B. Sc. (Microbiology) Semester V

Course Code	US05CMIC51	Title of the Course	Bacterial Genetics
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	• The course is structured with the aim to fulfil the objective of introducing basic concepts of molecular biology to the under graduate students of Microbiology. • To impart detailed knowledge regarding flow of genetic information in prokaryotes, steps of central dogma of life, replication of genetic material, transcription and translation. • To know about mutations in genetic material and its repair mechanisms. • To make students understand that knowledge of molecular genetics helps to understand evolution, cellular regulations and many other biological processes.

Course Content		
Unit	Description	Weightage* (%)
1.	**Gene structure and Replication in prokaryotes** a) DNA as genetic material b) Structure and chemistry of DNA, forms of DNA c) DNA replication in bacteria: DNA replication is semi conservative, DNA replication initiates from a single origin, replication machinery, events at replication fork, termination of replication, and replication of linear chromosomes. d) Models of replication (θ, rolling circle) e) Bacterial gene structure	25%
2.	**Gene Expression I** a) Central Dogma of gene expression and Teminism b) Transcription in bacteria: Introduction, Bacterial RNA polymerase, and promoter, stages of transcription: initiation, elongation, rho factor dependent and factor independent termination of transcription. c) Regulation of transcription initiation : Lactose operon 1. Negative Transcriptional Control of Inducible Genes 2. Catabolite repression in *E.coli* Tryptophan operon d) RNA dependent synthesis of RNA, RNA dependent synthesis of DNA.	25%

3.	**Gene Expression-II** (a) Transfer RNA: structure and role (b) Ribosome: structure and role (c) Genetic code: features and its deciphering (d) Translation: Activation of amino acids and charging of t-RNA, Initiation of protein synthesis, elongation of polypeptide chain, insertion of selenocysteine and pyrrolysine, termination of protein synthesis. (e) Protein modifications and secretion: Chemical modifications, Protein folding and molecular chaperones, protein splicing, protein translocation and secretion in bacteria	25%
4.	**Gene Variation (mutations) and repair.** (a) Introduction, spontaneous mutations, induced mutations, Evidence of spontaneous mutation (fluctuation test, replica plate technique) (b) Types of mutations (c) Chemical and physical mutagenic agents: U.V. radiation, 5BU, Nitrous acid, EMS, acridine dyes (d) Detection and isolation of mutants: auxotrophic mutants, antibiotic resistance mutants. (e) Mutagen and carcinogen identification (Ame's test) (f) DNA repair: Proof reading, mismatch, Exicision, Direct, Recombination and SOS.	25%

Teaching-Learning Methodology	The teaching- learning process will consist of lectures (large group) in which the teacher will use aids such as chalk as well as make power point presentation to introduce the topics encompassing the basic concepts of the subject. Model making of DNA and RNA structures, Seminars, poster presentations, Visualization of various mechanisms by showing educational videos from internet. Arranging debates in class. Performing experiments in laboratory.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Understand the importance of the master molecule "nucleic acid", get knowledge of DNA and RNA structures, genome organization of prokaryotes, gene structure and function.
2.	Understand about mechanism of prokaryotic DNA replication and machinery of DNA replication.
3.	Gets knowledge regarding Central Dogma of gene expression and all steps of the central dogma in detail like transcription, translation, replication and reverse transcription. Know about regulation of gene expression.
4	Understand about various RNAs, Ribosome, genetic code and their role in protein synthesis. Learn about Protein modifications and secretion in bacteria.
5	Understand how mutations and repair of genetic material influence evolutionary process. And will get information regarding chemical and physical mutagenic agents, types of mutations and DNA repair.

Suggested References:	
Sr. No.	References
1.	Prescott L, Harley J P, and Klein D A, Microbiology, 9th edition. Wm C.Brown - McGraw Hill, Dubuque, IA ltd.
2.	General Microbiology, by C.B. Powar and H.F. Daginawala, volume-I, Himalaya Publishing House, Reprint-2002
3.	Principles of Molecular Biology by Veer Bala Rastogi Revised and enlarged 2nd edition, MEDTECH.
4.	Biochemistry by Lehninger, Nelson and Cox, 4th Edition.
On-line resources to be used if available as reference material	

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B. Sc. (Microbiology) Semester – V

Course Code	US05CMIC52	Title of the Course	Microbial Metabolism
Total Credits of the Course	4	Hours per Week	4

Course Objectives:	To make the students familiar with: • Microbial Metabolism • Principle of Thermodynamics • The structure, Role and Different modes of ATP generation in bacteria. • The enzymes, enzyme kinetics and their regulation. • The introduction of the Biochemical pathways for degradation and biosynthesis of Carbohydrate, Lipid & Proteins as well as biosynthesis of peptidoglycan • Photophosphorylation and CO_2 Assimilation

Course Content

Unit	Description	Weightage* (%)
1.	**Principles of bioenergetics** a) Biochemical thermodynamics b) ATP (Structure and role) c) Biochemical mechanisms of ATP generation: -Oxidative phosphorylation:- ETC: organization, components and Mechanism of oxidative phosphorylation includes- Chemiosmotic theory, ATP Synthase & Rotational catalysis d) Substrate level phosphorylation e) photophosphorylation (cyclic and non-cyclic)	25
2.	**Enzymology** **a) Enzyme Kinetics** i. Definition : Zero and First order reaction ii. Substrate saturation curve: Michaelis -Menten Equation- Equilibrium and Steady state assumption, significance of M-M equation iii. Definition of Km, Turn over number (K_{cat}),Specificity constant(Kcat/Km) iv. - Double reciprocal plot **b) Regulation of enzyme action:** i. Allosteric, Covalent modification, Feedback inhibition ii. Enzyme inhibition : Reversible-(Competitive, Non-Competitive, Uncompetitive and Mixed), Irreversible iii. Introduction to Zymogen and Isoenzymes iv. Multi substrate reactions	25

3.	**Catabolism** a) **Introduction** i. Introduction to Metabolism, Catabolism and Anabolism ii. Role of precursor metabolites in metabolism **b) Carbohydrate Catabolism :** i. EMP pathway, Regulation of Glycolysis, PP Pathway, ED pathway ii. TCA cycle and its energetic, Regulation of TCA, Anaplerotic reactions, Glyoxylate cycle **c) Lipid Catabolism:** i. α ,β and ω oxidation of fatty acids ii. Beta oxidation of saturated fatty acids-Palmitic acid and its energetics. **d) Protein Catabolism:** i. Deamination: - Oxidative deamination, Transamination, Stickland reaction ii. Urea cycle **e) Fuelling reaction in Anaerobic chemotrophs:** Anaerobic respiration, Fermentation	25
4	**Anabolism:-** a) **Introduction** i. Strategies of biosynthesis ii. Methods of studying intermediary metabolism (Use of Biochemical mutants, Pulse labeling technique) **b) Carbohydrate Biosynthesis:-** i. Gluconeogenesis , ii. Reductive TCA cycle iii. Calvin-Benson cycle **c) Lipids Biosynthesis:-** i. Biosynthesis of saturated fatty acid **d) Biosynthesis of aminoacids:-** i. Aromatic family **e) Biosynthesis of peptidoglycan**	25

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Teaching-Learning Methodology	The major teaching- learning consists of lectures and discussions (large group) in which the teacher makes a use of chalk and talk as well as power point presentation and Video animation to introduce the learning objectives related to the basic concepts of the subject. These sessions incorporate space for participation and involvement of students through questions. The student's participation in laboratory on related theoretical concept is also required.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Projects, Viva-voce,Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Conceptualize their understanding of Microbial Metabolism
2.	Understand the Principle of Thermodynamics
3.	Describe the structure, role and different modes of ATP generation in bacteria.
4.	Gain knowledge of Enzymes, Enzyme kinetics and their regulation.
5.	Understand the Biochemical pathways for degradation and biosynthesis of carbohydrate, lipid & proteins and also biosynthesis of peptidoglycan
6.	Understand the photophosphorylation and CO_2 Assimilation

Suggested References:	
1.	Biochemistry by Lehninger, Nelson and Cox (4^{th} edition)
2.	Principles of Biochemistry by Zubey G. L.(1^{st}edition)
3.	General microbiology by Stanier R.Y. (5^{th} edition)
4.	Biochemistry, by U. Satyanarayan (5^{th} edition)
5.	Microbiology by Pelczar,Kreig&Chan (5^{th} edition)
6.	Enzymes Biochemistry, Biotechnology, Clinical chemistry by T. Palmer (2^{nd} edition)
7.	Outline of Biochemistry by Conn and Stumpf (5^{th} edition)
On-line resources to be used if available as reference material	

B. Sc. (Microbiology) Semester V

Course Code	US05CMIC53	Title of the Course	Virology and Mycology
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. Learn about bacterial viruses and their life cycle 2. Know about viruses of animals, plants, fungi, insects and other forms of life 3. Learn about oncogenic viruses 4. Learn about the impact of viruses on human life by understanding how they cause diseases, how they influence various industries and their use in biological control of pests 5. To understand fungi, learn symbiosis, understand their economic importance 6. Learn about opportunistic and air borne human diseases caused by fungi.

Course Content		
Unit	Description	Weightage* (%)
1.	**Viruses of Bacteria.** (a) Classification of bacterial viruses (b) One step growth experiment, Doermann's Premature lysis experiment (c) Lytic cycle of virulent phage T4.: Adsorption, penetration, synthesis of phage nucleic acids and proteins,assembly of phage particles and release of phage particles. (d) Temperate phages and lysogeny (lambda as model): Molecular mechanism for decision making process for establishing lysogeny or lytic pathway.Lysogenic conversion and its mechanism (e) S-S DNA Phages: Ø X-174, Fd (f) RNA phages: ds-RNA:Ø6 of *Ps syringae,* ss-RNA phages MS2, QB	25%
2.	**Viruses of Eukaryotes** (a) Animal Viruses: Introduction, Reproduction of animal viruses: adsorption, penetration and un-coating, replication and transcription in DNA and RNA viruses, synthesis and assembly, release. Cytocidal infections and cell damage. (b) Plant Viruses: Introduction and replication of T.M.V. (c) Viruses of fungi and protists. Insect viruses (d) Persistent, latent and slow viruses. Viruses and cancer. (oncogenic	25%

	viruses) (e) Viruses and Human: Diseases, viruses and Industry, Viruses and biological control.	
3.	**Fungi: General** (a) General characters, Thallus,kinds of mycelia, structure of fungal cell, fungal flagella, Aggregation and modification of hyphae (b) Nutrition in fungi: Nutritional requirements, Essential elements, sources of macroelements, modes of nutrition, mechanism of nutrition, symbiosis, mycorrhiza. (c) Homothallism and Heterothalism (d) Classification of Fungi. (e) Reproduction in fungi: Sexuality, Asexual reproduction, Sexual reproduction (f) Parasexual cycle	25%
4.	**Significance of Fungi** (a) Economic Importance of fungi (b) Secondary metabolites of fungi (c) Mycotoxins: Mycotoxins of food and feed Stuff: Aflatoxins, Ergot toxins, Mushroom toxins Amanita toxin, Toxins produced by mushrooms other than amanita. (d) Sex hormones in fungi (e) Human Diseases caused by fungi: • Superficial and subcutaneous mycosis • Systemic and Opportunistic mycosis (f) Plant diseases caused by fungi • Late blight of Potato • Early blight of Potato • Leaf spot of groundnut • Red rot of sugarcane	25%

Teaching-Learning Methodology	The teaching- learning process will consist of lectures (large group) in which the teacher will use aids such as chalk as well as make power point presentation to introduce the topics encompassing the basic concepts of the subject. Model making of bacteriophages, animal and plant viruses, poster making, seminars, power point presentations, storytelling of development of virology and mycology, growing fungi in labs, observing plaque formation during cultivation of bacteriophages. Visit to vaccine production units, mushroom cultivation units.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: The course is prepared with the aim to fulfil the objective of introducing basic concepts of Virology and Mycology to the undergraduate students of microbiology. After successful completion of the course a student will be able to	
1.	Understand the characteristics and importance of the viruses. Understand life cycles of virulent and temperate bacteriophages and will be introduced to single stranded DNA containing phages like Ø X-174, Fd, RNA phages like, Ø6 of *Ps syringae* and MS2, QB.
2.	Know about viruses of animals, plants, fungi, insects and other forms of life. What are the interactions of viruses with various hosts? How Viruses cause cancer. To know the impact of Viruses on Human life by understanding how they cause diseases, how they influence various Industries and can be exploited in biological control.
3.	Understand about general characters, classification, Nutrition and reproduction in fungi, the most exploited eukaryotic microbe. Know about symbiosis, mycorrhiza, lichens, Homothallism and Heterothalism.
4	Understand significance of fungi by knowing that economic importance, involvement in secondary metabolite production, mycotoxin production, sex hormones production
5	Know about and opportunistic human and plant diseases caused by fungi and various fungal pathogens

Suggested References:	
Sr. No.	References
1.	Dube H C, (1990), An Introduction to Fungi, 2nd edn, Vikas Publishing House Pvt Ltd

2.	Botany for Degree students FUNGI, B.R. Vashishta, A.K. Sinha, AnilKumar.Revised edition, S. Chand company
3.	Prescott L, Harley J P, and Klein D A, (2008), Microbiology, 7th edition. Wm C.Brown - McGraw Hill, Dubuque, IA ltd.
4.	Prescott L, Harley J P, and Klein D A, Microbiology 9th edition Wm C.Brown - McGraw Hill, Dubuque, IA ltd.
5	Molecular Genetics, An introductory Narrative", 2nd Edition, Gunther S. Stent and Richard Calendar 2nd edition, CBS Publishers and Distributors.
6.	An Introduction to Viruses, 4th Edition, by S.B. Biswas, Amita Biswas, Vikas Publishing House, PVT Ltd.
7	Text book of Microbiology –Anantnarayan and Paniker 10th EDITION, University Press:2017

On-line resources to be used if available as reference material
On-line Resources
https://youtu.be/Axj4PJFoGjA for introduction to viruses https://youtu.be/JH0csevu6Fg for Animal virus replication https://youtu.be/bDzCXvTgAGM Introduction to viruses

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(B. Sc.) (Microbiology) Semester- V

Course Code	US05CMIC54	Title of the Course	Fermentation Technology
Total Credits of the Course	4	Hours per Week	4

Course Objectives:	To make the students familiar with: • The role of microorganisms in fermentation processes. • Fermentation media formulation and use of sterilization methods at an industrial scale. • Use of different types of fermenters, there design and use of fermentation processes at a large scale. • Processes used for the recovery of different types of products.

Course Content		
Unit	Description	Weightage* (%)
1.	**Introduction to fermentation technology:** (a) Concept of fermentation technology (b) Range of processes and products (c) Industrially important microorganisms and their screening- Primary screening (antibiotic, organic acid, amylase and growth factor) and significance of secondary screening (d) Fermentation process outline (Upstream and Downstream Processes)	25
2.	**Upstream Processing-1** (a) Inoculum development: Introduction and Criteria for an ideal inoculum (b) Development of inocula for: Bacterial Processes (Vitamin B12), Yeast Processes: Baker's Yeast and Fungal Processes (b) Media for industrial fermentation (Ideal Characteristics) (c) Substrates for industrial fermentations (Carbon and Nitrogen Source) (d) Role of precursors, inhibitors and inducers in fermentation medium (e) Sterilization of air and media (f) Scale up and scale down	25
3.	**Fermenter design, type and control** (a) Methods of fermentation: Batch, Fed batch and Continuous, solid state fermentation (b) Industrial fermenter design (Criteria for the design/ Basic functions, design of typical stirred tank fermenter) (c) Types of fermenter: Stirred tank and Air lift fermenter (d) Components of fermenter and their uses: Impeller, Bearing Seals,	25

	Sparger and Baffles (e) Control of chemical and physical conditions: Temperature, pH and Foaming. (f) Introduction to mass transfer of oxygen: Introduction to oxygen transfer, methods for its determination: Sulphite Oxidation method, factors affecting KLa	
4.	**Downstream processing of fermentation products** (a) Criteria for the selection of recovery process (b) Separation of cells by filtration and centrifugation (c) Techniques for the disruption of microbial cells (d) Liquid: Liquid extraction of fermentation products (e) Product purification by chromatographic techniques (f) Product concentration by precipitation, ultra filtration and reverse osmosis (g) Finishing of product by drying and crystallization	25

Teaching-Learning Methodology	The major teaching- learning consists of lectures and discussions (large group) in which the teacher makes a use of chalk and talk as well as power point presentation to introduce the learning objectives related to the basic concepts of the subject. These sessions incorporate space for participation and involvement of students through questions. The student's participation in laboratory on related theoretical concept is also required.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learnerwill be able to:	
1.	Recognize the potential of microorganisms which can produce variety of economically viable products.
2.	Learn how microorganisms can be screened for production of various metabolites.

3.	Understand how inoculums for the industrial fermentations can be prepared and maintained.
4.	Appreciate the requirement of aseptic conditions and control of contaminations during the bioprocess.
5.	Identify and select appropriate media constituent required to produce the desire product.
6.	Understand on what basis cultivation methods are decided for a particular bioprocess
7.	Know the types of bioreactor configurations available for bioprocesses and will also be able to learn importance of various important components which constitute various parts of bioreactor.
8.	Understand the need for monitoring and control of various essential bioprocess parameters
9.	Learn various methods available for recovery and purification of fermentation products from the complex fermentation broth

Suggested References:

Sr. No.	References
1.	Principles of Fermentation Technology 2nd edition P.F. Stanbury, A. Whitaker and S.J. Hall.
2.	Fermentation Technology- VoI&Vol II – H.A. Modi.
3.	Industrial Microbiology. 1st edition, A.H. Patel.
4.	Biotechnology: A textbook of Industrial Microbiology. 2nd edition. Crueger W and Crueger

On-line resources to be used if available as reference material

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B. Sc. (Microbiology) Semester V

Course Code	US05CMIC55	Title of the Course	Microbiology Practical
Total Credits of the Course	08	Hours per Week	16

Course Objectives:	• Some basic techniques to study mutation, are given with the aim to full fill the objective of introducing basic concepts of molecular biology to the under graduate students of Microbiology. • To conceptualize their understanding of Microbial Metabolism, qualitative and quantitative analysis of bio molecules through various fundamental techniques like titrimetric estimation, colorimetric estimations and chromatographic techniques are kept. • To gain knowledge of enzymes, enzyme kinetics, enzyme assays, exercise is introduced. • To make students understand about cultivation of bacteriophages and fungi. • To recognize the potential of microorganisms which can produce variety of economically viable products, to learn how microorganisms can be screened for production of various metabolites and to understand how inoculums for the industrial fermentations can be prepared and maintained, exercises are designed.

Course Content based on core theory papers		
No	**Practical Section-1**	Weightage* (%)
1.	Study of microbicidal effect of UV rays	100%
2.	Isolation of *lac*– mutants of *Escherichia coli* using UV radiations as mutagen.	
3.	Reducing sugar (Glucose/ Jaggery) estimation by Cole's method	
4.	Reducing sugar (Glucose) estimation by DNS method	
5.	Protein estimation by Folin's method	
6.	Separation and identification of amino acids by Thin layer chromatography (TLC) and determination of Rf value.	
7.	Substrate saturation curve: study of Km and Vmax for invertase. (Group experiment)	

No	Practical Section-2	
1	Study of Biochemical reactions Based on Carbon source 1. Oxidative and fermentative breakdown of glucose 2. Fermentation of Sugars: Glucose, Lactose, 3. Glucose break down products: Methyl red test and Voges Proskauer's test 4. Citrate utilization test	
2	Study of Biochemical reactions Based on Nitrogen source I. Indole production test 2. H_2S production test 3. Urea utilization test 4. Casein hydrolysis test 5 . Gelatin Hydrolysis test 6. Deamination test 7. Ammonia production test 8. Nitrate reduction test	
3	Study of Biochemical reactions : Other tests 1.. Catalase test 2. Dehydrogenase test 3.. Oxidase test	
	Practical Section-3	
1.	Demonstration of various techniques for preservation of industrially important microorganisms.	
2.	Demonstration of centrifugation and precipitation process with reference to fermentation process.	
3	Isolation of bacteriophage from sewage./ Phage titration (enumeration)	
4	Isolation, cultivation and microscopic identification of economically important fungi — Mucor, Rhizopus, Aspergillus, Penicillium spp	
5	Fungal spore germination and microscopic examination of molds by slide culture technique. (Group experiment)	
6	Study **using photographs** of (i) Cytopathic effects caused by viruses: syncytia, nuclear inclusions, cytoplasmic inclusion, rounding off etc. (ii) Plant virus TMV using electron micrograph (Iii) vectors transmitting (viral infections): Mosquitoes, tick, sand flies, Biting midges (culicoides).	

	Practical Section -4	
1	Ethanol Estimation.	
2	Screening of Amylase producing bacteria from soil	
3	Production and estimation of amylase enzyme.	
4	Screening of Organic acid producing bacteria from soil.	
5	Screening of antibiotic producing bacteria by crowded plate technique	
6	Measurement of rate of aeration/ OTR by Sulphite oxidation method.	

Teaching-Learning Methodology	By practical batches .Giving students concepts, guidance and demonstration to perform specific practical.

Evaluation Pattern		
Evaluation of practical at University level requires **three** consecutive days and minimum **12 hours** (4 hrs x 3 days). Student should be evaluated for minimum four exercises for performance, well documented certified Journal and a viva voce.		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Understand effect of mutagenic agents, phenotypic change and the event of mutations. Will get information and experience regarding chemical and physical mutagenic agents
2.	Will get skills for analysis of bio molecules and enzyme assays. Also gets concept of metabolism of various compounds and develops idea regarding metabolic diversity in bacteria.
3.	Skills are developed for cultivation of fungi and bacteriophages from soil and sewage respectively.
4	Understand fundamental techniques of screening of micro organisms of industrial importance .would get concept of fermentation processes

Suggested References:	
Sr. No.	References
1.	Practical protocols and guidelines given in laboratories.
2.	Microbiology : A Practical Approach – Dr Bhavesh Patel and Dr Nandini Phanse
3.	Experimental Microbiology - Rakesh J.Patel & Kiran R. Patel, Volume I & II

On-line resources to be used if available as reference material