B. Sc. (Microbiology) Semester VI

Course Code	US06CMIC51	Title of the Course	Molecular Genetics
Total Credits of the Course	4	Hours per Week	4

Course Objectives:	• The major objective of this course is to develop clear understanding of various aspects of microbial genetics and genomes in relation to microbial survival and propagation and to enable students to better understand courses taught later such as recombinant DNA technology and other allied papers. • The main objective is to ensure that the student develops a clear comprehension of the concepts of recombinant DNA technology. The student will get acquainted with the tools and techniques used such as the enzymes, vectors, and cloning methods that can be used, and the applications of cloning such as creation of DNA libraries and recombinant products

Course Content		
Unit	Description	Weightage* (%)
1.	**Genetic Exchange** –I (a) Horizontal Gene transfer, creating variability the asexual way, fate of donor DNA during HGT (b) Molecular Recombination: Recombination at molecular level: Homologous recombination double Stranded break model and Non reciprocal homologus recombination, site specific recombination. (c) Bacterial Transformation. Introduction, Definition, competence, mechanism of transformation in *Streptococcus.pneumoniae, Neisseria gonnorhea* and *Haemophillus influenzae* (d) Bacterial Conjugation Introduction, Role of F-plasmid and secretary system, $F^+X\ F^-$, Hfr Conjugation, F' conjugation, other examples of conjugation. (e) Transduction Introduction, Generalized transduction, specialized transduction.	25%

2.	**Gene Exchange-II** (a) Plasmids: types and characteristics of: F plasmid, Col plasmid, Vi plasmid, Metabolic and resistance plasmids. (b) Transposable elements: Insertion sequences, composite transposons, Mechanisms of transposition: simple and replicative transposition (c) Development of Antibiotic resistance in bacteria: Introduction, origin and mechanism of development of drug resistance in bacteria and transmission of drug resistance (d) Microbes as tools of molecular biology (e) Gene Mapping: Interrupted mating for mapping of the bacterial genome	25%
3.	**Genetic engineering-I** (a) Outlines of Gene cloning (b) Isolation of DNA and RNA (c) Enzymes and steps in gene cloning: (1) Restriction endonucleases: Types, nomenclature, recognition sequences and cleavage pattern (2) DNA ligase and ligation, Modifications of cut ends (d) DNA sequencing : Maxam Gilbert and Sanger sequencing (e) Salient features of ideal vector (f) Vectors used in genetic engineering plasmids(pBr 322, pUC 18) Bacteriophages : lambda, cosmids. Artificial chromosome vectors: YAC and BAC (g) C-DNA library preparation	25%
4.	**Genetic engineering-II** **(**a) Salient feature of Host (b) Methods of introduction of DNA into Host cell: Transformation, transduction, transfection, electroporation, electron gun, micro injection (c) DNA probes: Definition, radioactive and non- radioactive labeling of probes. (d) Identification of nucleic acid: Southern blotting, Northern blotting, (e) Selection of recombinant clones: Colony hybridization, marker inactivation, Reporter gene (f) DNA fingerprinting and applications (g) Gene amplification using Polymerase chain reaction: Principle, procedure, types, application, advantages and limitations.	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.

	Video lectures of NPTEL and BISAG.

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.	Developed understanding of recombination of bacteria. Understood about the three well known mechanisms by which the genetic material is transferred among the microorganisms namely transformation transduction and conjugation.
2.	Are able to describe different types of plasmids and understand the consequences of recombination
3.	Develop, understand and apply tools and techniques involved in Genetic engineering.
4.	Understand the basic steps involved in gene cloning and its applications

Suggested References:	
Sr. No.	References
1.	Principles of Microbiology 2nd edition– R.M. Atlas
2.	Practical Biochemistry: Principles and Techniques – K. Wilson and Walker, 5th Edition, (Cambridge low price ed)
3.	Biotechnology – B.D.Singh, B.Sc edition, Kalyani publishers 3rd revised and enlarged reprint- 2008
4.	Biotechnology: The biological principles, M.D. Trevan and Gould. 11th reprint 2002

5.	Prescott L, Harley J P, and Klein D A, Microbiology, 8th and 9th edition. Wm C.Brown - McGraw Hill, Dubuque, IA ltd.
6	i Genetics A Mendelian Approach by Peter J. Russel .
7	Concise notes on Biotechnology By Rajni Gupta and Tarun Rajpal, Tata McGraw Hill Education Private Limited, New Delhi, Pages:
8.	Lehninger (Nelson and Cox) 4th Edition,

On-line resources to be used if available as reference material
Lectures and notes of NPTEL.

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B.Sc. (Microbiology) Semester VI

Course Code	US06CMIC 52	Title of the Course	Immunology and Medical Microbiology
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	The objectives of this course are to make students able to understand 1. Essence of fundamentals of immunology 2. Advances in Immunodiagnostics 3. Study of microbes that infect humans and the diseases they cause. 4. About Immunisation as an important contribution of microbiology to medicine. 5. Concepts of epidemiology and its impact on human life. 6. Diagnosis, prevention and treatment of various infectious diseases.

Course Content

Unit	Description	Weightage* (%)
1	**Fundamentals of immunology** a) Central [Primary] lymphoid organs, Peripheral [Secondary] lymphoid organs, Cells of Lymphoreticular system. B Cell maturation, T Cell maturation, Null cells, b) Antigens: its types and properties c) Antibodies (Immunoglobulins) :Definition, Structure, Function. and Classes of Immunoglobulins. d) Primary and Secondary Antibody response. e) Cytokines and Acute Phase Proteins. f) Introduction to Monoclonal antibodies and their applications.	25
2.	**Immunodiagnostics** a) Antigen-Antibody Reactions: General Features, Measurement of Antigen and Antibody, b) Serological Reactions: i) Precipitation Reactions, Definition, Mechanism – Zone Phenomenon and Lattice Hypothesis. Applications- Precipitation in Liquid Medium. ii) Agglutination reactions- Definition, Applications-Slide agglutination test, Tube agglutination test, Passive agglutination test. c) Immunohematology-ABO and Rh blood group system d) Techniques in Clinical Immunology: Complement fixation test, ELISA, Western Blot, RIA,Immunofluorescence	25

3.	**Epidemiology and Health care associated infections** **A. Epidemiology** a) Epidemiological terminology b) The epidemiologist's tools c) Recognition of infectious disease in a population d) The infectious disease cycle e) Epidemiological markers **B. Health care associated infections** a) Common type of Health care associated infections, Sources and reservoirs of health care associated infection, b)Mode of transmission of Microorganisms, c) Measures to control infection in the health care setting **C. Emerging and re-emerging infections** Emerging and re-emerging infections , their Transmission form animals to humans, Zika virus disease, Drug resistance, Indian scenario of Emerging and re-emerging infections	25
4.	**Human microbe interactions** **A. Diseases** Study of following diseases with respect to causative agent, pathogenesis, symptoms and treatment : a) Airborne diseases: Tuberculosis b) Food and waterborne diseases: Typhoid c) Contagious diseases: AIDS d) Insect borne diseases: Malaria, Dengue e) Zoonoses: Anthrax **B. Vaccines** a) Concept of Herd immunity b) Adjuvant c) Vaccines: introduction and production. d) Types of vaccines: Traditional vaccines, Recombinant vaccine : Subunit vaccine, DNA Vaccine, Plant as edible subunit vaccine, Attenuated recombinant vaccine, Vector recombinant vaccine Delivery of antigen by bacteria.	25

Teaching-Learning Methodology	A blended learning experience that combines traditional practices and e-learning was implemented to teach microbiological methods. Learning achievement was evaluated by questions about microbiology case-based problems.Students'perceptions were obtained by assessment questionnaire.

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 Immune system , antigens and antibody
2.	Understand clinical microbiology reaction.
3.	Study the important concepts of epidemiology and human diseases
4.	Explain the importance of Immunoprophylaxis

Suggested References:	
Sr. No.	References
1.	Prescott, Healey and Klein., Microbiology, $7^{th}$and 10^{th} Edition, Tata-McGraw Hill publications, Delhi.
2.	Ananthanarayan and Paniker's, Textbook of Microbiology,7^{th} and 10^{th} edition, Universities Press (India) Ltd, Hyderabad
3.	U. Satyanarayana, Biotechnology,1^{st} Edition (Reprinted 2008), Books and Allied (P) Ltd. Kolkata

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

B. Sc. (Microbiology) Semester – VI

Course Code	US06CMIC53	Title of the Course	Environmental Microbiology and Pollution Control
Total Credits of the Course	4	Hours per Week	4

Course Objectives:	After the successful completion of the course a student will be able to, • To learn about microbes and their ecosystem along with extreme environment. • To gain the knowledge regarding microbes in air and their control. • To comprehend regarding microbial Biodegradation and Bioleaching. • Learn various types of bioremediation, how to improve bioremediation using microbes and biodegradation of environmental pollutants. • Understand about bio fuels as energy sources. • Be acquainted with knowledge of bio fertilizers and their advantages in agriculture.

Course Content		
Unit	Description	Weightage* (%)
1.	**Microbial Environment** **A Concepts of Microbial Environment** • The Physical Environment • The Microenvironment and Niche • Biofilms and Microbial Mats • Microorganisms and Ecosystems • Microorganism Movement between Ecosystems • Extreme Environments **B Aeromicrobiology** • Introduction • Characteristics of the atmosphere with viable particles • Atmospheric dispersal of microbes • Microbial diversity of air • Enumeration of microorganisms in Air • The control of Bioaerosol	25
2.	**Microbial Biodegradation and Bioleaching** • Biodegradation of Environmental Pollutants : Alkyl Benzyl Sulfonates, Biomagnification of DDT • Microbial Transformation of Mercury (Heavy metals) • Bioleaching : Introduction, Microorganisms, Mechanism and Commercial process • Bioleaching of Copper, Uranium and other metals • Biosorption • Oil Pollutants • Oil Recovery (MEOR)	25

3.	**Environmental Biotechnology** • Bioremediation- Introduction • Bioremediation – Types of Bioremediation • Bioremediation of Petroleum Hydrocarbons • Bioremediation of Chlorinated Compounds (PCBs) • Bioremediation of Contaminated Soils and Waste lands • Genetic Engineering for more Efficient Bioremediation • Biodegradable Polymer • Bioinsecticides	25
4	**Biofuels and Biofertilizers** **A Biofuels** • Introduction • Renewable and Non-renewable energy resources • Features of Biofuels • Energy crops • Biogas: Substrate, Digesters, Microorganism, Advantages and Disadvantages • Bioethanol, Biobutanol, Biodiesel, Biohydrogen • Microbial fuel cells **B Biofertilizers** • Introduction • Bacterial Inoculants – Rhizobial Inoculants, Azotobacter Inoculants • Phosphate Solubilizing Microorganisms (Phosphate Biofertilizer)	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 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 participationin 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 the understanding of Ecosystem and extreme environments
2.	Gain knowledge of microbiology of air and control of bioaerosols
3.	Describe the role of microorganisms in Biodegradation and Bioleaching.
4.	Understand Concept of Bioremediation of Xenobiotics Compounds.
5.	Learn synthesis of biodegradable polymer and use of Bioinsectides in agriculture.
6.	Get acquainted with various Biofertilizers and application of Biofuels.

Suggested References:

1. Principles of Microbiology – R.M Atlas 2nd Edition
2. A Textbook of Biotechnology – R.C.Dubey
3. Microbial Ecology by Atlas & Bartha 4th edition
4. Biotechnology by U. Satyanarayan
5. Biotechnology by B. D. Singh (B.Sc Edition)
6. Microbiology Prescott Harley and Kleins 7th Edition
7. Microbiology Prescott Harley and Kleins 10th Edition
8. Textbook of Environmental Microbiology by P.A.Mohapatra

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

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B. Sc. (Microbiology) Semester VI

Course Code:	US06CMIC54	Title of the Course	Fermentation Technology-II
Total Credits of the Course	4	Hours per Week	4

Course Objectives:	• To make student capable for isolating hyper producing strains by applying appropriate method of strain improvement for economically viable metabolites. • To acquaint and sensitize students for conducting assays of various metabolites, to monitor quality parameters, to follow safety norms and GMP norms during different stages of manufacturing. • To make students able for handling, monitoring and treating industrial waste water and to make them aware about various discharge norms. Sensitize the students about market potential of fermented products and fermentation economics. • To make students understand thoroughly regarding the intricacies of various fermentation processes with respect to primary and secondary metabolites.

Course Content

Unit	Description	Weightage (%)
1.	**Strain improvement of industrially important microorganisms** a) Selection of natural variant, induced mutations (Physical and Chemical). b) Recombination in Bacteria, parasexual cycle in fungi, protoplast fusion and genetic technology. c) Regulation of metabolic pathway. d) Isolation of mutants producing primary and secondary metabolite. e) Improvement of strains by modifying properties other than yield of products. f) Maintenance and preservation of industrial cultures. g) List of culture collection centres in India.	25
2	**Assay and Quality control of fermentation products** a) Bioassay of fermentation product. b) Introduction to Quality assurance, Quality Control,Good Manufacturing Practice. c) Sterility testing and Endotoxin testing by LAL Test. d) Biosafety, Fermentation economics, Introduction to IPR and patenting. e) Methods of Immobilization of microbial enzymes and cells.	25

3.	**Industrial effluent treatment and Fermentation Economics** a) Nature of effluent generated by fermentation industries. b) Dissolve oxygen as an indicator of water quality. c) Site surveys, Strength of fermentation effluent. d) Effluent treatment processes: Physical, Chemical and Biological e) By products- Distilleries and Breweries f) Fermentation Economics.	25
4.	**Fermentative production of specific microbial products** a) Microbial Biomass: Brewers and Baker's Yeast b) Primary Metabolites: Glutamic acid, Cyanocobalamine, Ethanol and Citric acid. c) Secondary Metabolite: Penicillin d) Enzymes: Amylase e) Biotransformation: Steroid Transformation	25

Teaching-Learning Methodology	1. Conventional Chalk and talk method 2. Use of ICT tools and audio-visual aids. 3. Experiential Learning. 4. Industrial Visit and Case study.

Evaluation Pattern

Sr.No.	Details of the Evaluation	Weightage
1.	Internal Written/Practical Examination (As per CBSC R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, ViVa-voce,Quizzes, Seminar, Assignment,Attendance (As per C.B.C.S.R.6.8.3.)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to

1.	Improve the productivity of microbial metabolites of commercial importance and also increase the efficiency of fermentation process.
2.	Assay fermentation products at different stage of fermentation process and select best suitable assay method as per the nature of the product and process.
3.	Monitor the quality of the finished product in terms of its sterility and presence of endotoxin.
4.	Recognize the importance of Good Manufacturing Practice at the various stages of fermentative production and before releasing the product in to the market which type of quality checks are essential.
5.	Learn how by using technologies like immobilization, efficiency of bioprocesses can be made more efficient.
6.	Appreciate the economic considerations involved in bioprocess industry.
7	Know about the generation of industrial waste water, parameters to be monitored and learn various methods to treat such effluent in order to reduce its toxicity.
8..	Learn detailed fermentative production of some typical Primary and secondary

	metabolites to get the panoramic view of entire fermentation process.

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.	Cruger'sBiotechnology: A textbook of Industrial Microbiology. 2nd edition. Crueger W and Crueger A.
5.	Biotechnology: The Biological Principles. Trevan M D, Boffey S, Goulding K H, and Standury S, (eds), (1987),Tata McGraw-Hill, New Delhi, India.
6.	Industrial Microbiology. L.E. Casida J.R. New age International Publishers. Mumbai, India.

On-line resources:

1	https://nptel.ac.in/courses/102/105/102105058/
2.	https://swayam.gov.in/NPTEL

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B. Sc. (Microbiology) Semester VI

Course Code	US06CMIC55	Title of the Course	Microbiology Practical
Total Credits of the Course	08	Hours per Week	16

Course Objectives:	• Students understand the biological assay of antibiotics and Pharmaceutical compounds. • Cultivation of nitrogen fixing and other important bacteria from environment to understand their characteristics and importance • Introduce basic principles and application of analytical techniques in clinical microbiology and Haematology for students. • To Identify Pure culture on the basis of various characteristics. • To gain concept of marker genes, cell immobilization and sterility testing of pharmaceutical products.

Course Content : Practical based on core theory papers		
No	**Practical Section-1**	Weightage* (%)
1.	Study of marker genes for gene cloning: Isolation of antibiotic resistant mutants (gradient/ replica/ grid plate technique)	100
2.	Study of marker genes for gene cloning: Isolation of pigment less mutant of *Serratia marcescens* using UV radiations as mutagen.	
3	Isolation, cultivation and study of morphological and cultural characters of symbiotic and non symbiotic nitrogen fixing bacteria that can be exploited as bio fertilizer. a) Azotobacter b) Rhizobium.	
4	Isolation, Cultivation and study of morphological and cultural characters of *Bacillus subtilis, Bacillus megaterium, Bacillus cereus.*	
5	Isolation, Cultivation and study of morphological and cultural characters of filamentous bacteria: Actinomycetes	
6	Study of a bio film (aquatic)	
	Practical Section-2	
1	Determination of human blood group: ABO and Rh systems.	
2.	Estimation of haemoglobin by Sahli's acid haematin method	
3.	Total count of leucocytes.	

4	Total Count of erythrocytes	
4.	Differential count of leucocytes by Field's method	
5.	Physical and Chemical analysis of urine.	
6.	Estimation of blood sugar by Glucose oxidase and peroxidase method (GOD-POD)	
	Practical Section-3	
1.	Isolation, cultivation and study of cultural characters of Gram positive bacterium *Staphylococcus aureus*	
2.	Isolation, cultivation and identification of gram-negative bacteria Gram negative, lactose fermenter bacteria: *Escherichia coli, Enterobacter aerogens.*	
3.	Isolation, Cultivation and identification of *Gram negative lactose non fermenter bacteria: Proteus vulgaris, Pseudomonas aeruginosa*	
4.	Isolation, Cultivation and identification of *Gram negative lactose non fermenter bacteria: Salmonella typhi, Salmonella paratyphi* A, *Salmonella paratyphi* B.	
	Practical section -4	
1	Immobilization of yeast cells by sodium alginate method. (Demonstration or group experiment)	
2	Bioassay of Streptomycin.	
3	Sterility testing of a pharmaceutical product	
4	Study of Minimum inhibitory concentration (MIC) of an antibiotic for a well isolated bacterium.	
5	Study of antibiogram for a well isolated bacterium.	

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 h 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.	Apply the practical skill at pathological laboratories and pharmaceutical Industries.
2.	Aquatinted with routine laboratory techniques and tests used to analyze Blood and Serum samples.
3	Will be able to understand cultivation and characterization of microorganisms that are important in agriculture and can be exploited as bio fertilizers.
4.	Gain knowledge of basic characteristics of microbial cultures which can be used to identify the disease causing agent.
5	Conceptualize the importance of sterility for pharmaceutical products.

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
4.	Medical laboratory technology by K L Mukherjee , published by Tata McGraw Hill, New Delhi
On-line resources to be used if available as reference material	