lipase
6. Study of Hill reaction
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. Immobilization of yeast cells for invertase activity- making of beads, Determination of activity and count by haemocytometer.
4. Carrot explant culture.
5. Sterility testing of water for injection or DPT vaccine.
6. Chemical estimation of Penicillin
7. Biostatistics problem

Semester-VI : Text Books & Reference Books

USMB 601: Text books:

1. Peter J. Russell (2006), "Genetics-A molecular approach", 2nd ed.
2. Benjamin A. Pierce (2008), "Genetics a conceptual approach", 3rd ed., 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 ed., 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 edn. Mc Graw Hill international edition.
11. Primrose and Twyman, (2001), "Principles of gene manipulation and genomics", 6th ed, Blackwell Publishing
12. Arthur Lesk, (2009), "Introduction to Bioinformatics", 3rd Edition, Oxford University Press
13. Snustad, Simmons, "Principles of genetics", 3rd edn. John Wiley & sons, Inc.
14. A textbook of biotechnology R.C.Dubey 4 th ed.S.Chand.

Reference books:

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

USMB602 :TEXT BOOKS:

1. Jawetz, Melnick and Adelberg's Medical Microbiology, 26th Edition, Lange publication
2. Bacterial Pathogenesis –A molecular approach Abigail Salyer And Dixie Whitt 2nd Ed ASM press
3. Ananthanarayan and Panicker's, Textbook of Microbiology, 9th edition
4. Kuby Immunology, 6th Edition, W H Freeman and Company
5. Pathak & Palan, Immunology: Essential & Fundamental, 1st& 3rd Edition, Capital Publishing Company
6. Fahim Khan, Elements of Immunology, Pearson Education

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
3. http://www.macmillanlearning.com/catalog/static/whf/kuby/

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. Salle, A.J. Fundamental Principles of Bacteriology, 7thedn McGraw Hill Book Co.
7. Cohen, G.N. (2011). Microbial Biochemistry. 2ndedn, Springer
8. Madigan, M.T. and J.M. Martinko 2006. 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, 5thednW. H. Freeman and Company

USMB 604 : TEXT BOOKS

1. Casida L. E., "Industrial Microbiology" 2009 Reprint, New Age International (P) Ltd, Publishers, New Delhi
2. Stanbury P. F., Whitaker A. &HaII--S. J., 1997, "Principles of Fermentation Technology", 2nd Edition, Aditya Books Pvt. Ltd, New Delhi.
3. Crueger W. and Crueger A. 2000 "Biotechnology -"A Textbook of Industrial Microbiology", 2nd Edition, Panima Publishing Corporation, New Delhi.
4. R. C. Dubey, 2005 A Textbook of ''Biotechnology'' S. Chand and Company, New Delhi
5. H. A. Modi, 2009. ''Fermentation Technology'' Vol: 1 & 2, Pointer Publications, India
6. Prescott and Dunn's ''Industrial Microbiology''(1982) 4th Edition, McMillan Publishers
7. Research Methodology: Methods and Techniques By C. R. Kothari, New Age International, 2004

REFERENCE BOOKS:

1. Peppler, H. J. and Perlman, D. (1979), "Microbial Technology''. Vol 1 & 2, Academic Press.

2. Principles and application of Statistics in Biosciences byDrD.V.Kamat (2012),MananPrakashan

Modality Of Assessment

Assessment pattern for theory

Scheme of Examination

The performance of the learners shall be evaluated into two components. The learner's Performance shall be assessed by Internal Assessment with 25% marks in the first component & by conducting the Semester End Examinations with 75% marks in the second component. The allocation of marks for the Internal Assessment and Semester End Examinations are as shown below:-

Internal Assessment - 25% **25 marks.**

a) Theory **25 marks**

Sr No	Evaluation type	Marks
1	One class Test*	20
2	Active participation in routine class instructional deliveries Overall conduct as a responsible student, manners, skill in articulation, leadership qualities demonstrated through organizing co-curricular activities, etc.	05

Question Paper Pattern for Periodical Class Test for Courses at UG Programmes Written Class Test (20 Marks)

1.	Match the Column / Fill in the Blanks / Multiple Choice Questions (½ Marks each)	05 Marks
2.	Answer in One or Two Lines (Concept based Questions) (1 Mark each)	05 Marks
3.	Answer in Brief (Attempt Any Two of the Three) (5 Marks each)	10 Marks

Semester End Theory Assessment - 75% **75 marks**

1. Duration - These examinations shall be of **2.5 hours** duration.
2. Theory question paper pattern :-
   i. There shall be **five questions** each of **15** marks **(30 marks with internal option)**
   ii. On each unit there will be one question & fifth question will be based on entire syllabus.

iii. All questions shall be **compulsory** with internal choice within the questions.
iv. Questions may be sub divided into sub questions as **a, b, c, d, e & f** etc & the allocation of marks depends 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 where the course consists of Internal Assessment and Semester End Examination. The learners shall obtain minimum of 40% marks (i.e. **10 out of 25) in the Internal Assessment** and 40% marks in **Semester End Examination (i.e. 30 out of 75) separately**, to pass the course and **minimum of Grade E** in each project, wherever applicable, to pass a particular semester. A learner will be said to have passed the course **if the learner passes the Internal Assessment and Semester End Examination together.**

Practical Examination Pattern:

(A)Internal Examination:-

There will not be any internal examination/ evaluation for practicals.

(B) External (Semester end practical examination) :-

Sr.No.	Particulars	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 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 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

Semester V

Course	USMB-501			USMB-502			USMB-503			USMB-504			Grand Total
	Internal	External	Total	Internal	External	Total	Internal	External	Total	Internal	External	Total	
Theory	25	75	100	25	75	100	25	75	100	25	75	100	400
Practicals	-	50	50	-	50	50	-	50	50	-	50	50	200

Semester VI

Course	USMB-601			USMB-602			USMB-603			USMB-604			Grand Total
	Internal	External	Total	Internal	External	Total	Internal	External	Total	Internal	External	Total	
Theory	25	75	100	25	75	100	25	75	100	25	75	100	400
Practicals	-	50	50	-	50	50	-	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**