K. J. SOMAIYA COLLEGE OF SCIENCE AND COMMERCE, VIDYAVIHAR, MUMBAI 400 077

AUTONOMOUS- AFFILIATED TO UNIVERSITY OF MUMBAI

Scheme of Course Structure (Faculty of Science) 2020-2021

Syllabus for T.Y.B.Sc.

Program: B.Sc.

Course: Microbiology

(Choice based Credit System

with effect from

the Academic year 2020–2021)

Preamble

To the common man, Microbiology means the study of invisible mini wonders that only cause disease. In reality, the vast majority of microorganisms co-exist alongside us without causing any harm. On the contrary, many of them are required for our survival. Microbiology is a study of this microscopic world, It is a research oriented subject and plays a pivotal role in our daily lives.

After introducing the basics of Microbiology in Semester I and Semester II, syllabus progresses to include the topics of Immunology, Genetics, Biochemistry, Virology, Taxonomy, Dairy and Food Microbiology, basic and advanced Instrumentation in Semester III and Semester IV.

Semester V and Semester VI while focusing on the depth and applications of the above topics will also include new topics of Population genetics, Emerging infectious diseases, Bioinformatics, Biostatistics, Advanced Virology and basic Nanotechnology.

As mentioned in the syllabus, all the three courses of theory & practical are compulsory to B.Sc. Microbiology students (Semester III and IV). Choice is offered between Module III and Module IV in Course III in both Semester III and Semester IV.

The syllabi for the three-year undergraduate programme are designed to enable the students to understand and select an area of their interest to pursue further studies for post-graduation.

Graduate Attributes

The graduate in Microbiology would have-

1. Sound knowledge of the fundamentals of Microbiology
2. Basic understanding of the different fields of applied Microbiology.
3. Knowledge of recent developments in the various fields of Microbiology.
4. Skill set in performing Bacteriological techniques such as aseptic techniques, enumeration of bacteria, etc.
5. Ability to analyze, think, plan, execute and review experiment and experimental results.
6. Awareness about research planning and Ethical considerations in all the fields.
7. Entrepreneurial skills as an offshoot of interaction with several Industry experts.
8. Expertise in Communication skills
9. Gained life skills such as Team work, Leadership, Patience as a result of group project participation.

Syllabus -T.Y.B.Sc. Microbiology

Semester V	Course Number	Course Title	Course code	Credits	Hours	Periods (50 min)	Unit/ Module	Lectures (50 MINUTES) per Unit/ module	Examination		
									Internal Marks	External Marks	Total Marks
THEORY											
Core courses											
	I	Branches of Genetics and Basic Molecular Biology.	20US5MBMGMCI	2	30	36	3	12	40	60	100
	II	Medical microbiology and Immunology - I	20US5MBMMIC2	2	30	36	3	12	40	60	100
	III	Microbial Biochemistry -I	20US5MBMBC3	2	30	36	3	12	40	60	100
	IV	Bioprocess Technology- Upstream Processes	20US5MBBTC4	2	30	36	3	12	40	60	100

Discipline Specific Electives											
DSE	I	Environmental Microbiology	20US5MBEAM5	2	30	36	3	12	40	60	100
	II	Plant and Animal Biotechnology	20US5MBPAB6	2	30	36	3	12	40	60	100
	III (OPTIONAL)	Research Project		2	30	36			40	60	100
Skill Enhancement Electives											
SEC **	I	Food and Dairy Microbiology	20US5MBFDM7	1.5	23	28	2	14		60	60
PRACTICALS											
CORE COURSES											
	I	Branches of Genetics and Basic Molecular Biology	20US5MBPI	1	2	2.4			20	30	50
	II	Medical microbiology and Immunology - I	20US5MBPI	1	2	2.4			20	30	50

	III	Microbial Biochemistry-I	20US5MBP2	1	2	2.4			20	30	50
	IV	Bioprocess Technology-Upstream Processes	20US5MBP2	1	2	2.4			20	30	50

Discipline Specific Electives											
DSE	I	Environmental Microbiology	20US5MBP3	1	2	2.4			20	30	50
	II	Plant and Animal Biotechnology	20US5MBP3	1	2	2.4			20	30	50
	III(Optional)	Research Project		1	2	2.4			20	30	50
Skill Enhancement Electives											
SEC		Food and Dairy Microbiology	20US5MBFDM7	0.5	1	1.2			10	30	40
TOTAL				20							

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

Course – I

COURSE TITLE: Branches of Genetics and Basic Molecular Biology

COURSE CODE: 2OUS5MBMGMCI

[CREDITS - O2]

Course Learning Outcomes: After the successful completion of the Course, the learner will be able to:

1) Apply the concepts of Population Genetics to analyse population structure.
2) Identify the human genetic traits using pedigree analysis
3) Describe the steps and enzymology of prokaryotic replication.
4) Investigate the mechanisms of prokaryotic transcription and translation.

Module	TITLE AND CONTENT	NO OF LECTURES
I	**Classical and Population Genetics** **Learning Objectives:** 1) To state the branches of Genetics. 2) To explore the characteristics of model organisms in Genetics. 3) To state the Hardy-Weinberg rule. 4) To apply the Hardy-Weinberg rule to the study of population structure. 5) To describe the human Eukaryotic chromosome structure **Learning Outcomes**: After successful completion of the module, the learner will be able to: 1) Comprehend the branches of Genetics so as to justify their significance. 2) List the characteristic features of model organisms. 3) Calculate different genetic frequencies in a population study. 4) Evaluate the impact of different parameters on a population. 5) To describe different structural attributes of eukaryotic chromosome. 6) Construct pedigree analysis chart for analysis.	

	7) Tabulate different genetic traits.	
1.1	**Branches of Genetics:**	
	Introduction to the following terms:	1L
1.1.a.	Transmission genetics	
1.1.b	Molecular genetics	
1.1.c.	Population genetics	
1.1.d.	Quantitative genetics	
1.2	**Model Organisms:**	
1.2.a.	Listing the characteristics of model organisms in Genetics.	1L
1.2.b.	Examples of model organisms used in studies. Examples of studies undertaken using prokaryotic and eukaryotic model organisms.	
1.3	**Introduction to Human Genetics:**	
1.3.a.	Eukaryotic Chromosome structure : Levels of chromosome packaging, histones and non-histones, euchromatin and heterochromatin (types)	3L
1.3.b.	Mendelian genetics in humans- pedigree analysis	
1.3.c.	Human genetic traits recessive and dominant (examples) Sex- linked traits (examples)	2L
1.4.	**Population Genetics**	
1.4.a	Genetic structure of population, genotype and allelic frequencies. Introduction to Hardy- Weinberg Law and problems based on it.	3L
1.4.b	Genetic variation in natural population. Change in genetic structure of population: mutation, genetic drift, migration, natural selection	2L
2	**DNA Replication:** **Learning Objectives:** 1) To familiarize the learner with terminology, concepts and detailed process of DNA replication in prokaryotes.	

	2) To understand significance of historical experiments in replication. 3) To appreciate differences between DNA replication in prokaryotes and eukaryotes. **Learning Outcomes:** After the successful completion of the module, the learner will be able to: 1) Explain and analyse the significant historical experiments DNA replication. 2) Describe process of DNA replication in prokaryotes. 3) List the various proteins and enzymes involved in replication and explain their significance 4) Evaluate the differences between the process of DNA replication in prokaryotic and eukaryotic cells and some phages. 5) Appreciate the role of telomeres and telomerase. 6) Explain rolling circle mode of replication.	
	DNA Replication:	
2.1.	**DNA Replication features:** Conservative, Dispersive, Semi-conservative Bidirectional and semi-discontinuous	2L
2.2.	**Historical experiments** by Meselson and Stahl, Reiji and Tuneko Okazaki, J Cairns and Gyurasits and Wake.	2L
2.3.	**Prokaryotic DNA replication** :– Details of molecular mechanism involved in Initiation, Elongation and Termination.	3L
2.4	Enzymes and proteins associated with DNA replication: Primase, Helicase, Topoisomerase, SSB, DNA polymerases, Ligases, Ter and Tus proteins.	2L
2.5	Differences between prokaryotic and eukaryotic DNA, Consequences of telomere shortening, mechanism and role of telomerase	2L
2.6	**Rolling circle (θ)mode of replication**	1L
3	**Transcription and Translation:** **Learning Objectives:**	

	1) To explain the structure of gene to be transcribed. 2) To describe the molecular stages of transcription and translation. 3) To list the roles of different proteins involved in transcription and translation. 4) To investigate the mode of action of inhibitors of RNA polymerase. 5) To scrutinize the formation of peptide bond in translation. 6) To examine the action of amino-acyl tRNA synthetases. **Learning Outcomes**: After the successful completion of the module, the learner will be able to: 1) Summarize the positions and roles of different sequences of the gene to be transcribed. 2) Appreciate the roles of different inhibitors of RNA polymerase. 3) Schematically represent the stages of transcription. 4) Describe the rho-dependent and rho-independent types of termination of transcription. 5) Compare and contrast prokaryotic and eukaryotic transcription. 6) Investigate the sub-units of ribosomes in prokaryotes and eukaryotes. 7) Describe the different steps of post-translational modification of proteins.	
	Transcription and Translation:	
3.1.	**Transcription:**	
3.1.a.	Structure of prokaryotic and eukaryotic promoters. DNA dependent synthesis of RNA: RNA Polymerase- structure and role.	1L
3.1.b.	Description of steps of Transcription: Initiation, Elongation and Termination in prokaryotes in detail.	3L
3.1.c.	Only introduction to transcription in eukaryotes. Role of rho protein in transcription termination in prokaryotes. Inhibition of DNA dependent RNA polymerase.	1L
3.2.	**Translation:**	1L
3.2.a.	Types and description of structure of following RNA: m- RNA, t-RNA, r-RNA.	
3.2.b.	Structure of prokaryotic and eukaryotic ribosomes-	

	subunits. Description of steps of Translation: Initiation, Elongation and Termination in prokaryotes in detail. Formation of peptide bond. Only introduction to translation in eukaryotes.	4L
3.3.	**Post-Translational Modifications (PTM) of proteins:** Types of PTMs with one example each. Phosphorylation. Adenylation Glycosylation Formation of disulphide bonds.	2L

References:

1) Peter J. Russell (2006), ~~i~~Genetics-A molecular approach, 2nd edition.
2) Benjamin A. Pierce (2008), ~~G~~enetics a conceptual approach, 3rd edition, W. H. Freeman and company.
3) R. H. Tamarin, (2004), ~~P~~rinciples of genetics, Tata McGraw Hill.
4) M. Madigan, J. Martinko, J. Parkar, (2009), ~~B~~rock Biology of microorganisms‖, 12th edition Pearson Education International.
5) Fairbanks and Anderson, (1999), ~~G~~enetics, Wadsworth Publishing Company.
6) Prescott, Harley and Klein, ~~M~~icrobiology‖, 7th edition McGraw Hill international edition.
7) Robert Weaver, ~~M~~olecular biology‖, 3rd edition. McGraw Hill international edition.
8) Primrose and Twyman, ~~P~~rinciples of gene manipulation and genomics, 7th edition Blackwell Publishing.
9) Nancy Trun and Jaine Trempy (2004), ~~F~~undamental bacterial genetics Blackwell Publishing.
10) D Nelson and M Cox,(2005) ~~L~~ehninger's Principles of Biochemistry‖, 4th edition Macmillan worth Publishers.
11) Benjamin Lewin,~~G~~enes IX, Jones and Bartlett publishers.
12) JD Watson, ~~M~~olecular biology of the gene, 5th edition.
13) Snustad, Simmons, ~~P~~rinciples of genetics, 3rd edition. John Wiley & sons, Inc.

Evaluation Pattern: Theory

For course I

External Evaluation – Semester End Examination (60 M) - Duration: 2 hours

Paper Pattern

Question No	Module	Marks with Option	Marks without Option
1	I	30	20
2	II	30	20
3	III	30	20

Internal Evaluation - (40 M)

(Give different ways of internal evaluation finalised for each module)

Probable options:

Plickers

Testmoz

Google form

Moodle

Objective-MCQ

Short answer test

T. Y. B. Sc. (MICROBIOLOGY)

SEMESTER V - Practical

Course-I

COURSE CODE: 20US5MBP1

[CREDITS - 01]

Experiment Sr. no.	Title and Number of Credits	Number of hours
1.	Isolation of genomic DNA of *E. coli* (group experiment)	04
2.	Karyotyping	04
3.	Electrophoresis of genomic and plasmid DNA. (group experiment)	09
4.	Proteins electrophoresis Native and SDS-PAGE (group experiment)	08
5.	Cultivation of model organisms – *Drosophila melanogaster*	03
6.	Problems on Population Genetics	02

Evaluation pattern: Practical

External evaluation: 30 Marks practical examination at the end of each semester per course.

Internal evaluation: 20 marks

a) Rough Journal – 05

b) Fair Journal – 05

c) Viva- 10

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

Course – II

COURSE TITLE: Medical Microbiology and Immunology

COURSE CODE: 2OUS5MBMMIC2

[CREDITS - O2]

Course Learning Outcomes:
After successful completion of the Course, the learner will be able to:

1) Identify the aetiological agent responsible for Respiratory and Urinary tract infections.
2) Evaluate the choice of suitable antibiotics for treatment of infectious disease using bacteriological techniques.
3) Understand the role of Cytokines, APC, MHC, Complement in immune defence mechanism.

Module	TITLE AND CONTENT	NO OF LECTURES :
I	**HOST DEFENSE MECHANISM AND THERAPEUTIC TREATMENTS.** **Learning Objectives:** 1) To enable the learner to understand the concept of "non-specific host defence system" 2) To enable the learner to understand the role of anatomic barriers, nonspecific inhibitors, and phagocytic cells in host defence system **Learning outcome:** By the end of this course learners will be able to understand: 1) The different types cells, tissues and organs involved in immune response to various types of pathogens. 2) The factors contributing to non-specific host defence mechanism	
I.I. I.I.a.	**Non-Specific Host Defense Mechanisms** First Line of Host Defense Physical and Mechanical	4L

	Barriers: Skin, Mucous membranes Respiratory System Gastrointestinal Tract Genitourinary Tract	
1.1.b.	Antimicrobial Peptides: Cationic Peptides, Bacteriocins, Complement, Interferons and Acute Phase Proteins. Phagocytosis.	4L
1.1.c	Pathogen Recognition, Toll like Receptors, Intracellular Digestion Acute Inflammatory Response.	4L
2	**RESPIRATORY AND URINARY TRACT INFECTIONS** **Learning objective:** To enable the learner to understand- 1) The causative agents, its transmission and pathogenesis, 2) The Clinical Manifestations of the infections and the Laboratory Diagnostic procedures 3) The prophylactic measures and available treatment. **Learning outcome:** By the end of this course learners will be able to: 1) Differentiate and categorize the types of Respiratory tract and Urinary infections 2) Understand the virulence properties of pathogens causing Respiratory tract and Urinary infections	
	All infections are to be covered with respect to all details with emphasis on Etiology, Transmission, Pathogenesis, Clinical Manifestations, Lab Diagnosis, Prophylaxis, and Treatment	
2.1.	**URT (Upper Respiratory Tract infections)**	1L
2.1.a	Streptococcal Pharyngitis	1L
2.1.b.	Diphtheria	3L
2.1.c	Rubella, Measles, Mumps, Chickenpox	
2.2.	**LRT (Lower Respiratory Tract infections)**	2L
2.2.a.	Tuberculosis	2L
2.2.b.	Bacterial pneumonia	1L
2.2.c.	Influenza	
2.3.	**UTI (Urinary Tract infections)**	1L
2.3.a	Types of UTI, Clinical Manifestations, predisposing Factors Involved, pathogens	
2.3.b	Laboratory diagnosis	1L

3	**Components of immune system and their role in Immune response** **Learning Objective:** 1) To state the significance of components like Cytokines, APC, MHC of the immune system. 2) To describe their functions and mechanism of action. **Learning Outcome:** After successful completion of the module, the learner will be able to 1) Explain the role of cytokines, Antigen presenting cell, MHC and complement system in immune mechanism 2) Diagrammatically represent its functioning.	
	Detail syllabus – sub units.	
	Components of immune system and their role in Immune response	
3.1.	**Cytokines**	3L
3.1.a.	Properties and functions	
3.1.b.	Cytokines secreted by Th1 and Th2	
3.2.	**Antigen Presenting cells**	3L
3.2.a.	Antigen presentation	
3.2.b.	Antigen processing pathways (Cytosolic and Endocytic Pathway)	
3.3.	**MHC Complex and MHC molecules**	3L
3.3.a.	Organization of MHC genes	
3.3.b.	Structure of class I and class II molecules	
3.3.c	T-cell antigen receptors and MHC molecule	
3.4	**Complement System**	3L
3.4.a	Complement component and notation	
3.4.b.	Complement activation (Classical, Alternate and Lectin Pathway)	
3.4.c	Biological consequence of complement system	

References:

1) Ananthanarayan and Paniker, (2009), Textbook of Microbiology, 8th Edition. Universal Press
2) Cedric Mims et al, Medical Microbiology, 3rd Edition Mosby
3) Prescott, Harley, Klein, Microbiology. 6th Edition McGraw Hill
4) Konemann, Diagnostic Microbiology, 5th and 6th Edition. Lippincott

5) Teri Shors Jones Understanding Viruses Bartlett Publisher
6) Thomas J. Kindt, Richard A. G, Barbara A. Osburne (2007) Kuby Immunology: W. H. Freeman and Company, New York.
7) FahimHalim Khan, The elements of Immunology, Pearson Education.33
8) Pathak, S., Palan U, Immunology Essential and Fundamental. Pareen publications, Bombay.
9) Ian R. Tizard —Immunology, An Introduction, 4th - Edition, Saunders college publishing.

Evaluation Pattern: Theory

For course II
External Evaluation – Semester End Examination (60 M) - Duration: 2 hours
Paper Pattern

Question No	Module	Marks with Option	Marks without Option
1	I	30	20
2	II	30	20
3	III	30	20

Internal Evaluation - (40 M)
(Give different ways of internal evaluation finalised for each module)
Probable options:
Plickers
Testmoz
Google form
Moodle
Objective-MCQ
Short answer test

T. Y. B. Sc. (MICROBIOLOGY)

SEMESTER V - Practical

Course-II

COURSE CODE: 20US5MBP1

[CREDITS - 01]

Experiment Sr. no.	Title and Number of Credits	Number of hours
1.	Schematic /diagrammatic representation of each system/condition as per the theory syllabus (Respiratory, Urinary)	2
2.	Diagnostic Cycle of any one infection of each of the above systems (viz., in upper respiratory tract: Pharyngitis)	1
3.	Samples of various forms/procedures used for diagnostic tests - Request forms, Test reports, (Results, Panic report, alert report) to be drawn or attached in the journal.	1
4.	Tabulation of: A. Types of samples, containers, specimens, with reference to the symptoms/ infections. B. Transport media with reference to samples/suspected pathogen. C. Collection and Processing of samples in various infections. D. Primary isolation of suspected pathogens in different infections with reference to pathological sample. E. Rapid tests for identification of pathogens e.g. staining (Acid fast, Metachromatic granules, Capsule) F. Minimum biochemical media for identification of the pathogens listed in the syllabus i.e. *S. aureus, S. pyogenes E. coli, Klebsiella* spp (any one). *Proteus spp* (any one)., *Pseudomonas spp.*(any one), *Corynebacterium diphtheriae* G. List of samples to be used with the above:	3

	i. URT: Nasal swab, pus ii. LRT : sputum iii. UTI: Urine	
5.	Case study and problem solving for identification of the pathogen with reference to each of the infections (Include approach writing, suspected organisms, requirements for the identification tests and their justification rapid tests)	12
6.	Kirby-Bauer method for AST.(Project)	4
7.	Synergistic activity of antibiotics.	3
8.	E test(Demonstration).	1
9.	Acid fast staining for M. leprae	1
10.	Staining techniques for pathological samples	2

Evaluation pattern: Practical

External evaluation: 30 Marks practical examination at the end of each semester per course.

Internal evaluation: 20 marks

a) Rough Journal – 05
b) Fair Journal – 05
c) Viva- 10

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

Course – III

COURSE TITLE: Microbial Biochemistry-I

COURSE CODE: 20US5MBMBC3

[CREDITS - 02]

Course Learning Outcomes: After successful completion of the Course, the learner will be able to:

1) Evaluate the different types of solute transport mechanisms of a living cell.
2) Explain energy generation by oxidative phosphorylation.
3) Apply principles of bioenergetics to metabolic pathways.
4) Elucidate the convergence of different catabolic pathways in carbohydrate metabolism.

Module	TITLE AND CONTENT	NO OF LECTURES
I	**Solute Transport** **Learning Objectives:** 1) To describe the different models of biological membrane. 2) To define different terms related to solute transport. 3) To distinguish between simple diffusion, facilitated and active and passive transport. 4) To state different methods of studying solute transport. 5) To describe the mechanism of group translocation. 6) To recognize other modes of solute transport. **Learning Outcomes:** After the successful completion of the module, the learner will be able to: 1) Illustrate the use of proteoliposomes in solute transport. 2) State different modes of solute transport. 3) Compare and contrast between active and passive transport. 4) Describe the mechanism of group translocation. 5) Cite one example each of simple diffusion, facilitated and active transport.	

	6) Distinguish between primary and secondary active transport.	
1.1	**Structure and function of Biological membrane:** Fluid Mosaic Model, lipid rafts, Integral and peripheral proteins. Model membranes.	2L
1.2	**Methods of studying solute transport:** Preparation and use of proteoliposomes	1L
	Role of membrane in solute transport	1L
1.3	**Different mechanisms for uptake of solutes with one** example each:	6L
1.3. a	Passive diffusion	
1.3. b	Facilitated diffusion	
1.3. c	Active transport: Primary active transport: Binding proteins, Shock sensitive system (eg. Histidine uptake model, Maltose uptake)	
1.3.d.	Secondary active transport: (Uniport, Antiport, Symport) Mechanism of Group translocation: Phosphotransferase system	1L
1.3.e	Other examples of transport: Introduction to Siderophores. Iron Transport.	1L
2	**Bioenergetics:** **Learning Objectives:** 1) To understand functioning of electron transport system in cells. 2) To familiarize with mechanism of ATP generation. **Learning Outcomes:** After the successful completion of the module, the learner will be able to: 1) Describe the composition and functions of electron transport system. 2) Schematically describe electron transport in a few representative prokaryotes. 3) Differentiate between prokaryotic and eukaryotic electron transport system. 4) Describe the chemiosmotic hypothesis	

	5) Explain the structure and mechanism of ATP synthase 6) Analyse the difference between the shuttle systems Calculate energetics of TCA and EMP pathways.	
2.1. 2.2 2.3 2.4 2.5 2.6	Components, complexes and functions of Electron transport chain: Mitochondrial ETC, Bacterial ETC– *E. coli* -aerobic and anaerobic. Oxidative phosphorylation by Chemiosmotic coupling hypothesis Inhibitors and uncouplers Structure of Mitochondrial ATP synthase, Mechanism by Rotational catalysis Generation of electrochemical energy by- Bacteriorhodopsin ATP hydrolysis. Shuttle systems: Malate aspartate shuttle Glycerol -3- phosphate shuttle. Calculations of energetics of glycolysis and TCA, Balance sheet to be given with efficiency calculation.	3L 3L 2L 2L 1L 1L
3	**Catabolism of Carbohydrates:** **Learning Objectives:** 1) To study details of catabolic pathways of selected carbohydrates. 2) To analyse the multifunctional role of central metabolic pathways. 3) To identify the ways by which complex substrates converge to central metabolic pathways 4) To define the concept of fermentation. **Learning Outcomes**: After the successful completion of the module, the learner will be able to: 1) Differentiate between various structures of glucose polymers and their breakdown 2) Demonstrate how radiorespirometry can be used to identify simple biochemical pathways eg. EMP and ED. 3) Schematically represent and describe pathways listed in the syllabus	

	with structures of intermediates and enzymes. 4) Compare the various catabolic pathways for glucose catabolism Represent with structures and associated enzymes the metabolic pathways of different fermentations and analyse the differences between them.	
3.1.	**Catabolism of Carbohydrates:** Breakdown of polysaccharides –glycogen, starch, cellulose Breakdown of oligosaccharides – lactose, maltose, sucrose (by phosphorylysis) Utilization of monosaccharides – fructose, galactose	3L
3.2	**Major pathways-**	
3.2.a.	Glycolysis (EMP), TCA,	2L
3.2.b.	HMP ED pathway,	1L
3.2.c	Use of radio-respirometry with reference to EMP & ED.	1L
3.2.d	Anaplerotic reactions of TCA, glyoxylate bypass	2L
3.3.	**Other modes of fermentations in microorganisms:** Lactic acid (homo, hetero fermentative pathway, bifidum pathway) mixed acid, butanediol fermentations Acetone-butanol	3L

References:

1) Stanier. R.Y., Ingraham, J.L., Wheelis, M.L., Painter, R.R, (1987) General Microbiology, 5th edition, The Macmillan press Ltd.
2) Conn Stumpf, P. K., Bruening, G. R. H. (1987) Outlines of Biochemistry, 5thedition, John Wiley & sons.
3) Gottschalk, G., (1985), Bacterial Metabolism, 2nd edition, Springer Verlag.
4) White, D., (1995), The Physiology and Biochemistry of Prokaryotes, 3rdedition, Oxford University Press
5) Nelson, D, Cox, M, (2005), Lehninger Principles of biochemistry,4th edition, W. H. Freeman and Company.
6) Biochemistry 3rd edition, Mathews, Van Holde, Pearson Education.

7) Voet, D &Voet, J. G., (2004), Biochemistry, 3rd edition, John Wiley& Sons Inc
8) Zubey, G. L (1996), Biochemistry, 4th edition, Wm. C. B Brown publishers.

Evaluation Pattern: Theory

For course III

External Evaluation – Semester End Examination (60 M) - Duration: 2 hours

Paper Pattern

Question No	Module	Marks with Option	Marks without Option
1	I	30	20
2	II	30	20
3	III	30	20

Internal Evaluation - (40 M)

(Give different ways of internal evaluation finalised for each module)

Probable options:

Plickers

Testmoz

Google form

Moodle

Objective-MCQ

Short answer test

T. Y. B. Sc. (MICROBIOLOGY)

SEMESTER V - Practical

Course-III

COURSE CODE: 20US5MBMBP2

[CREDITS - 01]

Experiment Sr. no.	Title and Number of Credits	Number of hours
1.	Study of biochemical pathway and study of end products of enzymes in characterization of microorganisms oxidase, catalase, phosphatase –Qualitative detection and quantitative MR-VP test	09
2.	Detection of amylase activity	01
3.	Oxidative and fermentative utilization of glucose by microbes	02
4.	Detection of homo and mixed acid fermentation	10
5.	Isolation of mitochondria and assay for ETC activity	05
6.	Enrichment and isolation of cellulose digestors	03

Evaluation pattern: Practical

External evaluation: 30 Marks practical examination at the end of each semester per course.

Internal evaluation: 20 marks

a) Rough Journal – 05
b) Fair Journal – 05
c) Viva- 10

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

Course – IV

COURSE TITLE: Bioprocess Technology-Upstream Processes

COURSE CODE: 2OUS5MBBTC4

[CREDITS - O2]

Course Learning Outcomes : After successful completion of the Course, the learner will be able to:

1) Evaluate the fermenter design most suitable for optimum production of a microbial product.
2) Comprehend the need for strain improvement.
3) Illustrate the sterilization methods used in industrial fermentation processes.

Module	TITLE AND CONTENT	NO OF LECTURES
I	**Module: I : Strain Improvement and Sterilization:** **Learning Objectives:** The objectives of this unit are to: 1) Describe the need for strain improvement 2) Explore the different approaches for strain improvement 3) Evaluate the methods of sterilization 4) Illustrate filtration as an effective method of sterilization of media, air and exhaust air **Learning Outcomes:** After the successful completion of the module, the learner will be able to: 1) Recall and comprehend different methods of Strain improvement 2) Assess the advantages and disadvantages of batch and continuous sterilization methods 3) Differentiate between Depth and Absolute filters. Establish the process steps for filter sterilization of media	
I.I I.I.a	**Strain Improvement:** The random, empirical approach	 IL

I.I.b.	The power of recombination in 'Strain construction'	1L
I.I.c.	Directed screening for mutants with altered metabolism and methods of detection of mutants	2L
I.I.d	Recombinant DNA approaches to Strain Improvement for low- and medium-value products	1L
I.I.e.	Strain improvement for high value products	1L
I.2.	**Sterilization:**	
I.2.a.	Consequences of invasion in a fermentation by a foreign organism.	1L
I.2.b.	Sterilization criterion: Definition and significance.	
I.2.c.	Methods of Batch sterilization.	1L
I.2.d.	Methods of Continuous sterilization.	2L
I.2.e.	Mechanisms of filtration	1L
I.2.f.	Depth and Absolute filters	
I.2.g	Filter sterilization of fermentation media, air and fermenter exhaust air	1L
2	**Types of Bioreactors:** **Learning Objectives:** The objectives of this unit are to: 1) Describe the constructional variations of different fermenters 2) Outline the fermenter designs diagrammatically 3) Relate the need for different parts in a fermenter to the type of product **Learning Outcomes:** After the successful completion of the module, the learner will be able to: 1) Characterise the different fermenter designs 2) Relate the design of the fermenter to the conditions needed for optimum product formation 3) Evaluate the fermenter design with respect to economy of process and product formation 4) Justify the need for modified fermenter designs for Animal cell culture	

	Types of Bioreactors: Typical constructional features and their importance in the specific processes.	
2.1.	**Types of fermenters based on Power Input for mixing (mechanical, hydrodynamic and pneumatic)**	1L
2.1.a.	Mechanical-Waldhof fermenter,	1L
2.1.b	Hydrodynamic-deep-jet fermenter, trickling generator	1L
2.1.c	Pneumatic -air-lift fermenter, bubble-cap fermenter, acetator, cavitator.	4L
2.3.	**Animal cell culture reactors** (Stirred fermenters, Air-Lift fermenters, Radial flow fermenters, Microcarriers, Encapsulation, Hollow fibre chambers, Packed glass bead reactors, Perfusion Cultures).	2L
2.4.	**Photo-bioreactor, tower and packed tower fermenters, Biofilters and Fixed film processes.**	2L
2.5.	**Solid State fermenters, Membrane fermenters and Single use disposable fermenters.**	1L
3	**Fermentation Parameter- Monitoring and control:** **Learning Objectives:** The objectives of this unit are to: 1) Assess the requirement for monitoring of fermentation parameters 2) Evaluate the limitations of different methods of monitoring fermentation parameters 3) Appreciate the control mechanisms for parameters **Learning Outcomes:** After the successful completion of the module, the learner will be able to: 1) Categorise different types of sensors 2) Recall and Evaluate the different methods of monitoring fermentation parameters 3) Derive the ways to control the fermentation parameters 4) Analyse the output of monitoring devices 5) Differentiate between manual and automatic control of parameters	

3.1.	**Fermentation Parameter- Monitoring and control: Different types of sensors based on location and in relation to its application for process control.**	1L
3.2. 3.2.a. 3.2.b. 3.2.c. 3.2.d.	**Temperature Monitoring and Control:** Mercury-in-glass thermometers Electrical resistance thermometers. Thermistors. Temperature control	1L
3.3. 3.3.a. 3.3.b. 3.3.c	**Flow measurement and control:** Gases Liquids Control of flow of gases and liquids	1L
3.4. 3.4.a. 3.4.b. 3.4.c 3.3.d	**Pressure measurement and control:** Bourdon tube pressure guage Nested diaphragm-type pressure sensor Pressure bellows, Strain Guage, Piezoelectric transducer Pressure control	1L
3.5.	**Foam sensing and control**	1L
3.6. 3.6.a. 3.6.b. 3.6.c	**Measurement and control of dissolved oxygen:** Galvanic and Polarographic electrodes Fluorometric Oxygen sensor Control of dissolved oxygen.	2L
3.7. 3.7.a. 3.7.b. 3.7.c	**Inlet and exit gas analysis:** Deflection type paramagnetic oxygen analyser Thermal-type paramagnetic oxygen analyser Infrared analyser	2L
3.8.	**pH measurement and control:**	1L
3.9.	**Control systems:**	2L

3.9.a 3.9.b	Manual Control Automatic control i. Two- position controllers ii. Proportional controllers. iii. Integral controllers iv. Derivative controllers.	

References:

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2) Okafor N. (2007). Modern Industrial Microbiology and Biotechnology. Ist edition. Bios Scientific
Publishers Limited. USA
3) Waites M.J., Morgan N.L., Rockey J.S. and Higton G. (2001). Industrial Microbiology: An Introduction. Ist edition. Wiley – Blackwell
4) Glaze A.N. and Nikaido H. (1995). Microbial Biotechnology: Fundamentals of Applied Microbiology. Ist edition. W.H. Freeman and Company
5) Casida LE. (1991). Industrial Microbiology. Ist edition. Wiley Eastern Limited.
6) Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd edition. Panima Publishing Co. New Delhi.
7) Stanbury PF, Whitaker A and Hall SJ. (2006). Principles of Fermentation Technology. 2nd edition,Elsevier Science Ltd.
8) Stanbury PF, Whitaker A and Hall SJ. (2017). Principles of Fermentation Technology. 3rd edition,Elsevier Science Ltd.
9) Walsh Gary, (2011). Pharmaceutical Biotechnology. I st edition, Wiley-India edition.
10) E.M.T.El-Mansi and A.R.Allman (2012). Fermentation Microbiology and Biotechnology. 3rd edition. CRC Press.

Evaluation Pattern: Theory

For course IV

External Evaluation – Semester End Examination (60 M) - Duration: 2 hours

Paper Pattern

Question No	Module	Marks with Option	Marks without Option
I	I	30	20

2	II	30	20
3	III	30	20

Internal Evaluation - (40 M)
(Give different ways of internal evaluation finalised for each module)
Probable options:
Plickers
Testmoz
Google form
Moodle
Objective-MCQ
Short answer test
Piktochart
Test on OFFEE

T. Y. B. Sc. (MICROBIOLOGY)

SEMESTER V - Practical

Course-IV

COURSE CODE: 2OUS5MBP2

[CREDITS - 01]

Experiment Sr. no.	Title and Number of Credits	Number of hours
1.	Gradient plate technique for isolation of mutants	6
2.	Study of fermenter parts and demonstration of its working	14
3.	Enrichment methods for mutants	10

Evaluation pattern: Practical

External evaluation: 30 Marks practical examination at the end of each semester per course.

Internal evaluation: 20 marks

a) Rough Journal – 05
b) Fair Journal – 05
c) Viva- 10

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

Discipline Specific Elective DSE-I

COURSE TITLE: Environmental Microbiology

COURSE CODE: 2OUS5MBEAM5

[CREDITS - O2]

Course Learning Outcomes: After successful completion of the Course, the learner will be able to:

1) Analyse the significance of synchronous and regulated networks of different biogeochemical cycles functional in the ecosystem.
2) Summarize the data on different types of microbial products.
3) Implement the different methods of waste management.
4) Evaluate the potential of microbes in bioremediation.

Module	TITLE AND CONTENT	NO OF LECTURES
I	**Module: I : Biogeochemical Cycles:** **Learning Objectives:** 1) To describe different biogeochemical cycles operating in ecosystem. 2) To correlate the sulphur cycle to different reduced habitats. 3) To distinguish between different nitrogen sources. **Learning Outcomes:** After the successful completion of the module, the learner will be able to: 1) Schematically illustrate the flow of nutrients in ecosystem. 2) Appreciate the dynamic exchange of major elements between biotic and abiotic components. 3) Recognize the role of phosphate solubilizers. 4) Distinguish between nitrification and denitrification. Describe the degradation of carbon-based polymers.	
I.I	**Concept of Biogeochemical cycle and its significance.**	IL
I.2	**Carbon cycle:** Microbial degradation of cellulose,	3L

	hemicelluloses, lignin and chitin.	
1.3	**Nitrogen cycle:** Nitrogen fixation, ammonification, nitrification, denitrification and nitrate reduction	3L
1.4.	**Phosphorus cycle:** Phosphate immobilization and solubilisation	2L
1.5.	**Sulphur cycle:** Microbes involved in sulphur cycle	3L
2	**Microbial derived value-added products.** **Learning Objectives:** 1) To describe the production of features of Biofuels and appreciate its potential **Learning Outcomes:** After the successful completion of the module, the learner will be able to: 1) Discuss significance of Biofuels. 2) Describe the production of biofuels. 3) Apply the use of biotechnology for improvement of biofuel production methods	
2.1 2.1a 2.1b 2.2 2.3 2.4 2.5	**Biofuels:** Conventional fuels and their impact on the environment Oil, Coal, Natural gas Advantages and disadvantages of Biofuels. Conversion of Wood, Sugar and starch crops into biofuel, Hydrocarbon producing crops **Biogas** Benefits, Stages of Anaerobic digestion, types of digesters. factors affecting. **Bioethanol, Biobutanol** Advantages of Bioethanol over Petrol Production and Recovery of Bioethanol Future directions for Research and Development **Biodiesel:** Lipids as a source of Biodiesel Biodiesel from hydrocarbons **Biohydrogen:** Methods of production: (List of names of the methods) Roues of production of Bio hydrogen,	2L 3L 2L 1L 2L

2.6	Anaerobic fermentation , Photosynthetic algae In-vitro photosynthetic hydrogenase system **Microbial Fuel Cells** Features and applications. Comparison among different types of Biosensors	2L
3	**Microbial Bioremediation:** **Learning Objectives:** 1) To define the concept of bioremediation and allied terms. 2) To describe different types of bioremediation. 3) To be introduced to types and applications of Biosensors **Learning Outcomes**: After the successful completion of the module, the learner will be able to: 1) Describe different methods of bioremediation. 2) Appreciate the difference between in-situ and ex-situ bioremediation methods. 3) Recognize the role of biosurfactants in bioremediation. 4) Represent the structural components of Biosensors and list different types. 5) State and describe the applications of Biosensors. 6) Cite the characteristic features of biosensors	
3.1.	**Concept of Bioremediation and its significance:** **Types-** in-situ and ex-situ bioremediation.	1L
3.2. . 3.3	**Methods:** Bioremediation of hydrocarbons, dyes, paper and pulp industry, heavy metals, xenobiotics, common pesticides, oil spills. Biofilters. Bioaugmentation and Bioventing Role of Biosurfactants in bioremediation.	5L 1L 1L
3.4.	**Biosensors:** Introduction and features Schematic representation of components of a Biosensor Types of Biosensors: Brief description of each type.	4L

	Advantages of Biosensors Applications of Biosensors	

References:

1) Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th edition. Benjamin/Cummings Science Publishing, USA.
2) Madigan MT, Martinko JM and Parker J. (2014). Brock Biology of Microorganisms. 14th edition. Pearson/ Benjamin Cummings.
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4) Okafor, N (2011). Environmental Microbiology of Aquatic & Waste systems. Ist edition, Springer, New York.
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8) Lynch JM & Hobbie JE. (1988). Microorganisms in Action: Concepts & Application in Microbial Ecology. Blackwell Scientific Publication, U.K.
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12) Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.
13) B. D. Singh, (2010). Biotechnology- Expanding Horizon, 3rd Revised Edition, Kalyani Publishers.
14) R.C. Dubey, A Text Book of Biotechnology.4th edition, S.Chand & Co Ltd, New Delhi
15) S. N. Jogdand, (1999). Advances in Biotechnology, 2nd Revised Edition, Himalaya Publishing House.

Evaluation Pattern: Theory

For course: DSE-I

External Evaluation – Semester End Examination (60 M) - Duration: 2 hours

Paper Pattern

Question No	Module	Marks with Option	Marks without Option
1	I	30	20
2	II	30	20
3	III	30	20

Internal Evaluation - (40 M)

(Give different ways of internal evaluation finalised for each module)

Probable options:

Plickers

Testmoz

Google form

Moodle

Objective-MCQ

Short answer test

T. Y. B. Sc. (MICROBIOLOGY)

SEMESTER V - Practical

DSE Course-I

COURSE CODE: 20US5MBP3

[CREDITS - 01]

Experiment Sr. no.	Title	Number of hours
1.	Isolation and characterization of phosphate solubilising microorganisms.	04
2.	Isolation and characterization of ligninolytic fungi.	04
3.	Isolation and characterization of chitinase producing microorganisms.	04
4.	Enrichment, isolation and characterization of dye degrading microorganisms.	06
5.	Study of Microbial fuel cell- Demonstration/ visit to an institute producing Biofuels.	06
5.	Enrichment, isolation and characterization of phenol degrading microorganisms.	06

Evaluation pattern: Practical

External evaluation: 30 Marks practical examination at the end of each semester per course.

Internal evaluation: 20 marks

a) Rough Journal – 05
b) Fair Journal – 05
c) Viva- 10

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

Discipline Specific Elective DSE-II

COURSE TITLE: Plant and Animal Biotechnology

COURSE CODE: 2OUS5MBFDM7

[CREDITS - O2]

Plant and Animal Biotechnology

Course Learning outcomes: After successful completion of the Course, the learner will be able to:

1) Demonstrate the set-up requirements of plant tissue culture laboratory and culture techniques.
2) Establish animal cell lines by tissue culture techniques.
3) Demonstrate different methods to get transgenic crops and their applications in getting resistant varieties.
4) Evaluate the concept of hybridoma technology and in vitro fertilization.

Module	TITLE AND CONTENT	NO OF LECTURES
1	**Plant Tissue Culture**: **Learning Objective:** 1) The objective of the course is to familiarize the students with basic concepts of plant biotechnology. **Learning outcome**: By the end of the course, students will have sufficient scientific understanding & will be able to: 1) Demonstrate various sterilization techniques applied in plant biotechnology laboratory and know the components and preparation of media for tissue culture 2) Establish and maintain plant cells in tissue culture and understand culture of various plant organs. 3) Understand the significance and methods of protoplast isolation and fusion.	

1.1	Concepts of Cell theory & Cellular totipotency, Infrastructure & Organization of plant tissue culture laboratory – General & aseptic laboratory, different work areas, equipments & instruments required.	1L
1.2	Aseptic techniques – Washing & preparation of glassware, packing & sterilization, media sterilization, surface sterilization, aseptic workstation, precautions to maintain aseptic conditions	1L
1.3	Culture Media – Nutritional requirements of the explants, PGRs and their in vitro roles, media preparation	2L
1.4 1.4 a 1.4 b 1.4 c	Response of explants in vitro– Dedifferentiation and redifferentiation Organogenesis (direct and indirect) Embryogenesis (direct and indirect)	1L
1.5	Callus culture technique– Introduction, principle, factors affecting, Morphology & internal structure	2L
1.6	Suspension culture technique – Introduction, principle, types, synchronization	1L
1.7	Anther & pollen culture – Introduction, principle, factors affecting.	1L
1.8	Micropropogation	1L
1.9	Protoplast isolation and fusion.(Somatic Hybridisation)	1L
1.10	Hydroponics and Aeroponics	1L
2	**Animal Tissue culture** **Learning Objective :** 1)Complete understanding of the science of Animal Tissue Culture, with emphasis on their applications. **Learning Outcomes**: By the end of the course, students will have sufficient scientific understanding and will be able to: 1)Understand the basics of Animal tissue culture techniques.	

	2)Understand the usefulness of in-vitro cell culture model for various biological questions . 3)Know the preparation of media, assessment of cell growth. 4)Demonstrate the ability to establish and maintain animal cell lines in culture and cryopreservation techniques	
2.1.a 2.1.b	Introduction: Comparison with microbial culture Concept of monolayer, suspension, histotypic/ organotypic, organ culture. Precautions to avoid contamination by bacteria, Mycoplasma and fungi.	2L
2.2 2.2.a 2.2.b 22.c	Equipment and infrastructure Laboratory design Instruments used in ATC Labware: Types of Flasks ..	2L
2.3 2.3.a. 2.3.b.	Primary cell culture Source selection, different methods of establishing primary cell culture Special reference to fibroblast culture and lymphocyte culture	3L
2.4 2.4.a. 2.4.b	Characterization of cell lines Need for characterization Karyotyping, biochemical & genetic characterization of cell lines.	3L
2.5 2.5.a 2.5.b	Cell storage and distribution Cryopreservation Cell repositories	2L
3	**Applications of Plant and Animal cell cultures.** **Learning Objective:** 1.The objective of the course is to familiarize the students with new concepts and advanced research areas and applications of plant and animal biotechnology. **Learning outcome:** By the end of the course, students will have sufficient scientific	

	understanding & will be able to: 1.Understand the Growth and large Scale cultivation of Plant and Animal cells. 2.Demonstrate different methods to get transgenic crops and their applications in getting resistant varieties. 3.Learn the concept of hybridoma technology and invitro fertilization and their applications.	
3.1 3.1.a 3.1.b 3.2 3.3 3.4	Transgenics in crop improvement Methods of gene transfer: Biologica l(Agrobacterium mediated) Chemical and physical methods. Resistance to biotic stresses: Insect resistance Resistance to abiotic stresses, Herbicide resistance Terminator technology for use in hybrid seed production, Commercial transgenic crops. Gene drives for vector control In Vitro Fertilization & Transgenic Animals In vitro fertilization (IVF) in humans; embryo transfer (ET) in humans; superovulation, IVF and embryo culture in farm animals (e.g. cow); embryo transfer in cattle, Gene transfer or transfection (using eggs and cultured stem cells); targeted gene transfer; transgenic animals. (mice).Cloning of animals-Dolly sheep Production of therapeutic proteins & vaccines using cell culture.	4L 1L 5L 2L

Reference:

1) Plant tissue Culture : Theory and Practice by S.S. Bhojwani and M.K. Razdan, Elsevier, Amsterdam, 1996.
2) An Introduction to Plant Biotechnology by H. C. Chawla, Oxford and IBH,

2002. Gene Transfer to Plants by I.Potrykus and G. Spangenberg, Springer Lab Manual, Springer Verlag, 1997
3) R.C. Dubey, A Text Book of Biotechnology. S.Chand & Co Ltd, New Delhi
4) B. D. Singh, (2010). Biotechnology- Expanding Horizon, 3rd Revised Edition, Kalyani Publishers.
5) Culture of Animal Cells – A manual of basic technique and specialized applications by R. I. Freshney, 6th edition, Wiley-Blackwell, 2010.
6) Basic Cell Culture by J. M. Davis, 2nd Edition, Oxford University Press, 2002.
7) Sudha Gangal, Animal Tissue culture. Second edition. University Press (India) Pvt. Ltd. Hyderabad.

Evaluation Pattern: Theory

For course: DSE-II

External Evaluation – Semester End Examination (60 M) - Duration: 2 hours

Paper Pattern

Question No	Module	Marks with Option	Marks without Option
1	I	30	20
2	II	30	20
3	III	30	20

Internal Evaluation - (40 M)
(Give different ways of internal evaluation finalised for each module)
Probable options:
Plickers
Testmoz
Google form
Moodle
Objective-MCQ
Short answer test

T. Y. B. Sc. (MICROBIOLOGY)

SEMESTER V - Practical

DSE Course-II

COURSE CODE: 20US5MBP3

[CREDITS - 01]

Experiment Sr. no.	Title and Number of Credits	Number of hours
1.	MS media preparation.	4
2.	Establishment and maintenance of callus culture.	4
3.	Preparation of Artificial seeds.	4
4.	Viability test and cell counting	3
5.	Case study on transgenic animals and transgenic plants.	7
6.	Culture of chick embryo fibroblast (monolayer)-Visit Visit to Hydroponics facility.	8

Evaluation pattern: Practical

External evaluation: 30 Marks practical examination at the end of each semester per course.

Internal evaluation: 10 marks

a) Fair Journal – 05
b) Viva- 05

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

SEC – I

COURSE TITLE: FOOD AND DAIRY MICROBIOLOGY

COURSE CODE: 2OUS5MBFDM7

[CREDITS - O2]

Course Learning Outcomes: After successful completion of the Course, the learner will be able to:

1) Formulate the synthesis process of various fermented dairy products.
2) Explain the concepts of Probiotics, Nutraceuticals and SCP.
3) Differentiate between different types of foodborne disease-causing microorganisms.

Module	TITLE AND CONTENT	NO OF LECTURES
1	**Commercial Foods** : **Learning objective :** 1) Gain knowledge about the role of microorganisms in fermentation industry 2) Impart the current knowledge of probiotics and functional dairy products for health benefits. **Learning outcome :** After the completion of module, the learner will be able to: 1)State the significance of starter cultures in food industry 2)Understand the preparation of fermented products 3)Employ the microorganisms as Probiotics and Nutraceuticals	
1.1.a 1.1.b 1.1.c 1.1.d 1.1.e	Dairy starter cultures, Fermented dairy products: yoghurt, tofu, dahi, cheese. Other fermented foods: Idli, dosa, kombucha, green tea Probiotics: Health benefits, types of microorganisms used, probiotic foods available in market and nutraceuticals.	2L 6L 5L 1L

	Single cell protein.	
2.	**Food borne diseases** **Learning objective:** 1) Provide the information on food spoilage organisms 2) Understanding the causes of food borne diseases **Learning outcome:** After learning the module learner should be able to: 1) Differentiate between different types of food spoilage microorganisms causing different types of food borne disease 2) Review and analyse various preservation strategies for food to prevent food spoilage disease	
2.1.a.	Food intoxications: *Staphylococcus aureus*,	2L
2.1.b.	*Clostridium botulinum*	2L
2.1.c.	Mycotoxins,	2L
2.1.d.	Shigellosis,	2L
2.1.e.	Salmonellosis	2L
2.1.f.	*Entamoeba histolytica , Hepatitis E, Giardia lamblia*	2L
2.1.g.	*Yersinia enterocolitica*,	1L
2.1.h.	*Listeria monocytogenes*	1L

References:

1) Adams MR and Moss MO. (1995). Food Microbiology. 4th edition, New Age International (P) Limited Publishers, New Delhi, India.
2) Banwart JM. (1987). Basic Food Microbiology. Ist edition. CBS Publishers and Distributors,Delhi, India.
3) Davidson PM and Brannen AL. (1993). Antimicrobials in Foods. Marcel Dekker, New York.
4) Dillion VM and Board RG. (1996). Natural Antimicrobial Systems and Food Preservation. CAB International, Wallingford, Oxon.
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Evaluation Pattern: Theory

For course: SEC -I

External Evaluation – Semester End Examination (60 M) - Duration: 2 hours

Paper Pattern

Question No	Module	Marks with Option	Marks without Option
1	I	40	30
2	II	40	30

T. Y. B. Sc. (MICROBIOLOGY)

SEMESTER V - Practical

SEC Course-I

COURSE CODE:20US5MBFDM7

[CREDITS – 0.5]

Experiment Sr. no.	Title and Number of Credits	Number of hours
1.	Preparation of Idli batter, Determination of Microbial load	4
2.	Testing of acidity from idli batter	2
3.	Isolation of Lactic acid bacteria	2
4.	Isolation of spoilage causing microorganisms from milk, cheese and yoghurt.	7

Evaluation pattern: Practical (40M)

External evaluation: 30 Marks practical examination at the end of each semester per course.

Internal evaluation: 10 marks

a) Fair Journal – 05
b) Viva- 05

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Syllabus -T.Y.B.Sc. Microbiology

Semester VI	Course Number	Course Title	Course code	Credits	Hours	Periods (50 min)	Unit/ Module	Lectures (50 MINUTES)	Examination		
									Internal Marks	External Marks	Total Marks
THEORY											
Core courses											
	I	Mechanisms of Genetic Exchange, Mutation and Repair	20US6MBMGMC1	2	30	36	3	12	40	60	100
	II	Medical Microbiology and Immunology-II	20US6MBMMIC2	2	30	36	3	12	40	60	100
	III	Microbial Biochemistry-II	20US6MBMBC3	2	30	36	3	12	40	60	100
	IV	Bioprocess Technology-Downstream	20US6MBBPTC4	2	30	36	3	12	40	60	100

		Processing and Fermentations									
Discipline Specific Electives											
DSE	I	Recombinant DNA Technology and Advanced Virology	2OUS6MBRDV5	2	30	36	3	12	40	60	100
	II	Advances in Immunology and Medical Microbiology	2OUS6MBAIM6	2	30	36	3	12	40	60	100
	III (OPTIONAL)	Research Project		2	30	36			40	60	100
Skill Enhancement Electives											
SEC **	I	Advances in Microbial Techniques	2OUS6MBAMT7	1.5	23	28	2	14		60	60
PRACTICALS											
CORE COURSES											
	I	Mechanisms of Genetic ExchangeMutati	2OUS6MBPI	1	2	2.4			20	30	50

		on and Repair									
	II	Medical Microbiology and Immunology-II	20US6MBP1	1	2	2.4			20	30	50
	III	Microbial Biochemistry-II	20US6MBP2	1	2	2.4			20	30	50
	IV	Bioprocess Technology-Downstream Processing and Fermentations	20US6MBP2	1	2	2.4			20	30	50

Discipline Specific Electives											
DSE	I	Recombinant DNA Technology and Advanced Virology	20US6MBP3	1	2	2.4			20	30	50
	II	Advanc	20U	1	2	2.4			20	30	50

		es in Immunology and Medical Microbiology	S6MBP3								
	III	Research Project		1	2	2.4			20	30	50
Skill Enhancement Electives											
SEC		Advances in Microbial Techniques	20US6MBAMT7	0.5	1	1.2			10	30	40
TOTAL				20							

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

Course – I

COURSE TITLE: Mechanisms of Genetic Exchange, Mutation and Repair.

COURSE CODE: 20US6MBMGMC1

[CREDITS - 02]

Course Learning Outcomes: After successful completion of the Course, the learner will be able to:

1) Summarize the molecular mechanisms of Transformation, Conjugation and Transduction.
2) Compare and contrast natural and artificial transformation.
3) Describe the molecular machinery and mechanisms associated with plasmids, transposable elements and recombination.
4) Describe the molecular mechanisms of different mutations.

Module	TITLE AND CONTENT	NO OF LECTURES
1	**Genetic Exchange:** **Learning Objectives:** 1) To describe the molecular mechanisms of Transformation, Conjugation and Transduction. 2) To list the different proteins involved in the genetic exchange processes. 3) To investigate the role of F plasmid in conjugation. **Learning Outcomes**: After the successful completion of the module, the learner will be able to: 1) Summarize the hierarchy of the steps involved in genetic exchange processes. 2) Compare and contrast natural and artificial transformation. 3) Illustrate the steps to induce artificial transformation. 4) Apply the conjugation process to map the bacterial genes.	

	Differentiate between the generalized and specialised transduction.	
1.1 1.1.a 1.1.b 1.1.c 	**Genetic Exchange:** Gene transfer mechanisms in bacteria **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. **Conjugation:** i. Discovery of conjugation in bacteria (Lederberg and Tatum experiment). 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 behaviour of F‘ strains, Sex-duction. vi. Mapping of bacterial genes using conjugation (Interrupted mating experiment). vii. Problems based on conjugation. **Transduction**: i. Introduction and discovery. ii. Generalized transduction. iii. Use of Generalized transduction for mapping genes. iv. Specialized transduction. v. Problems based on transduction.	4L 4L 4L
2	**Plasmids, Transposons and Recombinantion** **Learning Objectives:** 1) To illustrate the steps in plasmid DNA extraction and separation. 2) To characterize the different types of plasmids. 3) To describe the different types of transposons. 4) To investigate the processes of transposition and recombination.	

	Learning Outcomes: After the successful completion of the module, the learner will be able to: 1) Summarize the steps and investigate the use of reagents in plasmid DNA extraction and separation. 2) Present an outline of the process of conjugative plasmids. 3) Identify the role of different types of plasmids. 4) Compare and contrast between composite and non-composite transposons. 5) Schematically represent and describe transposition and recombination.	
2.1. a	Plasmids: Physical nature of plasmids: Modular organization and types of plasmid. Detection and isolation of plasmids. Separation methods on the bases of size and conformation of plasmid DNA. Introduction to Plasmid incompatibility and Plasmid curing. Cell to cell transfer of plasmids Types and features of following plasmids i. Resistance Plasmids ii. Plasmids encoding Toxins and other Virulence characteristics iii. Col factor iv. Degradative plasmids v. Metabolic plasmids	2L 2L 2L
2.1.b	Transposable Elements in Prokaryotes: Insertion sequences. Transposons. i. Types: Composite and non-composite with one example each. Structure and properties. iii. General mechanism of integration of plasmids into chromosome. iv. Mechanism for Co-integrate formation for replicative transposition.	2L 2L

2.2.	Recombination in bacteria: General/Homologous recombination: Molecular mechanism of following models: i. Holliday model of recombination. ii. DSB (Double Strand Break) model of recombination. iii .Conservative Site –specific recombination-CSSR iv. Introduction to Insertion, Inversion and Deletion types of CSSR v. Introduction to Integrons	1L 1L
3	**Mutation and Repair** **Learning Objectives:** 1) To define mutation and its different types. 2) To determine the causative molecular mechanisms for different mutations. 3) To detect the mutants. 4) To state different types of repair mechanisms for DNA. **Learning Outcomes:** After the successful completion of the module, the learner will be able to: 1) State the role of mutation in evolution. 2) List different types and agents of mutation. 3) Apply the Replica plate method to determine the number of mutants. 4) Perform viable count to determine number of viable cells. 5) Tabulate different repair mechanisms for DNA.	
3.1. 3.1.a 3.1.b 3.1.c.	**Mutation and Repair** **Mutation** Terminology: alleles, homozygous, heterozygous genotype, phenotype, Somatic mutation, Germ-line mutation, Gene mutation, Chromosome Mutation, phenotypic lag, hotspots and mutator genes. **Fluctuation test (Adaptation versus Mutation theory)**	2L 1L

3.1.d.	**Types of mutations:** Point mutation, reverse mutation, suppressor mutation, frame shift mutation, conditional lethal mutation, base pair substitution, transition, trans version, missense mutation, nonsense mutation, silent mutation, neutral mutation, pleiotropic mutation.	3L
3.1.e	**Causes of mutations:** Natural/spontaneous mutation-DNA replication error, depurination, deamination.	2L
3.1.f.	**Induced mutation:** principle and mechanism with illustrative diagrams for: i. Chemical mutagens- base analogues, nitrous acid, hydroxyl amine, NTG. ii. Intercalating agents and alkylating agents. iii. Radiations- Ionizing and Non-ionizing radiations. iv. Environmental mutagens- Ames Test.	2L 1L
3.2.	**Detection of mutants – Visible mutants**, Nutritional mutants, Conditional mutants, Resistant mutants. DNA Repair –list different types (Tabulation)	1L

References:

1) Peter J. Russell (2006), —iGenetics-A molecular approach, 2nd edition.
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 edition, Pearson Education International.
5) Fairbanks and Anderson, (1999), —Genetics, Wadsworth Publishing Company.
6) Prescott, Harley and Klein, —Microbiology‖, 7th edition McGraw 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) Robert Weaver, —Molecular biology‖, 3rd edition. McGraw Hill international edition. 10.Primrose and Twyman, —Principles of gene manipulation and genomics‖, 7thed, Blackwell Publishing.
10) Nancy Trun and Jaine Trempy (2004), —Fundamental bacterial genetics‖ Blackwell Publishing.
11) D Nelson and M Cox, (2005) —Lehninger Principles of Biochemistry‖, 4th edition Macmillan worth Publishers.
12) Benjamin Lewin,—Genes IX‖, , Jones and Bartlett publishers.
13) JD Watson, —Molecular biology of the gene‖, 5th edition.
14) Snustad, Simmons, —Principles of genetics, 3rd edition. John Wiley & sons, Inc.

Evaluation Pattern: Theory

For course I

External Evaluation – Semester End Examination (60 M) - Duration: 2 hours

Paper Pattern

Question No	Module	Marks with Option	Marks without Option
1	I	30	20
2	II	30	20
3	III	30	20

Internal Evaluation - (40 M)
(Give different ways of internal evaluation finalised for each module)
Probable options:
Plickers
Testmoz
Google form
Moodle
Objective-MCQ
Short answer test

T. Y. B. Sc. (MICROBIOLOGY)

SEMESTER VI - Practical

Course-I

COURSE CODE: 20US6MBP1

[CREDITS - 01]

Experiment Sr.No.	Titles and Number of Credits	Number of hours
1.	Preparation of competent cells and transformation	04
2.	Genetics problems on Transformation, Conjugation and Transduction.	05
3.	UV survival curve – determination of exposure time leading to 90% reduction	08
4.	Isolation of mutants using UV mutagenesis	08
5.	Replica plate technique for selection & characterization of mutants auxotroph & antibiotic resistant	05

Evaluation pattern: Practical

External evaluation: 30 Marks practical examination at the end of each semester per course.

Internal evaluation: 20 marks

a) Rough Journal – 05
b) Fair Journal – 05
c) Viva- 10

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

Course – II

COURSE TITLE: Medical Microbiology and Immunology

COURSE CODE: 20US6MBMMIC2

[CREDITS - 02]

Course Learning Outcomes: After successful completion of the Course, the learner will be able to:

1) Categorize the virulence properties, pathogenesis, immunology and control measures associated with various pathogens of GI tract and Skin.
2) Categorize the virulence properties, pathogenesis, immunology and control measures associated with various pathogens of CNS and STD.
3) Discuss arthropod-borne diseases and emerging viral infections.
4) Summarize the ontogeny, differentiation and killing mechanism associated with T cell and B cell.

Module	TITLE AND CONTENT	NO OF LECTURES
I	MEDICAL MICROBIOLOGY **Learning objective:** To enable the learner to understand: 1) The etiological agents, their transmission and pathogenesis, 2) The Clinical Manifestations of the infections and the Laboratory Diagnostic procedures 3) The prophylactic measures and available treatment. **Learning outcome:** By the end of this course learners will be able to: 1) Differentiate and categorize the types of Gastrointestinal tract infections and Skin infections 2) Understand the virulence properties of pathogens causing Gastrointestinal tract infections and Skin infections	

	All infections are to be covered with respect to all details with emphasis on Etiology, Transmission, Pathogenesis, Clinical Manifestations, Lab Diagnosis, Prophylaxis, and Treatment.	
I.I.	**GI (Gastrointestinal Tract Infections)**	2L
I.I.a.	Salmonella	1L
I.I.b.	Shigella	1L
I.I.c	Hepatitis A	1L
I.I.d	*Entamoeba histolytica*	2L
I.I.e	Food Poisoning: Botulism, Staphylococcal	
I.2.	**Skin Infections**	
I.2.a	Pyogenic Streptococcal infections	2L
I.2.b	Pseudomonas	1L
I.2.c	Opportunistic diseases: Aspergillosis, Candidiasis	2L
2	**MEDICAL MICROBIOLOGY** **Learning objective:** To enable the learner to understand: 1) The etiological agents, their transmission and pathogenesis, 2) The Clinical Manifestations of the infections and the Laboratory Diagnostic procedures 3) The prophylactic measures and available treatment. **Learning outcome:** By the end of this course learners will be able to: 1) Understand the challenges of Sexually transmitted Diseases, Central nervous System infections and Emerging diseases 2) Understand the virulence properties as well as controlling measures of pathogens causing the Sexually transmitted Diseases, Central nervous System infections and Emerging diseases	
	All infections are to be covered with respect to all details with emphasis on Etiology, Transmission, Pathogenesis, Clinical Manifestations, Lab Diagnosis, Prophylaxis, and Treatment	
2.I.	**Sexually Transmitted Diseases**	4L
2.I.a	HIV infection	
2.I.b.	Syphilis	

2.1.c.	Gonorrhoea	
2.2.	**CNS (Central Nervous System Infections)**	3L
2.2.a.	Rabies	
2.2.b.	Bacterial Meningitis- Neisseria meningitidis	
2.3	**Arthropod vector borne infections:**	2L
2.3.a	Malaria , Dengue	
2.4	**Emerging and re-emerging infections:**	3L
	SARS, Zika, Nipah Virus.	
3	**Components of immune system and their role in Immune response** **Learning Objective:** 1) To describe how T cells and B cells are generated from primary lymphoid organs. 2) To describe the effector mechanism of T cells and B cells **Learning Outcome:** After successful completion of the module, the learner will be able to 1) Explain generation of T cells and B cells from primary lymphoid organs. 2) Describe and diagrammatically represent effector mechanism of T cells and B cells.	
3.1.	**T cell**	3L
3.1.a	Receptor, structure, organization	
3.1.b.	T cell development and maturation , positive, negative selection T cell activation and differentiation	
3.2	**Cell mediated effector response**	3L
3.2.a	Generation and target destruction by cytotoxic T cells	
3.2.b.	Kill mechanism of NK cells	
3.2.c.	Antibody dependent cell cytotoxicity	3L
3.3	**B cell**	
3.3.a	Receptor, structure and organization	
3.3.b	B cell development and maturation	
3.3.c	B cell activation and differentiation	
		3L
3.4.	**Humoral response**	
3.4.a.	Induction of humoral response, Primary and	

3.4b	secondary immune response. Germinal centres and antigen induced B cell differentiation	

References:

1) Ananthanarayan and Paniker, (2009), —Textbook of Microbiology, 8th Edition. Universal Press
2) Cedric Mims et al, — Medical Microbiology, 3rd Edition Mosby
3) Prescott, Harley, Klein, —Microbiology. 6th Edition McGraw Hill
4) Konemann, —Diagnostic Microbiology, 5th and 6th Edition. Lippincott
5) Teri Shors Jones —Understanding Viruses Bartlett Publisher
6) Thomas J. Kindt, Richard A. G, Barbara A. Osburne (2007) Kuby Immunology: W. H. Freeman and Company, New York.
7) FahimHalim Khan, —The elements of Immunology, Pearson Education.33
8) Pathak, S., Palan U, —Immunology Essential and Fundamental. Pareen publications, Bombay.
9) Ian R. Tizard —Immunology, An Introduction, 4th - Edition, Saunders college publishing.

Evaluation Pattern: Theory

For course II

External Evaluation – Semester End Examination (60 M) - Duration: 2 hours

Paper Pattern

Question No	Module	Marks with Option	Marks without Option
1	I	30	20
2	II	30	20
3	III	30	20

Internal Evaluation - (40 M)

(Give different ways of internal evaluation finalised for each module)

Probable options:

Plickers

Testmoz

Google form

Moodle

Objective-MCQ

Short answer test

T. Y. B. Sc. (MICROBIOLOGY)

SEMESTER VI - Practical

Course-II

COURSE CODE: 2OUS6MBPI

[CREDITS - OI]

Experiment Sr. no.	Title and Number of Credits	Number of hours
1.	Schematic /diagrammatic representation of each system/condition as per the theory syllabus (Gastrointestinal, Central Nervous system, Bacteremia)	2
2.	Diagnostic Cycle of any one infection of each of the above systems (viz GIT, CNS and Bacteremia.)	1
3.	Samples of various forms/procedures used for diagnostic tests - Request forms, Test reports.	1
4.	(Results, Panic report, alert report) to be drawn or attached in the journal.	1
5.	Tabulation of: Types of samples, containers, specimens, with reference to the symptoms/ infections	1
6.	Transport media with reference to samples/suspected pathogen. Collection and Processing of samples in various infections.	1
7.	Primary isolation of suspected pathogens in different	3

	infections with reference to pathological sample.	
8.	Rapid tests for identification of pathogens e.g. staining).	2
9.	Minimum biochemical media for identification of the pathogens listed in the syllabus i.e.Salmonella,Shigella	4
10.	List of samples to be used with the above: i.GIT. ii.CNS iii.Bacteremia	1
11.	Case study and problem solving for identification of the pathogen with reference to each ofthe infections (Include approach writing, suspected organisms, requirements for the identification tests and their justification rapid tests)	13

Evaluation pattern: Practical

External evaluation: 30 Marks practical examination at the end of each semester per course.
Internal evaluation: 20 marks (proposed)

a) Rough Journal – 05
b) Fair Journal – 05
c) Viva- 10

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

Course – III

COURSE TITLE: Microbial Biochemistry-II

COURSE CODE: 20US6MBMBC3

[CREDITS - 02]

Course Learning Outcomes: After successful completion of the Course, the learner will be able to:

1) Explain the metabolic pathways of nucleic-acids, proteins and catabolic pathways of lipids.
2) Evaluate the different regulatory mechanisms for metabolic pathways of a living cell.
3) Describe the anabolic processes for carbohydrates with detailed study of bacterial photosynthesis.

Module	TITLE AND CONTENT	NO OF LECTURES
I	**Metabolism of Nucleic-acids, Proteins and catabolism of Lipids:** **Learning Objectives:** 1) To describe the metabolic pathways of Nucleic-acids, proteins and catabolic pathways of lipids **Learning Outcomes**: After the successful completion of the module, the learner will be able to: 1)List different proteolytic enzymes and state their mode of action. 2) State the metabolic precursors of amino acids. 3) Discuss the metabolic fate of various amino acids 4) Differentiate between glucogenic and ketogenic amino acids. 5) Compare pathways for fermentation of single and pair of amino acids. 6) List amino acids of all families. 7) Schematically explain the synthesis of serine family. 8) Describe the catabolism of nucleotides. 9) Recognize the significance of de-novo and salvage pathways for nucleotide biosynthesis.	

	10) Describe the synthesis of ribonucleotides and deoxyribonucleotides	
1.1 1.1.a. 1.1.b. 1.1.c. 1.1d 1.2.. 1.3. 1.4. 1.5	**Catabolism of proteins:** Enzymatic degradation of proteins. Metabolic fate of amino acids (schematic only) glucogenic and ketogenic amino acids. Metabolism of single amino acids –Deamination, decarboxylation, and transamination Fermentation of single amino acids: Glutamate by *Clostridium tetanomorphum* Fermentation of pair of amino acids (Stickland reaction). **Anabolism of proteins:** Schematic representation of amino acid families Synthesis of amino acids of Serine family- Examples – serine, cysteine, glycine. **Catabolism of nucleotides:** Degradation of purine nucleotides up to uric acid formation. Recycling of purines and pyrimidines nucleotides by salvage pathway **Anabolism of nucleotides:** Synthesis of ribonucleotides and deoxyribonucleotides **Catabolism of Lipids:** Beta oxidation and energetics of palmitic acid Omega oxidation.	1L 1L 1L 2L 3L 2L 2L
2	**Metabolic Regulation:** **Learning Objectives:** 1) To understand, analyse and appreciate the regulation of and co-ordination between metabolic pathways.	

	2) To familiarize with basic concepts of different types of regulatory mechanisms acting at various cellular levels. **Learning Outcomes:** After the successful completion of the module, the learner will be able to: 1) Define various terms associated with cellular regulation. 2) Describe significance of allosteric proteins and enzymes with the specific example of ATCase. 3) Explain the concept of operons with the example of the lac operon 4) List and compare the various end-product inhibitions 5) Explain types of covalent modifications with details of glutamine synthetase. 6) Discuss regulation by proteolytic cleavage with examples.	
2.1	Cellular control mechanism acting at various levels of metabolism (tabulation only) Concepts of Repression and Induction, inhibition and activation, house-keeping genes.	1L
2.2.	**Allosteric proteins** –role as enzymes (ATCase) and regulatory proteins (Lac repressor, CAP).	2L
2.3.	**Regulation of gene expression**- Introduction to operon model and positive and negative regulation of operons: By DNA binding proteins eg. Lac operon, lactose utilization, Catabolite repression By multiple sigma factors , Terms: specificity factors, enhancers and activators.	2L
2.4.	**Regulation of enzyme activity** (Enzyme inhibition /activation) Mechanism of End-Product Inhibition	2L 1L
2.5.	End-Product Inhibition in branched pathways-Iso-functional enzymes, Concerted, Sequential,	1L

	Cumulative, Combined activation and inhibition.	
2.6	**Covalent modification of regulatory enzymes** – Types.	1L
	Glutamine synthetase system of *E. coli* in detail	1L
2.7	**Regulation by proteolytic cleavage**	
2.8	Regulation of EMP & TCA.	1L
3	**Anabolism of carbohydrates** **Learning Objectives:** 1) To learn concepts of photosynthesis in different groups bacteria. 2) To study light-dependent and light-independent reactions in bacteria. 3) To describe bacterial cell wall and glycogen synthesis in prokaryotes and eukaryotes. 4) To describe gluconeogenesis and its role in metabolism **Learning Outcomes:** After the successful completion of the module, the learner will be able to: 1) List and describe features of various photosynthetic bacteria. 2) Describe photosynthetic apparatus and light reactions 3) Compare cyclic and noncyclic photophosphorylation. 4) Differentiate between photosynthetic systems in green bacteria, purple bacteria and cyanobacteria. 5) Discuss Calvin Benson and reductive TCA cycles in detail with schematic representation and differentiate between the two. 6) Describe the biosynthesis of bacterial cell-wall and glycogen in prokaryotes and eukaryotes. 7) Interpret different bypass reactions in gluconeogenesis. 8) Evaluate the biochemical significance of gluconeogenesis.	
3.1. 3.1.a.	**Anabolism of glucose: Prokaryotic photosynthesis:** The phototrophic prokaryotes (Oxygenic	4L

	phototrophs, Anoxygenic phototrophs examples only)	
3.1.b.	Photosynthetic pigments and photosynthetic apparatus	
3.1.c.	Light reactions of purple photosynthetic bacteria, green sulphur bacteria (only schematic) and cyanobacteria (with details)	
3.1.d.	Dark reaction: Calvin Benson cycle and reductive-TCA	2L
3.2.	**Anabolism of Carbohydrate polymers:**	
3.2.a	Gluconeogenesis	2L
3.2.b	Biosynthesis of glycogen in prokaryotes and eukaryotes.	2L
3.2.c	Biosynthesis of Peptidoglycan	2L

References:

1) Stanier R.Y., Ingraham, J.L., Wheelis, M.L., Painter, R.R (1987) General Microbiology, 5th edition, The Macmillan press Ltd.
2) Conn, Stumpf, P. K., Bruening, G. R. H. (1987) Outlines of Biochemistry, 5thedition, John Wiley and Sons.
3) Gottschalk, G., (1985), Bacterial Metabolism, 2nd edition, Springer Verlag
4) White, D., (1995), The Physiology and Biochemistry of Prokaryotes, 3rdedition, Oxford University Press
5) Nelson, D, Cox, M, (2005), Lehninger Principles of biochemistry,4th edition, W. H. Freeman and Company
6) Voet, D & Voet, J. G., (2004), Biochemistry, 3rd edition, John Wiley& Sons Inc
7) Zubey, G. L (1996), Biochemistry, 4th edition, Wm. C. Brown publishers.

Evaluation Pattern: Theory

For course III
External Evaluation – Semester End Examination (60 M) - Duration: 2 hours
Paper Pattern

Question No	Module	Marks with Option	Marks without Option
1	I	30	20
2	II	30	20

3	III	30	20

Internal Evaluation - (40 M)

(Give different ways of internal evaluation finalised for each module)

Probable options:

Plickers

Testmoz

Google form

Moodle

Objective-MCQ

Short answer test

T. Y. B. Sc. (MICROBIOLOGY)

SEMESTER VI - Practical

Course-III

COURSE CODE: 20US6MBP2

[CREDITS - 01]

Experiment Sr. No.	Titles and Number of Credits	Number of hours
1.	Detection of lysine decarboxylase enzyme	2
2.	Estimation of chlorophyll in cells	5
3.	Estimation of carotenes in cells	5
4	Estimation of β-galactosidase activity in induced and non-induced cells of E. coli	5
5.	To study catabolite repression in *E.coli* by diauxic growth curve.	5
6.	Protein estimation by Lowry's method	4
7.	Estimation of uric acid	2
8.	Staining of glycogen granules	2

Evaluation pattern: Practical

External evaluation: 30 Marks practical examination at the end of each semester per course.

Internal evaluation: 20 marks

a) Rough Journal – 05
b) Fair Journal – 05
c) Viva- 10

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

Course – IV

COURSE TITLE: Bioprocess Technology- Downstream Processing and Fermentations

COURSE CODE: 20US6MBBPTC4

[CREDITS - 02]

Course Learning Outcomes: After successful completion of the Course, the learner will be able to:

1) Predict the use of downstream processes for efficient recovery of fermentation products.
2) Validate the purity of the product and the process steps.
3) Plan a logical flow for treatment of Industrial wastes.
4) Identify and describe the production of important microbial fermentation products.

Module	TITLE AND CONTENT	NO OF LECTURES
1.	**Recovery and Purification of Fermentation products:** **Learning Objectives:** The objectives of this unit are: 1) Understanding the principle of methods employed for product recovery 2) Exploring the different processes in relation to the product to be isolated 3) Formulating an appropriate plan for product recovery and purification **Learning Outcomes:** After the successful completion of the module, the learner will be able to: 1) Analyze the criteria and choose the recovery processes 2) Formulate the steps in the recovery of the given microbial product based on its physical, chemical and biological characteristics 3) Logically integrate and plan the downstream processes in sequence with respect to a product	

	Recovery and Purification of Fermentation products:	
1.1.	**Criteria for choice of recovery process**	1L
1.2.	**Biomass separation from fermentation media**	3L
1.2.a.	Foam Separation	
1.2.b.	Precipitation	
1.2.c.	Filtration,filter aids, plate-frame and rotary vacuum filters	
1.2.d.	Centrifugation - Cell aggregation and flocculation, Range of centrifuges	
1.3.	**Cell Disruption for intracellular products**	2L
1.3.a	Physico-mechanical methods	
1.3.b	Chemical methods	
1.4.	**Liquid –liquid extraction**, Solvent recovery, Two phase aqueous extraction, Reversed Micelle extraction Supercritical fluid extraction	1L
1.5	**Adsorption and removal of volatile products**	1L
1.6	**Chromatography-**	1L
1.6.a	Ion Exchange chromatography	
1.6.b	HPLC	
1.7	**Membrane processes-**	1L
1.7.a	Filtration-Ultra filtration, Microfiltration and Nano filtration	
1.7.b	Reverse osmosis	
1.7.c	Liquid membranes	
1.8	**Drying**	1L
1.9	**Crystallization and Whole broth processing**	1L
2	**Product analysis (E.g. Pharmaceutical product) and Treatment of Industrial Wastes** **Learning Objectives:** The objectives of this unit are: 1) Assess the product quality 2) Integrate the waste treatment methods for efficient and safe disposal of industrial waste 3) Review the treatment of pharmaceutical industry waste **Learning Outcomes:** After the successful completion of the module, the learner will be able to: 1) Verify the product quality and validate its purity	

	2) Choose the appropriate treatment process based on the constituents of the industrial waste. 3) Evaluate the quality of the waste by specific chemical and biological methods	
2.1. 2.1.a. 2.1.b. 2.1.c 2.1.d 2.1.e 2.1.f 2.2. 2.2.a. 2.2.b. 2.3.a. 2.3.b. 2.3.c 2.4	**Product analysis** Protein –Based contaminants Detection of Protein based product impurities Immunological approaches to detection of contaminants Endotoxin and other pyrogenic contaminants i. Pyrogen detection ii. Microbial and viral contaminants Miscellaneous contaminants Validation studies **Treatment of Industrial Wastes** Methods for determination of organic matter content in waste waters i. Dissolved oxygen ii. PV test iii. BOD iv. COD iv. Total Organic carbon v.Total solids, Total suspended solids, Total dissolved solids vi. Volatile suspended solids **Wastes from major industries- an overview** **Systems for the treatment of wastes** **i.** Aerobic breakdown of raw waste waters Activated sludge system and its modifications **ii.** The Trickling filter **iii.** Rotating discs **Anaerobic breakdown of sludge** **Waste water disposal in Pharmaceutical industry** **Government Regulatory Bodies(EPA)**	5L 2L 2L 2L 1L
3	**Industrial Fermentations:** **Learning Objectives:** The objectives of this unit are: 1) Charting out microbial fermentation processes	

	2) Integrate the Upstream processing, fermentation proper and downstream processing as a whole unit. 3) Guage the consequences of deviation from optimum parameters set **Learning Outcomes**: After the successful completion of the module, the learner will be able to: 1) Illustrate the microbial productions 2) Analyze the effect of various physical and chemical parameters on fermentation 3) Schematically represent in the form of flowcharts the microbial product formation	
	Industrial Fermentations:	
3.1	Alcohol from molasses	2L
3.2	Penicillins and semisynthetic penicillins.	2L
3.3.	Vitamin B_{12} from *Propionibacetrium*	2L
3.4	Baker's and Brewer's Yeast	2L
3.5	Citric acid and Vinegar	2L
3.6	Beer –Ale and Lager	2L

References:

1) Patel A.H. (1996). Industrial Microbiology. Ist edition, Macmillan India Limited
2) Okafor N. (2007). Modern Industrial Microbiology and Biotechnology. Ist edition. Bios Scientific
Publishers Limited. USA
3) Waites M.J., Morgan N.L., Rockey J.S. and Higton G. (2001). Industrial Microbiology: An Introduction. Ist edition. Wiley – Blackwell
4) Glaze A.N. and Nikaido H. (1995). Microbial Biotechnology: Fundamentals of Applied Microbiology. Ist edition. W.H. Freeman and Company
5) Casida LE. (1991). Industrial Microbiology. Ist edition. Wiley Eastern Limited.
6) Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd edition. Panima Publishing Co. New Delhi.
7) Stanbury PF, Whitaker A and Hall SJ. (2006). Principles of Fermentation Technology. 2nd edition,Elsevier Science Ltd.
8) Stanbury PF, Whitaker A and Hall SJ. (2017). Principles of Fermentation Technology. 3rd edition,Elsevier Science Ltd.
9) Walsh Gary, (2011). Pharmaceutical Biotechnology. I st edition, Wiley-India edition.
10) E.M.T.El-Mansi and A.R.Allman (2012). Fermentation Microbiology and Biotechnology. 3rd edition. CRC Press.

Evaluation Pattern: Theory

For course IV
External Evaluation – Semester End Examination (60 M) - Duration: 2 hours
Paper Pattern

Question No	Module	Marks with Option	Marks without Option
1	I	30	20
2	II	30	20
3	III	30	20

Internal Evaluation - (40 M)
(Give different ways of internal evaluation finalised for each module)
Probable options:
Plickers
Testmoz
Google form
Moodle
Objective-MCQ
Short answer test
Chart preparation using ICT tools
OFFEE test

T. Y. B. Sc. (MICROBIOLOGY)

SEMESTER VI - Practical

Course-IV

COURSE CODE: 20US6MBP2

[CREDITS - 01]

Experiment Sr.No.	Titles and Number of Credits	Number of hours
1.	Estimation of BOD	3
2.	Estimation of COD	3
3.	Fermentation efficiency of alcohol fermentation Sugar tolerance Alcohol tolerance Sugar estimation by Cole's ferricyanide method Alcohol estimation	6
4.	Bioassay of Penicillin	6
5.	Bioassay of Vitamin B_{12}	6
6.	Sterility testing of an injectible	5
7.	Visit to a fermentation industry-Report writing	1

Evaluation pattern: Practical

External evaluation: 30 Marks practical examination at the end of each semester per course.

Internal evaluation: 20 marks

a) Rough Journal – 05
b) Fair Journal – 05
c) Viva- 10

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

Discipline Specific Elective DSE-I

COURSE TITLE: Recombinant DNA Technology and Advanced Virology

COURSE CODE: 2OUS6MBRDV5

[CREDITS - O2]

Course Learning Outcomes: After successful completion of the Course, the learner will be able to:

1) Describe the role of different tools and the methods associated with recombinant DNA technology.
2) Analyse the applications of recombinant DNA technology.
3) Enumerate virus particles.

Module	TITLE AND CONTENT	NO OF LECTURES
I	**Introduction to Recombinant DNA Technology:** **Learning Objectives:** 1) To describe the steps in gene cloning. 2) To describe different methods adopted to obtain and process DNA. 3) To state characteristics of different vectors. 4) To introduce the recombinant DNA into host. **Learning Outcomes:** After the successful completion of the module, the learner will be able to: 1) Define the basic terms associated with recombinant DNA technology. 2) Cite the steps in gene cloning. 3) State the steps to use vectors to clone gene segments. 4) Compare and contrast between genomic and cDNA library. 5) Evaluate the properties of an ideal host and a vector. 6) Describe the transformation of the host.	
I.I. I.I.a.	**Basic terminology:** Concept of recombinant DNA, gene cloning, chimeric DNA. **Tools required:** Different enzymes and proteins required in gene cloning, Restriction endonucleases and its types.	IL

I.I.b.	Modification of cut ends- use of Linkers and Adaptors	2L
I.I.c	**Basic steps of gene cloning.** Genomic and cDNA library: Concept and preparation	1L
I.I.d.	**Methods of generating DNA fragments:** Restriction digestion Mechanical shear PCR Chemical synthesis Properties of an ideal host and a vector.	2L
I.I.e.	**Vectors used in Recombinant DNA Technology:** Cloning and Expression vectors	2L
I.I.f.	**Cloning and selection in following vectors:** Plasmids: pBR322 and pUC-19 vector. Phage: lambda phage Cosmids Shuttle vectors BAC and YAC	2L
I.I.g.	**Integration of DNA insert into vector** **Different situations:** Both sides cohesive and compatible Both ends cohesive and separately matched Both ends cohesive and unmatched Both ends blunt One end cohesive and compatible, the other end blunt	1L
I.I.h	**Introduction of recombinant DNA into a suitable host:** **Methods of transformation of host:** Increased competence by Calcium chloride treatment Infection by recombinant DNAs packaged as virions	1L
2	**Screening, selection of recombinant clones and Recombinant DNA Technology:**	**Applications of**

	Learning Objectives: 1) To describe the different methods of screening and selection of recombinant clones. 2) To list and describe the applications of recombinant DNA technology. **Learning Outcomes:** After the successful completion of the module, the learner will be able to: 1) Evaluate different strategies to screen and select recombinant clones. 2) State and describe different applications of recombinant DNA technology.	
2.1.	**Selection of recombinant clones containing recombinant DNA:** Reporter genes Elimination of non-recombinant DNA Identification of clones having recombinant DNAs.	1L
2.2	**Selection of clone containing a specific DNA insert:**	2L
2.2.a.	**Library screening strategies:** **Sequence dependent screening:** Colony hybridization	
2.2.b.	Gene tagging Screening by PCR	
2.3.	**Screening of expression protein product:**	2L
2.3.a.	Unique gene products	
2.3.b.	Antibodies specific to a protein product FACS	
2.3.c.	South-Western and North-Western screening.	
2.3.d.	**Applications of Recombinant DNA Technology:**	2L
2.3.e.	**Site-directed mutagenesis:** Method and application. Yeast two-hybrid system Protein-protein interaction. DNA fingerprinting Method and application DNA polymorphism: Types and detection: SNP, STR and VNTR	5L

	Gene therapy: Method and application	
3	**Advanced Virology:** **Learning Objectives:** 1) To describe the different methods for cultivation of viruses. 2) To describe the methods for visualization and enumeration of virus particles. 3) To state the characteristics of prions and viroids. **Learning Outcomes**: After the successful completion of the module, the learner will be able to: 1) Describe and implement different methods for cultivation of viruses. 2) State steps and methods to visualize and enumerate virus particles. 3) State the characteristics of prions and viroids.	
3.1.	**Cultivation of viruses:** Cell culture techniques, embryonated egg, laboratory animals, CPE and Inclusion bodies.	2L
3.2.	**Visualization and enumeration of virus particles.**	1L
3.3	**Measurement of infectious units:** i. Plaque assay ii. Fluorescent focus assay iii. Infectious centre assay iv. Transformation assay v. Endpoint dilution assay.	4L
3.4	**Measurement of virus particles and their components:** i. Electron microscopy ii. Atomic force microscopy iii. Hemagglutination iv. Measurement of viral enzyme activity. v. Prions and viroid's	3L 2L

References:

1. Peter J. Russell (2006), —Genetics-A molecular approachll, 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 McGraw 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. Robert Weaver, (), —Molecular biology‖, 3rd. Mc Graw Hill international edition. 10.Primrose and Twyman, (), —Principles of gene manipulation and genomics‖, 7thed, Blackwell Publishing 11. Arthur Lesk, (2009), —Introduction to Bioinformatics‖, 3rd Edition, Oxford University Press.
10. Flint, Enquist, Racanillo and Skalka, —Principles of virology‖, 2nd ASM press.
11. T. K. Attwood & D. J. Parry-Smith, (2003), —Introduction to Bioinformatics, Pearson education
12. Benjamin Lewin, —Genes IX Jones and Bartlett publishers.
13. JD Watson, —Molecular biology of the gene‖, 5th edition.
14. Snustad, Simmons, —Principles of genetics‖, 3rd edition John Wiley & sons, Inc.

Evaluation Pattern: Theory

For course :DSE-I

External Evaluation – Semester End Examination (60 M) - Duration: 2 hours

Paper Pattern

Question No	Module	Marks with Option	Marks without Option
1	I	30	20
2	II	30	20
3	III	30	20

Internal Evaluation - (40 M)
(Give different ways of internal evaluation finalised for each module)
Probable options:

Plickers
Testmoz
Google form
Moodle
Objective-MCQ
Short answer test

T. Y. B. Sc. (MICROBIOLOGY)

SEMESTER VI - Practical

COURSE: DSE I

COURSE CODE: 2OUS6MBP3

[CREDITS - OI]

Experiment Sr. no.	Title and Number of Credits	Number of hours
1.	Isolation of genomic DNA of *E. coli* (Demonstration)	O7
2.	Enrichment of coliphages, phage assay (pilot & proper).	O6
3.	Restriction enzyme digestion analysis. (Demonstration)	O5
4.	PCR (Demonstration)	O7
5.	Western Blot. (Demonstration)	O5

Evaluation pattern: Practical

External evaluation: 3O Marks practical examination at the end of each semester per course.

Internal evaluation: 2O marks

a) Rough Journal – O5
b) Fair Journal – O5
c) Viva- IO

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

Discipline Specific Elective DSE-II

COURSE TITLE: Advances in Immunology and Health Care Biotechnology

COURSE CODE: 2OUS6MBAIM6

[CREDITS - O2]

Course Learning Outcomes: After successful completion of the Course, the learner will be able to:

1) Summarize monoclonal antibody production and applications, principles of Immunohematology.
2) Evaluate the need for vaccination.
3) Explain different types of hypersensitivity reactions, autoimmune disorders and transplantation.
4) Appreciate the various methods for detecting genetic disease, drug designing and use of DNA fingerprinting in forensic science.

Module	TITLE AND CONTENT	NO OF LECTURES
I	**Monoclonal Antibodies, Immunohematology, Vaccines** **Learning Objectives:** 1) To define production and application of monoclonal antibodies. 2) To describe human blood group system, haemolytic disease of new born and method to detect it. 3) To explain different types of vaccines and to define active-passive immunization. **Learning Outcomes:** After the successful completion of module the learner should be able to: 1) Understand the significance of the use of monoclonal antibodies in different areas like research. 2) Recognise different blood group system and the significance of Rh incompatibility.	

	3) Appreciate role of vaccine in human health and compare different methods of immunization.	
1.1	**Monoclonal antibodies-**	3L
1.1.a.	Monoclonal antibodies- Production and applications	
1.2	**Immunohematology**	4L
1.2.a.	Human blood group system, ABO secretors and non-secretors, Rhesus system and list of other blood group system, Haemolytic disease among new born, Coombs test	
1.3	**Vaccine**	5L
1.3.a.	Active, passive immunization	
1.3.b.	Types of vaccines: Killed and attenuated vaccines, whole organism vaccine, purified macromolecules as vaccine, DNA vaccine	
1.3.c.	Use of adjuvant in vaccine	
1.3.d.	New vaccine strategies	
1.3.e	Ideal vaccines	
1.3.f.	Route of vaccine administration, Schedule failure in clinical vaccine	
2	**Hypersensitivity, Autoimmunity, Transplantation** **Learning Objectives :** 1) To describe the mechanism and manifestations of hypersensitivity. 2) To define and give examples of different types of autoimmune responses. 3) To describe different types of transplantation, its immune mechanism and methods for preventing its rejections. **Learning Outcomes :** After the successful completion of module the learner will be able to: 1) Explain the hypersensitivity reaction, its immune mechanism and pathological condition associated with it. 2) Describe about autoimmune disorders. List different types and different mechanisms explaining its manifestation. 3) List different types of transplantation and describe about rejection of graft by host and different method by which host will improve acceptance of graft.	

2.1	**Hypersensitivity**	5L
2.1.a.	Coombs and Gells classification	
2.1 .b.	Type I to Type IV hypersensitivity mechanism and manifestation	
2.2	**Introduction to Autoimmunity**	3L
2.2.a.	Definition of immune tolerance; immune suppression and auto immunity	
2.2.b.	Examples of autoimmune disorder	
2.2.c.	Possible mechanisms	
2.3	**Transplantation**	4L
2.3.a.	Terms used to denote different types of transplantation	
2.3.b.	Mechanisms of graft rejection	
2.3.c	Methods of increasing the acceptance of allograft	
3	**Health Care Biotechnology** **Learning objectives:** To enable the learner to: 1) Familiarize with newer disease diagnostic technique. 2) Know the methods of detecting genetic diseases. 3) Learn about the newer methods of disease treatment. 4) Describe applications of DNA fingerprinting in Forensic medicine. **Learning outcomes:** After the successful completion of module the learner will be able to: 1) Understand the newer methods of disease diagnosis and detection of genetic disease. 2) Elaborate on Drug designing, delivery and targeting. 3) Explain the concept of Gene Therapy. 4) Appreciate the use of DNA fingerprinting technique in forensic medicine.	
3.1.	**Disease diagnosis**	2L
3.1 a	DNA/RNA Probe	
3.1 b	Monoclonal Antibodies	
3.1 c	Autoantibodies	
3.1 d	Commercial potential of Diagnostics	
3.2	**Detection of genetic diseases**	2L
3.2 a	Obtaining foetal cells	

3.2 b	Disease detection	
3.2 c	Identification of genes causing genetic diseases	
3.3	**Disease treatment**	
3.3 a	Products from Non-recombinant organisms	3L
3.3 b	Products from Recombinant organisms	
3.3 c	Interferons	
3.3 d	Growth factors	
3.3 e	Monoclonal antibodies	
3.3 f	Artificial tissues/organs	
3.3 g	Therapeutic oligonucleotides	
3.4	**Drug designing, Drug delivery and targeting**	1L
3.5	**Gene therapy**	2L
3.5 a	Types of gene therapy	
3.5 b	Augmentation gene therapy	
3.5 c	Targeted gene transfer	
3.5 d	Ethical issues	
3.6	**DNA fingerprinting in forensic medicine**	1L
3.7	**Bioterrorism**	1L

References:

1) Thomas J. Kindt, Richard A. G, Barbara A. Osburne (2007) Kuby Immunology: W. H. Freeman and Company, New York.
2) Pathak S.S. and Palan U. (1997). Immunology essential and Fundamentals, Pareen publications, Bombay.
3) Ian R. Tizard, "Immunology- An introduction" 4th edition, Saunders College publishing.
4) Fahim Halim Khan (2009) "The Elements of immunology "Pearson Education, India.
5) B.D Singh (2010) "Biotechnology Expanding Horizon" 3rd Edition, Kalyani Publication.

Evaluation Pattern: Theory

For course:DSE -II

External Evaluation – Semester End Examination (60 M) - Duration: 2 hours

Paper Pattern

Question No	Module	Marks with Option	Marks without Option
1	I	30	20
2	II	30	20
3	III	30	20

Internal Evaluation - (40 M)
(Give different ways of internal evaluation finalised for each module)
Probable options:
Plickers
Testmoz
Google form
Moodle
Objective-MCQ
Short answer test

T. Y. B. Sc. (MICROBIOLOGY)

SEMESTER VI - Practical

COURSE: DSE II

COURSE CODE: 20US6MBP3

[CREDITS - 01]

Experiment Sr. no.	Title and Number of Credits	Number of hours
1.	Blood grouping, direct reverse typing	5
2.	Major- Minor compatibility test	4
3.	Determination of isoagglutinin titre.	4
4.	Coomb test- direct method and indirect method	5
5.	Preparation of heat killed vaccine and sterility testing of it.	5
6.	a) Visit to Microbiological Diagnostic laboratory b) Visit to Forensic laboratory	7

Evaluation pattern: Practical

External evaluation: 30 Marks practical examination at the end of each semester per course.
Internal evaluation: 20 marks

a) Rough Journal – 05
b) Fair Journal – 05
c) Viva- 10

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

SEC – I

COURSE TITLE: ADVANCES IN MICROBIAL TECHNIQUES

COURSE CODE: 20US6MBAMT7

[CREDITS - 02]

Course Learning Outcomes: After successful completion of the Course, the learner will be able to:

1) Apply Blotting and electrophoretic techniques for diagnostic application in genetic engineering and separation and analysis of biomolecules, respectively.
2) Explain the concepts of MALDI and SELDI in genetic engineering experiments
3) Evaluate the different methods of enzyme immobilization, their advantages and disadvantages.
4) Appreciate the different applications of Immobilized enzymes.

Module	TITLE AND CONTENT	NO OF LECTURES
I	**Tools in Genetic Engineering** **Learning Objectives:** 1) To provide a broad exposure to all basic techniques (Biochemical & Biophysical) used in current Modern Biology research. 2) To describe the applications **Learning Outcomes:** After the completion of this module learner will be able to: 1) Explain the principles and applications of Electrophoresis, PCR, RIA, FISH etc in research and related experiments. 2) Use and apply the knowledge of genetic engineering in problem solving and in practice.	
I.1	Electrophoresis- agarose gel electrophoresis,	4L

1.1.a 1.1.b 1.2.a 1.2.b 1.2.c 1.3 1.4. 1.4.a 1.4.b 1.5 1.6 1.7	pulse field gel electrophoresis, 2D gel electrophoresis. Matrix assisted laser desorption ionization (MALDI), Surface enhanced laser desorption ionization(SELDI), Electro spray ionization (ESI), PCR, Applications of PCR. Blotting Techniques: Southern, Northern and Western blotting. DNA finger printing Radioimmunoassay Fluorescence in situ Hybridization (FISH)	 3L 1L 3L 1L 1L 1L
2	**Immobilization of enzymes:** **Learning Objectives:** 1) To provide deeper insight into the fundamental techniques for immobilization of enzymes **Learning Outcomes:** After completion of this module the learner will able to: 1) Use the different methods of immobilization for enzymes at industrial level 2) Appreciate the applications of Immobilization	
2.1.a 2.1.b 2.1.c 2.1.d 2.1.e	Introduction Methods of Immobilization : Adsorption Covalent binding Entrapment Advantage of Immobilization Disadvantage of Immobilization Applications	1L 6L 2L 2L 3L

References:

1) R.C. Dubey, A Text Book of Biotechnology. S.Chand & Co Ltd, New Delhi

2) B. D. Singh, (2010). Biotechnology- Expanding Horizon, 3rd Revised Edition, Kalyani Publishers.
3) S. N. Jogdand, (1999). Advances in Biotechnology, 2nd Revised Edition, Himalaya Publishing House.

Evaluation Pattern: Theory

For course :SEC I
External Evaluation – Semester End Examination (60 M) - Duration: 2 hours
Paper Pattern

Question No	Module	Marks with Option	Marks without Option
1	I	40	30
2	II	40	30

T. Y. B. Sc. (MICROBIOLOGY)

SEMESTER VI - Practical

COURSE: SEC-I

COURSE CODE: 20US6MBAMT7

[CREDITS - 01]

Experiment Sr. no.	Title and Number of Credits	Number of hours (15)
1.	Immobilization of enzyme---preparation of alginate-enzyme/culture beads	2
2.	Qualitative and quantitative activity estimation of enzyme / culture beads	4
3.	Demonstration of Blotting techniques	5
4.	Visit to Instrumentation Facilities	4

Evaluation pattern: Practical

External evaluation: 30 Marks practical examination at the end of each semester per course.
Internal evaluation: 10 marks

a) Fair Journal – 05
b) Viva- 05
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