Learning Outcomes based Curriculum Framework

(LOCF) – Curriculum and Syllabus

For

M.Sc., MICROBIOLOGY

Vision of the University

- To provide quality education to reach the un-reached

Mission of the University

- To conduct research, teaching and outreach programmes to improve conditions of human living.
- To create an academic environment that honours women and men of all races, caste, creed, cultures, and an atmosphere that values intellectual curiosity, pursuit of knowledge, academic freedom and integrity.
- To offer a wide variety of off-campus educational and training programs, including the use of information technology, to individuals and groups.
- To develop partnership with industries and government so as to improve the quality of the workplace and to serve as catalyst for economic and cultural development.
- To provide quality / inclusive education, especially for the rural and un-reached segments of economically downtrodden students including women, socially oppressed and differently abled.

PREAMBLE

Under the advice and supervision of the University Grants Commission, the Choice Based Credit System (CBCS) curriculum for Microbiology at the postgraduate level has now been transformed into a new system called Learning Outcome Curriculum Framework (LOCF) (UGC). The LOCF approach considers the programme learning outcomes of the M.Sc. degree in Microbiology, as well as the learning outcomes of the courses taught as part of this programme, while keeping in mind the program's graduate

qualities. The curriculum was then created to match the learning objectives. It is expected that students who complete this programme would possess the necessary knowledge, abilities, temperament, and ethics in the field of microbiology. Aside from the curriculum's content, the teaching and learning methods have also been designed to attain these qualities. The curriculum includes a wide range of learning assessment tasks. These exercises would not only aid to assess the students' knowledge/skills, but they would also help to enrich the teaching learning processes.

The study of microorganisms or microbes such as bacteria, viruses, fungus, algae, protozoa, and infectious proteins such as prions is known as microbiology. Microbes are extremely important because their diverse activities range from the transmission of diseases to the production of highly useful products such as antibiotics, vitamins, enzymes, alcohol, fermented foods, and the recycling of nutrients from dead and decaying organic matter in the environment. Microbiology, as a science, plays a vital role in health, agriculture, the environment, and industry. Several breakthroughs in the previous two to three decades that have had a considerable impact on these fields of human endeavour have pushed Microbiology to the forefront of global teaching, research, and development.

The completion of a microbiology graduating course merely establishes a foundation for fundamental knowledge of the field. Microbiology has been transformed and enriched thanks to inventions, advances, and technology. The demand for professional labour necessitates a deep understanding of the subject. It also necessitates the incorporation of cutting-edge information and new technology in order to meet society's evolving needs. Experienced labour is preferred by the public and private sectors. In light of this, the M.Sc. Microbiology LOCF-2022 course is designed to provide comprehensive and up-to-date knowledge of the field, allowing students to enter the public and private sectors with ease. The course is unique in that it requires 6 months of research projects. Students have the option to work at nationally and internationally renowned research institutes and enterprises throughout this time. As a result, professional human resources are produced in accordance with societal needs. Other research parts of the course include scientific writing, research proposal writing, publication preparation, and research poster preparation for conferences, and the entire process also produces new minds to work as scientists.

Programme Learning Outcomes of M.Sc., Microbiology

A candidate who receives a PG degree in Microbiology, i.e., M.Sc. degree, must have acquired/developed the competences listed in the Program Employability section. During the course of the study, results and programme specific outcomes will be compared to course outcomes.

Programme Employability Outcomes of M.Sc., Microbiology

1. Acquire knowledge and comprehension of microbiology ideas as they apply to various fields such as medicine, industry, the environment, genetics, agriculture, and food.
2. Demonstrate key practical skills/competencies in dealing with microorganisms for research and use in the lab and land, including the application of appropriate microbiological techniques.
3. Capable of applying microbiological knowledge and abilities to analyse microbe-related problems, communicate them to peers/team members/other stakeholders, and implement remedial measures/studies, among other things.
4. Gain a wider understanding of the science of microbiology, allowing them to identify difficult societal issues and plan their professional career to discover novel answers.

Programme Outcome

1. **PO1 Disciplinary Knowledge**

   This programme offers knowledge on aspects and concepts of microbiology, life-cycle, their physiology and metabolism, diagnostic procedures, imparting knowledge on gene manipulation, bioinformatics, food (agriculture), environment, industrial, medical and pharmaceuticals which enable them to apply solve the problems in microbiology.

2. **PO2 Communication Skills**

   Enable the students to communicate the scientific findings and analysis through Research paper writing, project writing, by giving periodic assignments, seminars, presentation of research findings in conferences and seminars, and presentation of project results in viva-voce. All these aspects are based on different disciplines of microbiology.

3. **PO3 Critical Thinking**

   The students get critical thinking on various avenues of standardization of microbiological techniques, disease diagnosis and management.

4. **PO4 Problem Solving**

   The understanding of advanced technologies in microbiology enables the students to identify novel medicines from microbes, survey and analyse the problems in disease diagnosis and solving them.

5. **PO5 Analytical Reasoning**

   The practical related to isolation, identification and interpretation of microbiology based research and arriving valid conclusions.

6. **PO6 Research Related Skills**

   One semester (Final semester) Microbiology research based project involves ability to define problem, formulate the hypothesis, draw conclusions and report the results are included in the students' curriculum.

7. **PO7 Co-operation / Team Work**

   Develop an independent thinker and researches effectively and be a part of a team member or lead a team and take part in multidisciplinary research. Team works among the students to establish the role of microorganisms in food, medical and environmental microbiology included in the curriculum create co-operation within student community to solve the problems.

8. **PO8 Scientific Reasoning**

   The programme offers analysis of microbiology based data, its critical evaluation and reasoning.

9. **PO9 Reflective Thinking**

   Develop reflective thinking in Microbiology, drug from microbes, resource utilization and management for the benefit of the society.

10. PO10 Information / Digital Library

Almost all the course in Microbiology teaching is based on knowledge dissemination involving ICT. For the project data analysis appropriate analysis is recommended.

11. PO11 Self-directed Learning

Microbiology project works, Practical's and group works make a self-directed approach among the student community.

12. PO12 Multicultural Competence

Microbiology based industrial visits, visit to national organization, and participation of international webinars create the multi-cultural competence among students.

13. PO13 Moral & Ethical Awareness / Reasoning

Create moral and ethical practices in project oriented data collection, presentation of results, entrepreneurship.

14. PO14 Leadership Readiness / Qualities

Create start-up/entrepreneurship based grouping of teams and inculcating of leadership qualities among students.

15. PO15 Life-long Learning

Establishment of research forum, invitation of alumni and exchange of knowledge among students creates life-long learning among students.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1:

Analyse the fundamental ideas and biodiversity of microorganisms (bacteria, fungus, actinomycetes, viruses, algae) in order to develop critical thinking skills in various domains of microbiology. Understand the genetic systems of prokaryotes as well as the physiology, metabolism, and biochemistry of microbes. The structure and functions of the cell, as well as the molecular biology of prokaryotic cellular structure, will be covered. Learn basic Microbiology laboratory skills, techniques, and competence in the use of research tools, clinical approaches, and observation analysis.

PSO2:

Demonstrate the importance of pathogen immunity, pathogenesis, cultivation, diagnosis, and control in various health and pharmaceutical sectors using treatments and prophylaxis.

PSO3:

Assess and evaluate the demands, potentials, and impacts of microorganisms that are relevant to food, soil, and agriculture, in order to ensure environmental protection and food quality.

PSO4:

Design appropriate bioprocessing and fermentation techniques, with a focus on being familiar with microbe applications for industrial biomass production and the synthesis of valuable compounds through fermentation.

PSO5:

Understanding the fundamentals of recombinant DNA technology (RDT) and investigating the use of genetic engineering to generate GMOs, gene therapy, and other applications. Apply bioinformatics, biochemistry, and genetics concepts to the betterment of society through analytical and molecular approaches.

PSO6:

Analyze the importance of research using statistical methods and present the results in research forums. Ensure biosafety and bioethics in order to promote social responsibility and environmental awareness, as well as obtain Intellectual Property Rights (IPR) for varied research findings. Employability and lifelong learning need the use of computing, communication, and entrepreneurial abilities.

Structure of M.Sc., (Microbiology) LOCF degree program:

The overall structure of the course to be implemented from the academic year 2022-2023 onwards is as follows.

A. Master of Science in Microbiology programme will last for two years. The course will be divided into four semesters, with two semesters in each year.

B. Four categories of courses will be offered: Core Compulsory Courses: Includes theoretical as well as practical courses, Core Elective Courses: Include theoretical courses and its department specific courses. The students must opt for three core elective courses for the semesters 1, 2 and 3 out of six courses offered by the department, two courses for each semester. Open Elective: For the 1st,

2nd, 3rd and 4th semester, students may opt for any one open elective offered through swayam portal (e-PG pathasala-INFLIBNET) and MOOCs. Skill Enhancement Elective Course: A separate project training-based course that leads to a dissertation worth nine credits is also one of the core courses.

C. Candidates must appear for four core compulsory theory courses, one core elective course, and one open elective course from e-PG pathasala-INFLIBNET in semester I. The candidate must finish two practical courses as specified in the syllabus for semester I and the practical examinations for Practical Courses 1 and 2 will be held at the end of the semester. Total credits for the semester I is 26. In semester 2, the candidate must take four core compulsory courses, one core elective course, and one open elective course from MOOCs. Two practical courses will be held in semester II, as specified in the curriculum, and practical examinations for practical courses 3 and 4 will be held at the end of the semester. Totally 26 credits is allotted for the II semester.

D. There will be four core compulsory courses, two practical courses, one core elective course, and one open elective course from MOOCs in Semester III. The practical examinations for practical courses 5 and 6 will be held at the end of the semester III. The total credits for the semester III is 26. Semester IV is devoted exclusively to project/dissertation work with a credit of 9, as well as one open elective paper from e-PG pathasala-INFLIBNET with 3 credits. The elective paper will have a theory examination at the end of semester IV. The total credits for the IV semester is 12.

E. Students will be required to participate in an internship programme for three weeks (21 days) during the second semester summer vacation to learn about research approaches and work presentation in industries or research institutes. The internship will be awarded 100 points and 3 credits in total. Students will work on their internships, complete the experimental/internship work, and submit the internship report within the time frame specified, *i.e*., before the start of the third semester, i.e., the second year of their study..

F. The entire M.Sc. in Microbiology course will be covered in 19 theory papers: 12 core compulsory courses, 3 core elective courses, 4 open elective courses - 2 from MOOC's and 2 from e-PG pathasala-INFLIBNET, 6 core compulsory practical courses, and an internship (major project with Dissertation). Each core theory course will be addressed in four one-hour weekly lectures, and the

core elective courses and open elective courses will be addressed in three one-hour weekly lectures. Each practical course will be covered in two four-hour practical turns per week. As a result, the students will work for each practical on two days of the week. The total credits for the entire programme is 93.

A complete syllabus for each paper is included, as well as a list of suggested reading that can be augmented with other books/papers. While older editions of books are recommended for certain topics, the books that are commonly prescribed are the most recent editions.

Eligibility for admission: Candidates who have completed Bachelor's degree in science in Microbiology / Biochemistry / Biotechnology / Zoology with Botany ancillary / Botany with Zoology ancillary / Plant Science and Biotechnology / Advanced Zoology and Animal Biotechnology / Biology / Life Science / Nutrition and Dietetics / Medical Lab Technology / Nursing / Genetics / Agriculture / Industrial Microbiology / Immunology / Molecular Biology / Industrial Biotechnology / Environmental Science / Virology / Bioinformatics / B.S.M.S / B.A.M.S / B.U.M.S. / B.F.Sc./ B.E. or B.Tech in Biotechnology or any other degree that may be considered as equivalent top by the Manonmaniam Sundaranar University are eligible for admission

Subject Type	**Code**	**Subject Title**	**Hrs. /week**	**L**	**T**	**P**	**C**	**Maximum Marks**			
				Hrs/ week	**Hrs/ week**	**Hrs/ week**	**Credits**	**Exam hours**	**Internal Assessment**	**External Assessment**	**Total**
SEMESTER I											
Core Compulsory Theory Courses											
Core -1		Biochemistry & Biochemical Techniques	4	4	-	-	4	3	25	75	100
Core-2		Cell & Molecular Biology	4	4	-	-	4	3	25	75	100
Core-3		General Microbiology	4	4	-	-	4	3	25	75	100

Core-4		Microbial Physiology & Metabolism	4	4	-	-	4	3	25	75	100
Core Compulsory Practical Courses											
Major Practical -1		Practical I: Core -1 & Core-2	4	-	-	4	2	3	50	50	100
Major Practical –2		Practical II: Core -3 & Core-4	4	-	-	4	2	3	50	50	100
Core Elective Theory – Any one from the following											
Elective -1		Biostatistics & Computer Application	3	3	-	-	3	3	25	75	100
		Aquatic Microbiology									
Open elective											
ePG-Pathsala		To be selected latter	3	3	-	-	3	3	25	75	100
		Sub-Total	**30**	**22**	**-**	**8**	**26**		**200**	**600**	**800**
SEMESTER II											
Core Compulsory Theory Courses											
Core -5		Bacteriology & Virology	4	4	-	-	4	3	25	75	100
Core-6		Mycology & Phycology	4	4	-	-	4	3	25	75	100
Core-7		Immunology	4	4	-	-	4	3	25	75	100
Core-8		Microbial Genetics	4	4	-	-	4	3	25	75	100
Core Compulsory Practical Courses											
Major Practical -3		Practical 3: Core-5 & Core-6	4	-	-	4	2	3	50	50	100
Major Practical – 4		Practical 4: Core-7 & Core-8	4	-	-	4	2	3	50	50	100
Core Elective Theory Courses – Any one from the following											
Elective 2		Food Microbiology	3	3	-	-	3	3	25	75	100
		Marine Microbial Technology									
Open Elective Course											

MOOCs on line course			3	3	-	-	3	3	25	75	100
		Sub-Total	**30**	**22**	**-**	**8**	**26**		**200**	**600**	**800**
Internship							**3**				**100**
SEMESTER III											
Core Compulsory Theory Courses											
Core -9		Recombinant DNA Technology	4	4	-	-	4	3	25	75	100
Core-10		Bioprocess Technology	4	4	-	-	4	3	25	75	100
Core-11		Medical Microbiology	4	4	-	-	4	3	25	75	100
Core-12		Bioremediation	4	4	-	-	4	3	25	75	100
Core Compulsory Practical Courses											
Practical 5		Practical 5: Core-9 & Core-10	4	-	-	4	2	3	50	50	100
Practical 6		Practical 6: Core-11 & Core-12	4	-	-	4	2	3	50	50	100
Core Elective Theory Courses – Any one from the following											
Elective 3		Biosafey, Bioethics & IPR	3	3	-	-	3	3	25	75	100
		Bioinformatics									
Open Elective Course											
MOOCs on-line course			3	3	-	-	3	3	25	75	100
		Sub-Total	**30**	**22**	**-**	**8**	**26**		**200**	**600**	**800**
SEMESTER IV											
Open Elective Course											
ePG-Pathsala			3	3	-	-	3	3	25	75	100
Project		Project & Viva voce	-	-	-	-	9		50	50	100
		Sub-Total					**12**		**75**	**125**	**200**
			93	**69**	**-**	**24**	**93**		**675**	**1925**	**2700**

ASSESSMENT FOR STUDENTS

Internal Assessment (Theory Courses - 25 marks):

Each course has three internal assessments, each worth for 15 marks. The average of the two best results from each of the three tests would be considered for 15 marks. For each course, the student should submit one 5-mark assignment and present a 5-seminar seminar.

External Assessment (Theory Courses - 75 marks):

Question Paper Pattern at end of each semester - University Examination Pattern

Sub. Code:

Title of the course

Semester: **Max. Marks : 75**

Time : 3 hrs

Section–A (10 X 1 mark =10 marks)

Answer all the questions in one or two sentences

Section – B (5 X 5 marks = 25 marks)

Answer all the questions (minimum 200 words) by selecting either ‘a’ or ‘b’

Section – C (5 X 8 marks = 40 marks)

Answer all the questions (minimum 500 words) by selecting either ‘a’ or ‘b’

Semester	**I Semester**
Course Type	**Core Compulsory Paper - 1**
Title of the Course	**BIOCHEMISTRY & BIOCHEMICAL TECHNIQUES**

Course Code			
Teaching Hours	**60 Hours/ Semester : 4 Hours/ week**		
	BIOCHEMISTRY & BIOCHEMICAL TECHNIQUES	**Credits: 4**	**Max. Marks: 100 (Internal: 25, External 75)**

Course Prerequisites:
The student should have a basic knowledge on chemistry and biomolecules

CODE:	**BIOCHEMISTRY & BIOCHEMICAL TECHNIQUES**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**

Course Objectives	• To understand the basic principles of chemistry & physics related to biology • To understand the structures and functions of bio-molecules • To provide an depth knowledge of metabolic pathways in the living systems • To provide an in-depth knowledge on enzymes and bioenergetics • To provide an advanced understanding of the core principles and applications of various techniques used in biology/biotechnology

Module 1	**Biochemistry in General**	**8 hours**

Structure of atoms, molecules and chemical bonds. Principles of biophysical chemistry (pH, buffer, reaction kinetics, thermodynamics, colligative properties). Stabilizing interactions (Vander Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.); Composition, nature of bonds/linkages.

Module 2	**Classification and Functions of Biomolecules**	**12 hours**

Classification, structure, physiological and biochemical functions of carbohydrates, amino acids, proteins, lipids, nucleic acids, vitamins, minerals and hormones.

Module 3	**Bioenergetics, Carbohydrate, Lipid & Aminoacid Metabolism**	**16 hours**

Bioenergetics: Bioenergetics-basic principles; Equilibria and concept of free energy; common biochemical reactions; Phosphoryl group transfers and ATP; biological high energy compounds; Biological oxidation –reduction reactions and its importance in electron transfer, coupled reactions.

Metabolism: General Introduction, types. ***Carbohydrate metabolism*** - Glycolytic pathway; Gluconeogenesis; Reciprocal regulation of Glycolysis and gluconeogenesis, Pentose phosphate pathway; Pyruvate Dehydrogenase Complex, its mechanism of action and regulation, Kreb's cycle; Electron Carriers, Electron transport and Oxidative phosphorylation; Photophosphorylation; Synthesis of glycogen, glycogenolysis, metabolic diseases related to carbohydrate metabolism. ***Lipid metabolism*** - Mobilization and transport of lipids, Oxidation of lipids: beta, alpha & omega oxidation, oxidation of saturated fatty acids, Oxidation of unsaturated fatty acids, and oxidation of odd chain fatty acids; Formation and oxidation of Ketone bodies; Biosynthesis of saturated fatty acids; synthesis of odd chain and unsaturated fatty acids, regulation of fatty acid biosynthesis; Biosynthesis of triglycerols; Biosynthesis of cholesterol and its regulation, metabolic diseases related to lipid metabolism. ***Amino acids metabolism*** - Amino acid degradation: deamination and transamination reactions; alpha ketoglutorate, succinate, fumarate and oxaloacetate pathways of amino acid oxidation; Metabolic fate of amino groups: role of glutamate and glutamine, urea cycle: reactions and regulation, Biosynthesis of amino acids, Regulation of amino acid biosynthesis, genetic defects in amino acid metabolism, metabolic diseases related to amino acid metabolism.		
Module 4	**Nucleic Acid Metabolism & Biocatalysts**	**15 hours**
Nucleic acid metabolism - *De novo* synthesis of purine and pyrimidine nucleotides; Catabolism of purine and pyrimidine; Disorders of purine and pyrimidine metabolism; Integration of metabolism. ***Biocatalysts*** - general principles of catalysis; Enzyme characteristics and classifications; monomeric and oligomeric enzymes; Specificity of enzymes; Active sites and binding site of enzymes, energy considerations, enzyme activity and its measurements, factors affecting enzyme activities; Enzyme kinetics: methods for investigating enzyme kinetics, Michaelis-Menton equation; regulatory enzymes, allosteric enzymes and their regulation; Mechanisms of enzyme catalysis: acid-base catalysis and covalent catalysis; Enzyme inhibition and its types, Enzyme activation; Reaction mechanism of enzymes: chymotrypsin, lysozyme, Structure function relationship of enzymes		
Module 5	**Biochemical Techniques**	**9 hours**
Principle, working and applications of centrifugation, filtration; chromatography – Paper, TLC, ion exchange, size exclusion, affinity, adsorption, GLC, HPLC; Electrophoresis – Agarose, PAGE – SDS; Spectrophotometric techniques- UV, Visible, IR, NMR and MASS		
ReferenceBooks	1. Cooper. T.G., 2011, The Tools of Biochemistry, Wiley India Pvt. Ltd. 2. Donald Voet, Judith G. Voet, 2011, Biochemistry, 4th Edition, Willey Science. 3. Donald Voet, Judith G. Voet, 2018, Biochemistry, Willey Science.	

	4. Jain, J.L., Sunjay Jain, Nitin Jain, 2016, Fundamentals of Biochemistry, 7th Edition, S. Chand & Company Pvt Ltd. 5. Keith Wilson, John Walker, 2012, Principles and Techniques of Biochemistry and Molecular Biology, 7th edition, Cambridge University Press. 6. Nelson, D.L., and Cox, M.M., 2017, Lehninger Principles of Biochemistry, 7th Edition, MacMillan International Edition. 7. Reginald H. Garrett, Charles M. Grishm, 2013, Biochemistry, 4th Edition, Saunders College Publishers. 8. Rodwell, V., Bender, D., Anthony Weil, P., Kennelly, P., Botham, K., 2015, Harpers Illustrated Biochemistry, 30th Edition, LANGE. 9. Rodwell, V., Bender, D., Anthony Weil, P., Kennelly, P., Botham, K., 2018, Harpers Illustrated Biochemistry, 31st Edition, LANGE. 10. Satyanarayana, U., 2017, Biochemistry, 5th Edition, Books and Allied Pvt. Ltd., Kolkata. 11. Trevor Palmer, 2008, Enzymes: Biochemistry, Biotechnology and Clinical Chemistry, 5th Edition, Horwood Publishing Limited.

After the completion of the course, the student will be able to

Course Outcomes	**Cognitive Level**
CO1: Understand the fundamental concepts of chemistry, biology, physics and basic concepts about biochemistry at the atomic level	K1, K2
CO2: Explain the classification, and function of biomolesules like carbohydrates, lipids, proteins, nucleic acids etc.	K1, K2
CO3: Identify the different classes of polymeric biomolecules and their monomeric building blocks, analyze and study the chemical and biochemical properties of biomolecules and also understand	K1, K2, K3, K4, K5

the relationships between biological molecules	
CO4: Understand the concepts of enzyme kinetics in living system	K1, K2, K3, K4
CO5: Critically analyze and interpret the results obtained from biological experiments and understanding of solving biological problems using various techniques	K1, K2, K3, K4

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

Mapping of CO with PO

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PO14**	**PO15**
CO1	H	H	M	M	M	L	L	M	L	H	L	L	L	L	M
CO2	H	H	M	M	M	L	L	M	L	H	L	L	L	L	M
CO3	H	H	M	M	M	L	L	M	L	H	L	L	L	L	M
CO4	H	H	M	M	H	L	L	M	L	H	L	L	L	L	M
CO5	H	H	M	M	H	H	M	M	M	H	L	M	M	L	H

H- High, M – Medium, L - Low

Mapping of CO with PSO

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
CO1	H	M	L	L	H	L
CO2	H	M	L	L	H	L
CO3	H	M	L	L	H	L

CO4	H	M	L	L	H	L
CO5	H	M	L	L	H	L

H - High, M – Medium, L – Low

Semester	**I Semester**		
Course Type	**Core Compulsory Paper-2**		
Title of the Course	**CELL & MOLECULAR BIOLOGY**		
Course Code			
Teaching Hours	**60 Hours/ Semester: 4 Hours/ week**		
	CELL & MOLECULAR BIOLOGY	**Credits: 4**	**Max. Marks: 100 (Internal 25; External: 75)**

Course Prerequisites:

The student should possess basic knowledge on general aspects about cell and its various organelles. They may have the brief knowledge on the functions of the cell in the body like

transcription, translation, genetic codes etc.

CODE:	CELL AND MOLECULAR BIOLOGY	L	T	P	C
		4	-	-	4
Course Objectives	• To understand the molecular components of plasma membrane, their arrangements and role in making the cell live. • To give a clear knowledge on the transport of nutrients in and out of cells by various mechanisms. • To impart knowledge on the cytoskeleton of cells and their contribution in cell cycle, cell adhesion and communication between cells. • To give a knowledge on chromosomal DNA and its role in gene expression and regulation.				
Module 1	**Introduction to Plasma Membrane**				**12 hours**
Experimental systems in Cell Biology. Bio-membranes - Molecular composition and arrangement functional consequences - Transport across cell membrane- Diffusion, active transport and pumps and uniports, symports and antiport - Membrane potential - Co-transport by symports or antiporters - Transport across epithelia.					
Module 2	**Cytoskeleton**				**12 hours**
Microfilaments and microtubules-structure and dynamics - Microtubules and mitosis - Cell movements-intracellular transport, role and kinesin and dynein, signal transduction mechanisms Cilia and flagella - Cell-cell signaling - Cell surface receptors - Second messenger system - MAP kinase pathways - Signaling from plasma membrane to nucleus.					
Module 3	**Cell-cell Adhesion and Communication**				**12 hours**
Ca^{++} dependent homophilic cell-cell adhesion - Ca^{++} independent homophilic cell-cell adhesion- Gap junctions and connexons - cell matrix adhesion – integrins – collagen - Non-collagen components - cell cycle - mitosis and meiosis - cyclins and cyclin dependent kinases - regulation of CDK- cyclin activity.					
Module 4	**Genome Organization**				**12 hours**

Hierarchy in organization - chromosomal organization of coding and non-coding DNA – regulation of gene expression - mobile DNA - morphological and functional elements of eukaryotic chromosomes - Genetic analysis in Cell Biology		
Module 5	**Intracellular Protein Traffic**	**12 hours**
Protein synthesis on free and bound polysomes - uptake into ER - membrane proteins, Golgi sorting, post-translational modifications - biogenesis of mitochondria, and nuclei - trafficking mechanisms - biology of cancer - biology of aging - apoptosis-definition, mechanism and significance.		
ReferenceBooks	1. Aberts, B., Bray, D., Lewis, J, Ratf, M., Roberts, K., and Watson, J.D., 2002, Molecular Biology of the Cell, Garland Publishing Inc., New York. 2. Ajoy Paul, 2011, Text Book of Cell and Molecular Biology, Books and Allied Pvt. Ltd., Kolkata. 3. De Robertis, E.D.P. and De Robertis, E.M.F., 1995, Cell and Molecular Biology, 8th Edition, B.I. Waverly Pvt. Ltd. 4. Karp, G., 1996, Cell and Molecular biology: Concepts and Experiments, John Wiley & Sons. 5. Lewin, B., 2004, Genes, 8th Edition, Pearson Prentice Hall. 6. Lodish, H., Berk, A., Matsudaira, P., Kaiser, C.A., Krieger, M., Scott, M.P., Zipursky, S.L., and. Darnell, J., 2004, Molecular Cell Biology, 5th Edition, W.H. Freeman and Company. 7. Watson, J.D., Hopkins, N.H., Roberts, J.W., Steitz J.A., and Weiner, A.M., 1987, Molecular Biology of the Gene, 4th Edition, Benjamin / Cummings.	

After the completion of the course, the student will be able to –

Course Outcome	**CognitiveLevel**
CO1: Understand and analyze the molecular components of plasma membrane of a cell and their arrangement, their role in transport of micro and macromolecules between its internal and external environment.	K1, K2. K4

CO2: Know about microtubules and microfilaments in making the cytoskeleton of a cell and how they help in the transport of molecules needed for cell cycle. Also, know about the cell surface receptors and how they work in cell signaling through signal transduction pathway.	K1, K2
CO3: Acquire knowledge on adhesion molecules and structures that make contact between two adjacent cells; know about the fact lying behind on the growth of cells by mitosis and meiosis and the factors involved in cell cycle regulation.	K3, K4, K5
CO4: Know the facts behind the gene organization of chromosomes and how the genes get expressed and regulated. Know about the use of genes in genetic analyses.	K2, K3, K5
CO5: Understand the process of translation and how the translated protein is getting segregated and reach their respective organelles for their suitable function.	K1, K2

K1- Remember; K2- Understand; K3- Apply; K4- Analyze; K5- Evaluate; K6- Create

Mapping of CO with PO

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PO14**	**PO15**
CO1	H	M	M	M	L	M	M	L	L	M	M	M	M	L	L
CO2	H	M	M	M	L	M	M	L	L	M	M	M	M	L	L
CO3	H	M	M	M	L	M	M	L	M	M	M	M	M	L	L
CO4	H	M	M	M	L	M	M	L	M	M	M	M	M	L	L
CO5	H	M	M	M	L	M	M	L	M	M	M	M	M	L	L

H - High, M – Medium, L - Low

Mapping of C O with PSO

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	L	M	L	M	M
CO2	H	L	M	L	M	M
CO3	H	L	M	L	M	L
CO4	H	L	M	L	M	L
CO5	H	L	M	L	M	L

H - High, M – Medium, L - Low

Semester	**I Semester**				
Course Type	**Core Compulsory Paper-3**				
Title of the Course	**GENERAL MICROBIOLOGY**				
Course Code					
Teaching Hours	**60 Hours/ Semester : 4 Hours/ week**				
	GENERAL MICROBIOLOGY	**Credits: 4**	**Max. Marks: 100 (Internal: 25, External 75)**		
Course Prerequisites:					
CODE:	**GENERAL MICROBIOLOGY**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**
Course Objectives	To become familiar with the foundation concepts of history of Microbiology, understand the structure and functions of a typical prokaryotic cell and learn and understand the microbial diversity in the living world.				
Module 1	**History of Microbiology**		**12 hours**		

History and Scope of Microbiology – Generation theory – Contribution of Leuwenhoek, Louis Pasteur, Robert Koch, Edward Jenner, Joseph Lister, Winogradsky, Waksman and John Tyndall. Classification of microorganisms - Haeckel's three kingdom concept, Whittaker's five kingdom concept, Carl Woes three domain system, bacterial classification (outline) according to Bergey's manual of systemic Bacteriology.		
Module 2	**Morphology of bacteria**	**12 hours**
Morphological types, cell wall of Gram negative, Gram positive bacteria and halophiles, cell wall synthesis, capsule composition and function, cell membranes in eubacteria, archaebacteria and cyanobacteria, cell membrane-functions, periplasmic space, structure and function of flagella, cilia and pili, gas vesicles, chlorosomes, carboxysomes, magnetosomes and phycobilisomes, reserve food materials – polyhydroxybutyrate, polyphosphates, cyanophycin and sulphur inclusions, general account on mycolpasma.		
Module 3	**Algae**	**12 hours**
General characteristics, classification, structure and reproduction of algae: Chlorophyta (Green algae), Diatoms, Rhodophyta (Red algae); fungi: cell wall – chemical composition and functions, membranes and their functions, nutritional strategies of fungi, structure and life cycle of fungi Ascomycetes (Aspergillus), Zygomycetes (Mucor), Basidiomycetes (Agaricus) and Protozoa.		
Module 4	**Virus**	**12 hours**
Discovery, distinctive properties, morphology and ultra-structure of virus, classification, cultivation and purification assay of virus. Bacteriophages - structural organization and life cycle - lytic, lysogenic. Viral related agents - viroid and prion.		
Module 5	**Microscopes**	**12 hours**
Principle and application of bright field, dark field, phase contrast, fluorescence, electron microscope- TEM and SEM, polarized microscope and confocal microscopy.		
ReferenceBooks	1. Atlas, R.A. and Bartha, R., 2000, Microbial Ecology, Fundamentals and Application, Benjamin Cummings, New York. 2. Dubey, R.C., and Maheswari, D.K., 2013, A text book of Microbiology, Revised Edition, S. Chand and Company Ltd, NewDelhi. 3. Madigan, M.T., Martinka, M., Parker, J. and Brock, T.D., 2000, 12th Edition, Biology Microorganisms, Prentice Hall, New Jerry. 4. Mark Wheelis, 2010, Principles of Modern Microbiology, Jones & Bartlett	

	India Pvt. Ltd., New Delhi. 5. Pelczar, M.J., Schan, E.C. and Kreig, N.R., 2010, Microbiology – An Application Based Approach, 5th Edition, Tata McGraw Hill Publishing Company Limited, New Delhi. 6. Prescott, L.M., Harley, J.P. and Helin, D.A., 2008, Microbiology, 5th Edition, McGraw Hill, New York. 7. Schlegal, H.G., 1995, General Microbiology, 7th Edition, Cambridge Univeristy Press. 8. Stanier, R., Lingraham, Y., Wheelis, M.L. and Painter, R.P., 1986, General Microbiology, 5th Edition, Macmillan, London. 9. Stryer, L., 2010, Biochemistry, Seventh Edition, W.H. Freeman and Company, New York. 10. Tortora G.J., Funke, B.R.and Case, C.L., 2009, Microbiology, Ninth Edition, Dorling Kindersely (India) Pvt. Ltd., Noida.

On the successful completion of the course, students will

Course Outcomes	**Cognitive Level**
CO1: Understand the history and scope of Microbiology, Contribution of different scientist for the development of microbiology and different system of classification of microbes	K1, K2, K4, K5
CO2: Acquire a thorough knowledge on the structure and function of cell wall and cell membrane of gram positive, gram negative and halophilic bacteria	K1, K2, K3, K4, K5
CO3: Understand and remember structure and reproduction of Algae and Fungi.	K1, K2
CO4: Develop knowledge on virus and bacteriophages. The difference between the lytic and lysogenic life cycle of virus will be analyzed by the students.	K1, K2, K3, K4, K6
CO5: Understand the principles and function of different types of microscopes and selection of particular microscope for observing different objects	K1, K2, K3, K4, K5

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

Mapping of CO with PO

	PO1	PO2	PPO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
CO1	H	M	M	M	M	L	M	L	M	M	M	L	M	L	L
CO2	L	M	H	M	H	L	M	L	H	M	M	L	M	L	L
CO3	M	M	H	M	L	L	L	L	H	M	M	L	M	M	L
CO4	L	M	M	M	M	L	M	L	M	M	M	L	L	L	L
CO5	M	M	M	M	H	L	M	L	M	M	M	L	L	M	L

H - High, M – Medium, L - Low

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	M	M	L	M	L
CO2	H	M	M	L	M	L
CO3	H	M	M	L	M	L
CO4	H	M	M	L	M	L
CO5	H	M	M	L	M	L

H - High, M – Medium, L – Low

Semester	**I Semester**				
Course Type	**Core Compulsory Paper - 4**				
Title of the Course	**MICROBIAL PHYSIOLOGY AND METABOLISM**				
Course Code					
Teaching Hours	**60 Hours/ Semester : 4 Hours/ week**				
	Microbial Physiology and Metabolism	**Credits: 4**	**Max. Marks: 100 (Internal: 25, External 75)**		
Course Prerequisites: The student should have a basic knowledge on microbiology					
CODE:	**MICROBIAL PHYSIOLOGY AND METABOLISM**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**
Course Objectives	The main aim of this course is to introduce the students to the vast world of Microbiology. This course covers a range of topics in Basic Microbiology from the historical perspective to structure, composition of microbes, their interactions with the environment and their impact on the humans.				
Module 1	**Growth of Bacteria**			**12 hours**	
Phases of growth, growth kinetics - batch culture, continuous culture and synchronous culture - induction of synchrony, factors affecting growth - nutrition, aeration, temperature and pH, physiological adaptation to extreme environmental conditions, nutritional types and metabolic diversity - types based on carbon, energy and electron sources.					
Module 2	**Bacterial Photosynthesis**			**12 hours**	
Historical background, general types of microbial photosynthesis - oxygenic and anoxygenic, structure of photosynthetic pigments – chlorophylls, bacteriochlorophyll, carotenoids and phycobilins; photosynthetic bacteria - green sulphur and purple; mechanism of photosynthesis - non-cyclic and cyclic electron transport, photophosphorylation; carbon assimilation - Calvin, reverse citric acid cycle and hydroxyl propionate cycle.					
Module 3	**Nitrogen Metabolism**			**12 hours**	

Nitrogen cycle - ammonification, nitrification, denitrification and nitrogen fixation; nitrogenase enzyme, physiology of nitrogen fixation in symbiotic and free living bacteria, genetics of nitrogen fixation, acetylene reduction assay, transamination and deamination.		
Module 4	**Microbial Stress Responses**	**12 hours**
Osmotic stress and osmoregulation; aerobic to anaerobic transitions; oxidative stress; pH stress and acid tolerance; thermal stress and heat shock response; nutrient stress and starvation stress. Fermentative pathways in specific group of microbes: alcoholic, lactic acid, formic, mixed, propionic, butyric, butanol, butanediol fermentation. Anaerobic respiration.		
Module 5	**Bioenergetics**	**12 hours**
Principles and laws of thermodynamics, coupling of chemical reactions - TCA cycle, electron transport chain, and chemiosmotic theory of Mitchell. Biomembranes: Fluid mosaic model, transport across membrane - diffusion, osmosis, active transport and group translocation.		
ReferenceBooks	1. Deb, A.C., 2006, Fundamentals of Biochemistry, New Central Book Agency Pvt. Ltd., Kolkata. 2. Donald Voet and Judith G. Voet, 2011, Biochemistry, 3rd Edition, John Wiley and Sons, Inc. New York. 3. Madigan, M.T., Martinka, M., Parker, J. and Brock, T.D., 2000, Biology Microorganisms, 12th edition, Prentice Hall, New Jerry. 4. Moat, A.G. and Foster, W., 2002, Microbial Physiology, 4th Edition, John Wiley and Sons, New York. 5. Nelson, D.L. and Cox, M.M., 2012, Lehingers's Principles of Biochemistry, Sixth Edition, Mac Millan worth Publishers, New Delhi. 6. Postgate, J., 1998, Nitrogen Fixation, 3rd Edition, Cambridge University Press. 7. Salisbury, F.W. and W. Ross, 1992, Plant Physiology, 4th Edition, Wardsworth Publishing Company, California. 8. Satyanarayana, U. and Chakrapani, U., 2013, Biochemistry, 4th Edition Book and Allied Pvt. Ltd., Kolkata. 9. Srivastava, M.L., 2008. Microbial Biochemistry, Narosa Publishing House, New Delhi. 10. Stryer, L., 2010, Biochemistry, 7th Edition, W.H. Freeman and Company, New York.	

After the completion of the course, the student will be able to

Course Outcomes	**Cognitive Level**
CO1: Understand the scope and importance of Microbiology, classification schemes, cultivation, preservation and maintenance of microbial cultures. microbial structure and function and study the comparative characteristics of prokaryotes and eukaryotes and also understand the structural similarities and differences among various physiological groups of eubacteria/archaea. : Master skills in aseptic techniques as well comprehend the importance of cleaning and decontamination.	K1, K2, K5, K6
CO2: Understand the microbial transport systems and the modes and mechanisms of energy conservation in microbial metabolism – Autotrophy and heterotrophy Know the various Physical and Chemical growth requirements of bacteria and get equipped with various methods of bacterial growth measurement	K1, K2
CO3: Understand the phases of growth, requirements and factors affecting growth; adaptation to extreme environmental conditions. Nutritional types and metabolic diversity	K1, K2
CO4: Understanding History and types of photosynthesis, state the difference between oxygenic and anoxygenic photophosphorylation. Knowledge on different mechanism of photosynthesis	K1, K2

CO5: Design a mechanism that would allow a bacterium to protect its nitrogenase from oxygen. Analyze the symbiotic relationship that some N_M-fixing bacteria have with plants. Identify what the bacteria contribute and what the plant contributes. Describe the process of methanogenesis in terms of electron transport and energy generation	K1, K3, K5

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

Mapping of CO with PO

	PO1	**PO2**	**PPO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PO14**	**PO15**
CO1	H	M	M	M	H	M	M	L	M	M	M	M	M	M	L
CO2	H	M	M	M	H	M	M	L	M	M	M	M	L	M	L
CO3	H	M	M	M	H	M	M	L	M	M	M	M	L	M	M
CO4	H	M	M	M	H	M	M	L	M	M	M	M	L	M	M
CO5	H	M	M	M	H	M	M	L	M	M	M	M	L	M	M

H - High, M – Medium, L - Low

Mapping of CO with PSO

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
CO1	H	H	H	M	H	M
CO2	H	M	M	H	M	M
CO3	H	M	L	M	M	L
CO4	M	H	M	M	H	L
CO5	H	M	M	M	H	M

H - High, M – Medium, L - Low

Semester	**I Semester**					
Course Type	**Core Compulsory Course Practical - 1**					
Title of the Course	**BIOCHEMISTRY & BIOCHEMICAL TECHNIQUES AND CELL & MOLECULAR BIOLOGY**					
Course Code						
Teaching Hours	**60 hours/semester: 4 hours/week**					
	BIOCHEMISTRY & BIOCHEMICAL TECHNIQUES AND CELL & MOLECULAR BIOLOGY	**Credits: 2**	**Max. Marks: 100 (Internal: 50; External: 50)**			
Course Prerequisites: The students should know the basics of biochemistry & knowledge on the cell structure and functions of various organisms						
CODE:	**BIOCHEMISTRY & BIOCHEMICAL TECHNIQUES AND CELL & MOLECULAR BIOLOGY**	**L**	**T**	**P**	**C**	
		-	**-**	**4**	**2**	
Course Objectives	• To inculcate/impart skills to perform various tests/assays and experiments. • To provide qualitative & quantitative analysis of the macromolecules in the given sample and analyze the results. • To provide students with a deep insight of the various biochemical reactions and cellular processes through quantitative and qualitative analysis of the samples provided. • To understand different types of cells and their structure • To analyze the biochemical parameters of blood. • To learn the karyotyping of organisms and understand the mitosis and meiosis process.					

1. Qualitative analysis of protein, carbohydrate, lipid and nucleic acids
2. Quantification of total carbohydrate
3. Quantification of aminoacids by ninhydrin method
4. Quantification of protein by Lowry's method
5. Quantification of RNA by Orcinol method

6. Quantification of DNA by diphenyl amine method
7. Analysis of DNA by Agarose gel electrophoresis (Demonstration)
8. Separation of any biomolecule by Thin Layer Chromatography
9. To study different phases of mitosis in Onion root tip.
10. To study meiosis in Grasshopper testis.
11. Human buccal smear to show squamous epithelial cells
12. To study the Barr body from the smear of buccal epithelial cells (FEMALE)
13. Preparation of polytene chromosomes of Chironomous larva/Drosophila.

After the completion of the course, the student will be able to

Course Outcomes	**Cognitive Level**
CO1: Improved skills to perform various tests/assays and experiments.	K1, K2, K3, K4, K5
CO2: Design and analyze the experiments related with the different molecules and use of the various techniques the kinetics and rationale behind each phenomenon	K1, K2, K3, K4, K5, K6
CO3: Use the techniques, skills, and modern tools necessary for imbalances in various life processes, design a research project, collect and analyze data, and interpret results	K3, K4, K5
CO4: Analyze the mechanism of mitosis, meiosis and enumerate the structure of polytene chromosome of chironomous larvae.	K4, K3

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

Mapping of CO with PO

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PO14**	**PO15**

CO1	H	H	M	L	H	H	H	L	M	M	H	H	H	H	M
CO2	H	H	M	L	H	H	H	L	M	M	H	H	H	H	M
CO3	H	H	M	L	H	H	H	L	M	M	H	H	H	H	M
CO4	H	H	M	L	H	H	H	L	M	M	H	H	H	H	M
CO5	H	H	M	L	H	H	H	L	M	M	H	H	H	H	M

H - High, M – Medium, L - Low

Mapping of CO with PSO

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
CO1	H	M	L	L	H	L
CO2	H	M	L	L	H	L
CO3	H	M	L	L	H	L
CO4	H	M	L	L	H	L
CO5	H	M	L	L	H	L

H - High, M – Medium, L – Low

Semester	**I Semester**		
Course Type	**Core Compulsory Course Practical - 2**		
Title of the Course	**GENERAL MICROBIOLOGY AND MICROBIAL PHYSIOLOGY & METABOLISM**		
Course Code			
Teaching Hours	**60 hours/semester: 4 hours/week**		
	GENERAL MICROBIOLOGY	**Credits: 2**	**Max. Marks: 100**

	AND MICROBIAL PHYSIOLOGY & METABOLISM		**(Internal: 50; External: 50)**

Course Prerequisites:
The students should know the basics skills on microbiology practicals

CODE:	**GENERAL MICROBIOLOGY AND MICROBIAL PHYSIOLOGY & METABOLISM**	**L**	**T**	**P**	**C**
		-	**-**	**4**	**2**
Course Objectives	The candidate will gain hands-on knowledge and acquire adequate skill required to sterilize media and to prepare, inoculate observe and distinguish bacteria, fungi and their growth patterns in different media. The student will also get a thorough input to analyse end evaluate the difference between different microorganisms.				

1. Gram's staining.
2. Negative staining.
3. Simple staining.
4. Capsule (Spore) staining.
5. AF staining.
6. Motility of bacteria by Hanging drop method.
7. Biochemical test
8. Bacterial growth determination by spectrophotometer method.
9. Isolation of bacteria from soil and sea water.
10. Isolation of fungi from soil and Marine products
11. Principle and methods of sterilization
12. Preparation of media: nutrient broth, nutrient agar plate, soft agar
13. Pure culture techniques: streak plate, spread plate and pour plate
14. Motility determination – Hanging drop method
15. Isolation and enumeration of bacteria from different environmental samples
16. Enumeration of bacteria - viable count (plate count) and total count (Haemocytometer count) Direct microscopic observation of fungal spores and mycelium
17. Staining method: simple, negative, Gram's staining and spore staining
18. Fungal slide culture
19. Measurement of growth rate and generation time by turbidometry method

After the completion of the course, the student will be able to

Course Outcomes	**Cognitive Level**
CO1: Able to use different staining methods to differentiate bacteria, bacterial spores and capsules. Apply different biochemical test for identifying bacteria up to genus level.	K1, K2, K3, K4, K5
CO2: Able to isolate microalgae and fungi from natural environment and preparation of different culture media for growing bacteria, algae and fungi.	K1, K2, K3, K4, K5
CO3: Understand various physical and chemical means of sterilization -Sterilization techniques. Competently prepare different types of media	K1, K2, K3, K5
CO4: Understanding the skill to perform different methods of isolation, enumeration, maintenance and preservation of microorganisms, and skill for viable counting	K1, K2, K3, K5
CO5: Understanding, the knowledge and skill to analyse and differentiate between different types of Microorganisms based on their staining, motility characteristics	K1, K2, K3

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

Mapping of CO with PO

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PO14**	**PO15**
CO1	H	H	H	H	H	M	H	H	H	M	H	M	H	L	M

CO2	H	H	H	H	H	M	H	H	H	M	H	M	H	L	M
CO3	H	H	H	H	H	M	H	H	M	M	H	M	H	L	M
CO4	H	H	H	H	H	M	H	H	M	M	H	M	H	L	M
CO5	H	H	H	H	H	M	H	H	M	M	H	M	H	L	M

H- High, M – Medium, L - Low

Mapping of CO with PSO

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
CO1	H	H	H	M	H	L
CO2	H	H	H	M	H	L
CO3	H	H	H	M	H	L
CO4	H	H	H	M	H	L
CO5	H	H	H	M	H	L

H - High, M – Medium, L – Low

Semester	**I Semester**		
Course Type	**Core Elective Paper 1 A**		
Title of the Course	**BIOSTATISTICS & COMPUTER APPLICATION**		
Course Code			
Teaching Hours	**45 Hours/ Semester : 3 Hours/ week**		
	BIOSTATISTICS & COMPUTER APPLICATION	**Credits: 3**	**Max. Marks: 100 (Internal: 25, External 75)**

Course Prerequisites: The student should possess basic knowledge on general aspects about biostatistics, statistical data representations, statistical measures and analysis of biological data, as well as to know the available statistical tools and interpretation of statistical data through computer software.					
CODE:	**BIOSTATISTICS AND COMPUTER APPLICATION**	**L**	**T**	**P**	**C**
		3	**-**	**-**	**3**
Course Objectives	• To know the basic concepts of biostatistics like history & growth of statistics and statistical methods • To understand about data, their types, and methods involved in collection of data and presentation of data through various modalities. • Enable to understand the statistical measures through determination of averages, deviations, test of significance, hypothetical analysis, correlation & Regression analysis, etc. • To understand about basic computer application in relation with analysis of biological data by using various computer software technique.				
Module 1	**Statistical Introduction**				**9 hours**
Definition of statistics, History and growth of statistics, Statistical methods, Types of biological data, Population, Samples from populations and Random sampling.					
Module 2	**Data Interval and Representation**				**9 hours**
Collection, organization and tabulation of data, Diagrammatic representation of data, Types of diagrams and Graphical representation of data.					
Module 3	**Statistical Measures**				**9 hours**
Measures of Central Tendency- mean, median and mode, Measures of dispersion and variability – range, dispersion measured with quartiles, mean deviation, variance and standard deviation, Comparison of means and variances.					
Module 4	**Statistical Hypothesis and Analysis**				**9 hours**

Proportion of data – Examples of proportion data, Statistical treatment of proportion of data, Chi square test and goodness of fit, Application of Chi square test, Sampling and Hypothesis: One and Two sample hypothesis, Test of Significance, Analysis of Variance: One way and Two way ANOVA classification, Regression and Correlation analysis.		
Module 5	**Introduction to Computer**	**9 hours**
Basic Computer Applications: Purpose of computer, types of computer, Hardware and Software, Programming language, Commercial software: Windows, MS Word, Excel, Power point, Statistical packages: Sigma stat, SPSS-Intra and Internet, Email, Website Creation, Database in Biology: Pub Med, Sequence Analysis, Genome and Protein database genome research.		
ReferenceBooks	1. Bhose, S.B., 2011, Text book of Computer Application and Biostatistics, Trinity publishing House, India. 2. Bliss, C.I.K., 1967, Statistics in Biology, Vol. I, Mc Graw Hill, New York. 3. Campbell, R.C., 1974, Statistics for Biologists, Cambridge University Press, New York. 4. David Baskeen, 2008, Introduction to Computer Application and Concept, Cengage Learning Public, UK. 5. Gupta, S.P., 2010, Practical Statistics, S. Chand and Company, New Delhi. 6. Hand Book of Experimental Immunology, Blackwell Publications Ltd., Oxford. 7. Jerrold H. Zar, 2009, Biostatistical Analysis, 5th Edition, Pearson Publications, India. 8. Lutz, W., 1967. Statistics Methods as Applied to Immunological data, app. In : D.M. Weir (ED).	

After the completion of the course, the student will be able to

Course Outcomes	**Cognitive Level**
CO1: Understand about the basic concepts of Biostatistics, its history and development, meaning of data, different types of statistical data, etc.	K1, K2

CO2: Know about how to collect biological data and its presentation by following various methodologies like tabulation, diagrammatic and graphical representations.	K2, K3
CO3: Interpret and determine the biological data through some basic statistical measures like measures of Central tendency, Dispersion and variation analysis.	K3, K4, K5
CO4: Test and analyse the biological data through hypothetical assumption or creation by following some statistical treatments with Chi square test, students 't' test, ANOVA test, Correlation and Regression analysis	K4, K5, K6
CO5: Know about computer application in statistical data analysis, study about available basic software's & hardware's and statistical packages related to data base in biology.	K3, K4, K6

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

Mapping of CO with PO

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PO14**	**PO15**
CO1	L	H	M	L	M	H	L	M	L	H	M	L	H	L	M
CO2	L	H	M	L	M	H	L	M	L	H	M	L	H	L	M
CO3	L	H	M	L	M	H	L	M	L	H	M	L	H	L	M
CO4	L	H	M	L	M	H	L	M	L	H	M	L	H	L	M
CO5	L	H	M	L	M	H	L	M	L	H	M	L	H	L	M

H – High, M – Medium, L - Low

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	L	L	L	L	L	H
CO2	L	L	L	L	L	H
CO3	L	L	L	L	L	H
CO4	L	L	L	L	M	H
CO5	L	L	L	L	M	H

H - High, M – Medium, L – Low

Semester	**I Semester**		
Course Type	**Core Elective Paper – 1B**		
Title of the Course	**AQUATIC MICROBIOLOGY**		
Course Code			
Teaching Hours	**45 Hours/ Semester : 3 Hours/ week**		
	AQUATIC MICROBIOLOGY	**Credits: 3**	**Max. Marks: 100 (Internal: 25, External 75)**
Course Prerequisites: Have a basic knowledge on microbiology			

CODE:	**AQUATIC MICROBIOLOGY**	**L**	**T**	**P**	**C**
		3	**-**	**-**	**3**

Course Objectives	• To know about the composition of waste water, their indicators both biological and chemical • To get an idea about the water disinfection, waste water treatment, drinking water treatment and biotechnological applications of water treatment	
Module 1	**Characteristics of Water & its Composition**	**9 hours**
Biological characteristics of water, microorganisms in sewage and seawater, saprophytism in stored water, composition of domestic waste water, COD, BOD, total organic carbon content, transmission of water borne diseases, indicator microorganisms.		
Module 2	**Water and waste water disinfection**	**9 hours**
Water and waste water disinfection – factors influencing disinfection, type of disinfectants, their mode of action, toxicology.		
Module 3	**Waste water treatment**	**9 hours**
Activated sludge process – biology of sludge, nutrient removal, pathogen removal, bulking, foaming, biofilm reactors, waste stabilization ponds. Sludge processing – screening, thickening, dewatering, conditions, stabilization, composting, anaerobic digestion of waste water and sludge, biological aerosols and bio-odours from waste water treatment plants and their control.		
Module 4	**Drinking water treatment**	**9 hours**
Drinking water treatment – storage, prechlorination, coagulation, water softening, filtration, activated carbon treatment, biological treatment, disinfection. Water distribution system – biofilm formation, problems caused by biofilms. Other biological problems associated with water treatment and distribution, home devices for water treatment.		
Module 5	**Biotechnological applications of waste treatment**	**9 hours**
Biotechnological application in waste treatment – bioagumentation, use of enzyme, use of immobilized cells, biosensors, application of recombinant DNA technology for waste water reuse.		
ReferenceBooks	1. Gabriel Britton (Ed.), 1994, Waste water Microbiology, Wiley – Liss Publications. 2. Purohit, S.S., 2000, Microbiology Fundamental and Applications, 6th	

	Edition, Agrobios Publishers. 3. Chatwall, G.R., (Ed), 2003, Encyclopedia of Environmental Water Pollution, Vol. 1 – 3, Chatwall, Anmol Publications Pvt. Ltd., New Delhi. 4. Gerhard Rheinheimer (Ed.), 1986, Aquatic Microbiology – Methods, 4th Edition, John Wiley & Sons. 5. Ian T. Paulsen and Andrews J. Holmes (Eds.), 2013, Environmental Microbiology-Methods and Protocols, 2nd Edition, Humana Press.

After the completion of the course, the student will be able to

Course Outcomes	**Cognitive Level**
CO1: Understand the characteristics of water and waste water and the biological and chemical indicators	K1, K2, K3, K4
CO2: Factors affecting water & waste water treatment, their types and mode of action	K1, K2, K3
CO3: Understand how to treat the waste water, its methods and its implications	K2, K3, K4, K5
CO4: Understand how to treat the drinking water, its methods and its implications	K2, K3, K4, K5
CO5: Biotechnological applications in water treatment	K3, K4, K5

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

Mapping of CO with PO

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PO14**	**PO15**
CO1	H	M	M	M	L	M	M	M	L	L	L	L	L	L	M

CO2	H	M	M	M	L	M	M	M	L	L	L	L	L	L	M
CO3	H	M	M	M	L	M	M	M	L	L	L	L	L	L	M
CO4	H	M	M	M	L	M	M	M	L	L	L	L	L	L	M
CO5	H	M	M	M	L	M	M	M	L	L	L	L	L	L	M

H – High, M – Medium, L - Low

Mapping of CO with PSO

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
CO1	H	M	H	M	L	L
CO2	H	M	H	M	L	L
CO3	H	M	H	M	L	L
CO4	H	M	H	M	L	L
CO5	H	M	H	M	L	L

H - High, M – Medium, L – Low

Semester	**II Semester**		
Course Type	**Core Compulsory Paper - 5**		
Title of the Course	**BACTERIOLOGY & VIROLOGY**		
Course Code			
Teaching Hours	**60 Hours/ Semester : 4 Hours/ week**		
	BACTERIOLOGY & VIROLOGY	**Credits: 4**	**Max. Marks: 100 (Internal: 25, External 75)**

Course Prerequisites: The students should have a basic knowledge on microbiology					
CODE:	**BACTERIOLOGY & VIROLOGY**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**
Course Objectives	• To introduce knowledge on the structure of bacteria, viruses, • Provide knowledge on fundamentals of bacterial & viral classification • Develop understanding of infection processes, host range, cultivation and purification assays using molecular techniques				
Module 1	**Morphology and Structure of Bacteria**				**12 hours**
Morphological types – cell walls of archaebacteria – Gram negative – Gram positive, eubacteria – eukaryotes, L forms – cell wall synthesis, antigenic properties – capsule – types, composition and function, cell membranes – structure – composition, properties. structure and function of flagella – cilia – pili – gas vesicles – chromosomes					
Module 2	**Classification of Microorganisms**				**12 hours**
Introduction – Haeckel's three kingdom concept – Whitaker's five kingdom concept – three domain concept of Carl Woese, basis of microbial classification – classification and salient features of bacteria according to the Bergey's Manual of Determinative Bacteriology, Cyanobacteria, Prochlorons and Cyanelles.					
Module 3	**History, Morphology and Structure of Viruses**				**12 hours**
History**:** Discovery of viruses and development of Virology (contributions of pioneers), nature, origin and evolution of viruses. Properties of viruses**:** Physical- morphology and structure, sedimentation, electrophoretic mobility, buoyant density, antigenic nature of viruses, biological host range, transmission (vector and non-vector), virus stability, Nomenclature and classification of viruses: Criteria used for naming and classification, Current ICTV classification of viruses of bacteria, plants and animals and humans. Isolation, cultivation, assay and maintenance of bacterial, plant and animal viruses: Experimental plants and tissue cultures. Experimental animals, embryonated eggs, organ cultures, primary and secondary cell cultures, suspension and monolayer cell cultures, cell strains, cell lines.					
Module 4	**Purification of viruses**				**12 hours**

Need for virus purification. Extraction of viruses from tissues, clarification, concentration of viruses in clarified extracts by physical and chemical methods, further purification of viruses by rate zonal / equilibrium density gradient centrifugation, criteria of virus purity, quantitation and preservation of purified virus preparations. Quantitation of viruses: Infectivity assay methods (plaque, pock, end point, local / systemic assay of plant viruses), physical (EM), serological (HA, HI, immunofluorescence, ELISA) and chemical (viral protein and nucleic acid based) approaches. Major characteristics of the following virus families / genera / groups: *Adenoviridae, Bromoviridae, Bunyaviridae, Caulimoviridae, Flaviviridae, Geminiviridae,Hepadnaviridae, Herpesviridae, Orthomyxoviridae, Paramyxoviridae, Parvoviridae,Picornaviridae, Potyviridae, Poxviridae, Reoviridae, Retroviridae, Rhabdoviridae,Tobamovirus*, Insect Viruses: Biology of major RNA and DNA viruses of insects and their applications.		
Module 5	**Bacteriophages**	**12 hours**
Biology of major RNA (MS2, Qβ, Ø6) and DNA (T-even and T-odd, lambda, Mu, Øx174, M13) bacteriophages, biology of cyanophages. Algal and fungal viruses: Biology of viruses of Phycodnaviridae, Partitiviridae and Totiviridae. Biology of sub-viral agents: Satellite viruses, sat-RNAs, viroids virusoids and prions, Concept of molecular parasitism, importance of viruses in human welfare with suitable examples.		
ReferenceBooks	1. A Practical Guide to Clinical Virology, 2002, 2nd edition, Haahcim, Pattison & Whitley-Wiley 2. Bergey's Manual of Systemic Bacteriology 3. Corat, H.F., Kimball, P.C., and Levy, J.A., 1994, Virology, 3rd Edition, Blackwell Scientific Publications, Oxford. 4. Dimmock, N.J., and Primrose, S.B., 1994, Introduction of Modern Virology, 4th Edition, Blackwell Scientific Publications, Oxford. 5. John B Carter, 2013, Virology: Principles and Applications: A Review, John Wiley & Sons. 6. Vinod Singh, 2010, Text of Bacteriology, International Book Distributing Co. 7. Lennetter, E.H., 1984, Diagnostic Procedures for Viral and Rickettsial Diseases, American Public Health Association, NY. 8. Mathews, R.E., 1992, Functional of Plant Virology, Academic Press, San Diego. 9. Morg, C.and Timbury, M.C., 1994, Medical Virology, 10th Edition,	

	Churchil Livingston, London. 10. Topley and Wilson, 1995, Text book on Principles of Bacteriology, Virology and Immunology, Edward Arnold, London. 11. Williams Hayes, 1985, The Genetics of Bacteria and Their Viruses, Blackwell Scientific Publishers, London.

After the completion of the course, the student will be able to

Course Outcomes	**Cognitive Level**
CO1: Knowledge on how to compare and contrast the structure of cell membranes and cell walls in Bacteria and Archaea. To differentiate between Gram positive and Gram negative bacteria; Explain how specialized structures (e.g., pili/fimbriae, capsules, lipopolysaccharides, spores, or flagella) enable a microbe to survive in a given environment	K1
CO2: Gives understanding on the classification of microbes	K1
CO3: Understanding on nomenclature and classification of viruses-bacterial viruses, plant viruses; knowledge about viruses and the chemical nature of viruses, different types of viruses infecting animals, plants and bacteria; Deep knowledge and understanding and skill on the principal purposes of cultivating viruses. Describe three ways in which viruses are cultivated	K1, K3
CO4: Understand the knowledge of skills on methods of purification of viruses; the possible causative agents, modes of transmission, virulence factors, diagnostic techniques and prevention/treatment for different viral diseases of human, plant	K1, K3, K6

,animal and insect viruses	
CO5: Provide a thorough description of lysogenic and lytic bacteriophage infections; Biology of subviral agents	K2, K1

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

Mapping of CO with PO

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PO14**	**PO15**
CO1	H	M	M	M	M	M	M	H	H	M	M	M	L	L	M
CO2	H	M	M	M	M	M	M	H	H	M	M	M	L	L	M
CO3	H	M	M	M	M	M	M	H	H	M	M	M	L	L	M
CO4	H	M	H	M	M	M	M	H	H	M	M	M	L	L	M
CO5	H	M	M	M	M	M	M	H	H	M	M	M	L	L	M

H – High, M – Medium, L - Low

Mapping of CO with PSO

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
CO1	H	H	M	L	L	L
CO2	H	H	M	L	L	L
CO3	H	H	M	L	L	L
CO4	H	H	M	L	L	L
CO5	H	H	M	L	L	L

H - High, M – Medium, L – Low

Semester	**II Semester**				
Course Type	**Core Compulsory Paper - 6**				
Title of the Course	**MYCOLOGY & PHYCOLOGY**				
Course Code					
Teaching Hours	**60 Hours/ Semester : 4 Hours/ week**				
	MYCOLOGY & PHYCOLOGY	**Credits: 4**	**Max. Marks: 100 (Internal: 25, External 75)**		
Course Prerequisites: The students should have a general knowledge on microbiology					
CODE:	**MYCOLOGY & PHYCOLOGY**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**
Course Objectives	To study the distribution, life cycle and cellular organization of fungi and algae and to enrich the learners on isolation and culture of phytoplankton.				
Module 1	**Morphology & Life Cycle**				**12 hours**
Introduction to Mycology, classification, structure and cell differentiation, division of Myxomycota, Acrasiomycetes, Hydromyxomycetes, Myxomycetes, Plasmo-diophoromycetes, Chytridiomycetes, Hypochytridiomycetes, Oomycetes, Zygomycotina – Zygomycetes, Tricomycetes, evolutionary tendencies in lower fungi.					
Module 2	**Classification of Fungi**				**12 hours**
Ascomycotina – Hemiascomycetes, Plectomycetes, Pyrenomycetes, Discomycetes, Laboulbenomycetes, Loculoascomycetes, Basidiomycotina, Teliomycetes, Hymenomycetes. Deuteromycotina – Hypomycetes, Coelomycetes, Blastomycetes.					
Module 3	**Fungal Diseases**				**12 hours**
Heterothalism, sex hormones in fungi; physiological specialization phylogeny of fungi; Lichens-					

classification of lichens, habit and habitat and economic importance. Mycorrhizaecto mycorrhia, endomycorrhiza, vesicular arbuscular mycorrhiza. fungi as insect symbiont, fungal diseases – systemic and subcutaneous, mycoses, candidiasis, pneumocystis, blastomycoses, deterophytosis.		
Module 4	**Microalgae**	**12 hours**
Isolation of microalgae, commercially important phytoplankton, commercial production of microalgae, photobioreactor, harvesting technology, phytoplankton in aquaculture industry, oil industry and carotenoid industry.		
Module 5	**Algae**	**12 hours**
Distribution of algae, classification of algae, algal nutrition, algal structure and reproduction. Chlorophyceae, Pheophyceae, Rhodophyceae, Diatoms, Euglenoids, algal ecology and algal biotechnology.		
ReferenceBooks	1. Alexopoulos, C.J., Mims, C.W., and Blackwell, M., 1996, Introductory Mycology, 4th Edition, John and Sons, Inc. 2. Alexopoulos, C.J. and C.W. Mims, 1979, Introduction to Mycology, 3rd Edition, Wiley Eastern Ltd., New Delhi. 3. Gopal Bhattacharya, 2013, Text Book of Mycology, Neha Publishers & Distributors. 4. Kumar, H.D., 1990, Introductory Phycology, 2nd Edition, Affiliated East Western Press. Mehrotra, R.S. and K.R. Anexia, 1990, An Introduction to Mycology, New Age International Publishers. 5. Sreekumar, S., 2015, Microbiology, Phycology, Mycology, Lichenology and Plant Pathology, Medtech Publishers. 6. Vashishta, B.R. and Sinha, A.K., 2008, Fungi, S Chand and Company Ltd. New Delhi. 7. Vashishta, B.R., 2005, Algae, 3rd Edition, S Chand and Company Limited, New Delhi.	

After the completion of the course, the student will be able to

Course Outcomes	**Cognitive Level**

CO1: Acquire knowledge on morphology and life cycle of different divisions of fungi.	K1, K2
CO2: Develop ideas on the division of fungi such as Ascomycotina, Basidomycotina and Deuteromycotina	K1, K2
CO3: Obtain knowledge on Lichens, Mycorrhiza and Fungal diseases such as cutaneous, subcutaneous and systemic.	K1, K2, K3, K4
CO4: Acquire knowledge on isolation, culture, harvest and commercial importance of algae.	K1, K2
CO5: Understand about the distribution, classification, structure and reproduction of algae.	K1, K2, K4

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

Mapping of CO with PO

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PO14**	**PO15**
CO1	M	L	H	M	L	L	L	L	L	M	M	M	L	L	L
CO2	M	L	H	M	L	L	M	L	L	M	M	M	L	L	L
CO3	M	L	H	H	H	L	M	M	H	M	M	M	L	L	L
CO4	M	L	H	M	H	L	M	M	H	M	M	M	L	H	L
CO5	M	L	H	L	M	L	M	M	H	M	M	M	L	H	L

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	M	M	L	L	L
CO2	H	M	M	L	L	L
CO3	H	M	M	L	L	L
CO4	H	M	H	H	L	L
CO5	H	M	M	L	L	L

H - High, M – Medium, L – Low

Semester	**II Semester**				
Course Type	**Core Paper - 7**				
Title of the Course	**IMMUNOLOGY**				
Course Code					
Teaching Hours	**60 Hours/ Semester : 4 Hours/ week**				
	IMMUNOLOGY	**Credits: 4**	**Max. Marks: 100 (Internal: 25, External: 75)**		
Course Prerequisites:					
CODE:	**IMMUNOLOGY**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**
Course Objectives					
Module 1	**Immunology- Fundamental Concepts and Anatomy**		**12 hours**		

Components of innate and acquired immunity; phagocytosis; complement and inflammatory responses; organs and cells of the immune system - primary and secondary lymphoid organs and tissues; haematopoiesis- immune cells; antigens - immunogens, haptens and super antigens.		
Module 2	**Immune Components and Vaccinology**	**12 hours**
Lymphokines and cytokines; immunoglobulins-structure, classes and biological functions; genetic organization of immunoglobulin genes and generation of antibody diversity; applications and monoclonal antibodies; major histocompatibility complex - mhc genes, structure and functions; immunization practices: active and passive immunization; vaccines.		
Module 3	**Immune Effector Responses**	**12 hours**
Humoral immune responses - B cell maturation, activation and differentiation and humoral immune response; cell mediated immune response- T cell development and activation, mechanism of cell mediated immune response; T-cell and B-cell receptors; antigen processing and presentation; antigen recognition; interaction of T-cell and B-cell; immunological memory and immunotolerance.		
Module 4	**Antigen-Antibody Interactions**	**12 hours**
Affinity, avidity, lattice theory; immuno precipitation and agglutination techniques, immunoelectrophoresis, radio-immunoassay, ELISA, immunoblotting, immunofluorescence, flow cytometry; monoclonal antibodies and hybridoma technology; CMI techniques- lymphoproliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays, apoptosis.		
Module 5		**12 hours**
Immunity to infection: Bacteria, viral, protozoan and parasitic infections; hypersensitivity- Type I-IV- detection methods; autoimmunity- mechanism, types of autoimmune diseases; Transplantation immunology, immunological basis of graft rejection –tissue matching and immuno suppression; tumour immunology, cancer and the immune system; Immunodeficiency diseases.		
ReferenceBooks	1. Abas, Lichtman and ShivPillai, 2021, Cellular and Molecular Immunology, 10th Edition, Elsevier 2. Jeffrey K. Actor, 2011, Elsevier Integrated Review Immunology and Microbiology, 2nd Edition. 3. Joseph A. Bellanti, 2016, Immunology IV: Clinical Applications in Health and Disease, Georgetown University School of Medicine, Washington, DC. 4. Kuby, J., 1999, Immunology, W.H. Freeman and Company, New	

	York. 5. Murphy and Weaver, 2016, Janeway's Immunobiology 9th Edition, W.W. Norton & Company. 6. Paul, 2012, Fundamental Immunology, 7th Edition, Lippencott Williams & Wilkins, Kluwer. 7. Punt, Stranford, Jones and Owen, 2019, Kuby Immunology, 8th Edition, W.H. Freeman and Company, New York. 8. Rich, Fleisher, Shearer, Schroeder, Frew and Weyand, 2018, Clinical Immunology: Principles and Practice, 5th Edition, Elsevier. 9. Roitt, 2000, Essential Immunology, Blackwell Scientific Publishers. 10. Williams, 2011, Immunology: Mucosal and Body Surface Defences, John Wiley & Sons, Ltd.

At the end of the course the students can expect to learn the following

Course Outcomes	**Cognitive Level**
CO1: Understand the fundamental concepts of immunity and Gain an in-depth knowledge of characteristics and functions of the organs and cells of the immune system. Assimilate knowledge on the characteristics that make the molecules to act as antigens.	K1, K2
CO2: Knowledge on the molecular components of the immune system like lymphokines, cytokines, immunoglobulins and understand the organisation of genes and antibody repertoire. understand the cell surface proteins essential to differentiate self and non-self molecules and the pathways for antigen processing and presentation.	K1, K2
CO3: Demonstrate an understanding of the overlapping roles of innate and adaptive immunity and able to compare and contrast	K1, K2, K4

the unique roles of humoral and cell-mediated immunity in response to pathogens. Gained knowledge on Prophylactic measures and different types of vaccines.	
CO4: The understanding of the antigen antibody reactions will enable the students to develop the skill to decide on the selection of specific assays according to the samples and need. Gain potential for research projects/ novel diagnostic kits development based on disease diagnosis and prophylaxis.	K3, K4, K5, K6
CO5: Comprehend the overreaction by our immune system; Apply the knowledge of molecular and cellular basis of immunity to understand the role of immunity in infections, transplantation, autoimmune disease, immune deficiency and cancer. Gain potential for development of research projects based on immunological changes and its advancements.	K2, K3, K6

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

Mapping of CO with PO

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PO14**	**PO15**
CO1	M	L	L	L	L	L	L	L	L	M	L	L	L	L	L
CO2	M	L	M	L	L	L	L	L	L	L	M	L	L	L	L
CO3	M	L	M	L	L	M	L	L	L	L	M	L	M	L	M
CO4	H	H	H	H	H	H	M	H	M	L	M	M	M	H	H
CO5	H	H	H	H	M	H	M	M	M	M	M	M	M	H	H

H – High, M – Medium, L - Low

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	L	L	L	L	L	L
CO2	L	M	L	M	L	L
CO3	L	L	L	L	L	L
CO4	H	M	L	L	L	M
CO5	H	H	L	L	L	M

H - High, M – Medium, L – Low

Semester	**II Semester**		
Course Type	**Core Paper - 8**		
Title of the Course	**MICROBIAL GENETICS**		
Course Code			
Teaching Hours	**60 Hours/ Semester : 4 Hours/ week**		
	MICROBIAL GENETICS	**Credits: 4**	**Max. Marks: 100 (Internal: 25, External: 75)**
Course Prerequisites: The student should have a basic knowledge on genetic material of prokaryotes			

CODE:	**MICROBIAL GENETICS**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**

Course Objectives	• To provide a comprehensive detail on microbial genomes • To provide an understanding of the genetic constituents of bacteria with special emphasis on various approaches • To impart thorough knowledge on gene regulation and transfer mechanisms. • To understand the different modes of gene regulation in microorganisms, and the importance of bacterial transposition and its applications.	
Module 1	**Basics of Microbial Genetics**	**12 hours**
Gene, chromosome – prokaryotic & eukaryotic chromosomes, genome, organisation in prokaryotes and eukaryotes – DNA content law of DNA constancy & C value paradox – cot curve. Prokaryotic transposable elements – Insertion Sequences, composite and non-composite transposons, Replicative and Non replicative transposition, Mu transposon. Eukaryotic transposable elements - Yeast (Ty retrotransposon), Drosophila (P elements), Maize (Ac/Ds). Uses of transposons and transposition. Mutations and mutagenesis: Definition and types of Mutations; Physical and chemical mutagens; Molecular basis of mutations; Functional mutants (loss and gain of function mutants); Uses of mutations. Reversion and suppression: True revertants; Intra- and inter-genic suppression; Ames test; Mutator genes.		
Module 2	**Bacterial Genetics**	**12 hours**
Bacterial chromosomes, E. coli chromosome structure, circular genetic map, plasmids - structure, classification, copy control, incompatibility, F-factor, col and R plasmids, Genetic mapping of E. coli, genetics of quorum sensing in bacteria. Gene concept - regulation of bacterial gene expression. Lactose system - coordinate regulation, Lac components, positive and negative regulation, catabolite repression. Tryptophan operon - attenuation. Arabinose operon and its regulation.		
Module 3	**Gene Transfer & Recombination**	**12 hours**
Gene Transfer Genetics & Mechanisms: Transformation - Discovery, mechanism of natural competence. Conjugation - Discovery, mechanism, Hfr and F' strains,Interrupted mating technique and time of entry mapping. Transduction - Generalized transduction, specialized transduction, LFT & HFT lysates, Mapping by recombination and co-transduction of markers; Recombination: types - homologous or general, site specific and random recombination, general recombination between homologous DNA- Holliday model, double strand model of general recombination, enzymes involved in recombination, rec - proteins. Chromosomes & DNA replication in archaea, gene		

transfer in archaea, deletion mapping, complementation, intragenic complementation, heteroduplex mapping, foot printing, chromosome walking and chromosome jumping.		
Module 4	**DNA Damage & Repair**	**12 hours**
DNA damages - Types, hit theory, UV radiation. DNA repair: post irradiation effects on survival levels - photo reactivation, liquid holding recovery. Biochemistry repair mechanism: excision, recombination and SOS repair.		
Module 5	**Fungal, Bacterial & Archael Genetics**	**12 hours**
Yeast as a model organism for eukaryotic genetic research – chromatin structure, genetic recombination and gene regulation. Meiotic & mitotic mapping, gene conversion, heterothallism & mating type, tetrad analysis & linkage detection in Neurospora. Structure, genome organisation and replication of bacteriophages – T7, T4 – rII locus, ϕX174 & M13 phages, genetics of *Agrobacterium*.		
ReferenceBooks	1. Das, S, and Dash, H.R., 2018, Microbial Diversity in the Genomic Era, 1st Edition, Academic Press. 2. Freifelder, D., 2008, Microbial Genetics, 18th Edition, Narosa Publishing House, New Delhi. 3. Gardner, Simmons and Snustad, 2010, Principles of Genetics, 8th Edition, Wiley India Pvt. Ltd. 4. Jeyanthi, G.P., 2009, Molecular Biology, MJP Publishers, Chennai. 5. Johnson, 1994, Molecular Genetics of Yeast – A Practical Approach, Oxford University Press. 6. Kalia, V.C., Shouche, Y., Purohit, H.J. and Rahi, P., 2017, Mining of Microbial Wealth and MetaGenomics 1st Edition, Springer Nature Singapore Pvt. Ltd. 7. Klug, Cummings and Spencer, 2016, Concepts of Genetics, 10th Edition, Pearson Education, India. 8. Krebs, J.E., Elliott, S and Goldstein, 2017, Lewin's GENES XII, 12th Edition, Jones and Bartlett Publishers. 9. Lewin B., 2017, Gene XII, Oxford University Press Oxford. 10. Moore and Frazer, 2002, Essential Fungal Genetics, Springer. 11. Primrose and Twyman, 2003, Principles of Genome Analysis and Genomics, Blackwell Publishing Company.	

	12. Snyder, L, Peters, Henkin and Champness, 2013, Molecular Genetics of Bacteria 4th Edition, ASM Press. 13. Stanley R. Maloy, John E.C. and Freifelder, D., 2008, Microbial Genetics, Narosa Publishing House, New Delhi. 14. Streips and Yasbin, 2002, Modern Microbial Genetics, 2nd Edition, Wiley Publications.

At the end of the course the students can expect to learn the following

Course Outcomes	**Cognitive**
CO1: Understanding the structure and functions of genomes of different microbial groups and microbial genetics.	K1, K2, K4
CO2: Understanding the processes behind mutations and other genetic changes.	K1, K2, K3, K4
CO3: Identifying and distinguishing genetic regulatory mechanisms at different levels.	K2, K3, K4, K5
CO4: Able to understand the different recombination mechanisms in microorganisms, and the basic genetics behind the DNA damage and repair mechanisms.	K2, K3, K4
CO5: Able to plan basic experiments in microbial genetics concerned with clarifying phenotypes and their relationship with the genotype using common methods in microbial genetics	K2, K3, K4, K5

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

Mapping of CO with PO

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PO14**	**PO15**
CO1	H	M	M	L	M	L	M	L	M	M	M	M	L	L	H

CO2	H	M	M	L	M	L	M	L	M	M	M	M	L	L	M
CO3	H	M	M	L	M	L	M	L	M	M	M	M	L	L	H
CO4	H	M	M	M	M	M	M	L	M	M	M	M	L	L	M
CO5	H	M	M	M	M	M	M	L	M	M	M	M	L	L	H

H – High, M – Medium, L - Low

Mapping of CO with PSO

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
CO1	H	M	M	L	H	L
CO2	H	M	M	L	H	L
CO3	H	M	M	L	H	L
CO4	H	M	M	L	H	M
CO5	H	M	M	L	H	M

H - High, M – Medium, L – Low

Semester	**II Semester**		
Course Type	**Core Compulsory Course Practical - 3**		
Title of the Course	**BACTERIOLOGY & VIROLOGY AND MYCOLOGY & PHYCOLOGY**		
Course Code			
Teaching Hours	**60 hours/semester: 4 hours/week**		
	BACTERIOLOGY & VIROLOGY AND MYCOLOGY &	**Credits: 2**	**Max. Marks: 100 (Internal: 50;**

	PHYCOLOGY		External: 50)

Course Prerequisites:
The student should have a basic practical knowledge on microbiology and especially on isolation of microorganisms

CODE:	BACTERIOLOGY & VIROLOGY AND MYCOLOGY & PHYCOLOGY	L	T	P	C
		-	-	4	2

Course Objectives	Understand the architecture of viruses, Know the methods used for isolating, cultivating and studying viruses To understand the isolation, identification, counting and harvest of microalgae To know about the techniques for culture and identification of fungal spores

1. Isolation of bacteriophages from sewage water
2. Cultivation of viruses in embryonated Eggs: different routes of inoculation.
3. Virus inclusion bodies (slides)
4. Determination of stability of plant virus in cell sap- TIP, DEP, LIV.
5. Determination of chlorophylls in healthy and virus diseased leaves.
6. Purification of viruses by different chemical and physical methods
7. Isolation and identification of microalgae from seawater.
8. Harvest of microalgal cells by different methods.
9. Enumeration of algal cells by counting chamber method
10. Isolation of marine fungi from marine environment.
11. Mushroom cultivation technique.
12. Identification of fungal spore by staining.
13. Identification of fungal diseases in selected plants and animals (Etiology).

After the completion of the course, the student will be able to

Course Outcomes	Cognitive Level
CO1: Acquire hands on experiences on isolation methods, identification, different methods of culture, media preparation, enumeration, and harvesting of microalgae	K1, K2, K3, K4, K5

CO2: Acquire hands on experiences on isolation methods, identification, of fungal disease diagnosis	K1, K2, K3, K4, K5
CO3: Understanding skill on different methods of isolation and cultivation of viruses	K1, K2, K3
CO4: Understanding on virus inclusion bodies	K1, K2
CO5: Understanding and knowledge on purification of viruses by chemical and physical methods	K1, K2, K3

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

Mapping of CO with PO

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PO14**	**PO15**
CO1	H	M	H	M	M	M	M	M	M	M	H	M	H	M	L
CO2	H	M	H	M	M	M	M	M	M	M	H	M	H	M	L
CO3	H	M	H	M	M	M	M	M	M	M	H	M	H	M	L
CO4	H	M	H	M	M	M	M	M	M	M	H	M	H	M	L
CO5	H	M	H	M	M	M	M	M	M	M	H	M	H	M	L

H – High, M – Medium, L – Low

Mapping of CO with PSO

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
CO1	H	H	M	L	L	L
CO2	H	H	M	L	L	L
CO3	H	H	M	L	L	L
CO4	H	H	M	L	L	L

CO5	H	H	M	L	L	L

H – High, M – Medium, L - Low

Semester	**II Semester**		
Course Type	**Core Compulsory Course Practical - 4**		
Title of the Course	**IMMUNOLOGY AND MICROBIAL GENETICS**		
Course Code			
Teaching Hours	**60 hours/semester: 4 hours/week**		
	IMMUNOLOGY AND MICROBIAL GENETICS	**Credits: 2**	**Max. Marks: 100 (Internal: 50; External: 50)**

Course Prerequisites:
The student should have a basic practical knowledge on microbiology, especially the isolation of microorganisms and immunological techniques

CODE:	**IMMUNOLOGY AND MICROBIAL GENETICS**	**L**	**T**	**P**	**C**
		-	**-**	**4**	**2**

Course Objectives

- To get an idea about blood grouping
- To get an idea about the antigen-antibody reactions
- To inculcate/impart skills to perform various tests/assays and experiments.
- To provide an complete idea about the mutation studies in microorganisms
- To provide students with a deep insight gene transfer mechanism especially transformation in microorganisms

1. Identification of lymphoid organs and cells.
2. Preparation of serum, plasma and antigens.
3. Direct agglutination to determine ABO blood grouping.
4. Determination of differential leukocyte count.
5. Isolation and enumeration of RBC from human blood.
6. Antigen- antibody reaction – Precipitation - ODD/SRID/CID
7. Antigen- antibody reaction – Agglutination- blood grouping/active/passive agglutination

8. Cell viability/cytotoxicity assay
9. Enzyme Linked Immune Sorbant Assay – Demonstration
10. Isolation of nucleic acid and characterization by gel Electrophoresis
11. Inactivation of microorganisms by different mutagens.
12. Production, isolation and characterization of mutants.
13. Determination of mutation rate – natural and induced
14. Isolation, characterization and curing of plasmids.
15. Preparation of competent cells and transformation of *E.coli* using plasmid DNA

After the completion of the course, the student will be able to

Course Outcomes	**Cognitive Level**
CO1: Understand the immune system of mammal and fish	K2
CO2: Learn the working principle of Antigen antibody reactions and apply it for disease diagnosis (understand/apply)	K2
CO3: Learn experiments of hematology and identify the defects of immune cells	K3, K5
CO4: Able to develop projects related to development of immunostimulants and its application	K5
CO5: Understand practically how gene transfer occurs in microorganisms, and able to understand the mutation studies in microorganisms	K2, K4, K5

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

Mapping of CO with PO

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PO14**	**PO15**

CO1	H	M	H	L	L	L	H	L	M	M	H	M	L	L	L
CO2	H	M	H	L	L	L	H	L	M	M	H	M	L	L	L
CO3	H	M	H	L	L	L	H	L	M	M	H	M	L	L	L
CO4	H	M	M	L	L	L	M	L	M	M	H	M	L	L	L
CO5	H	M	M	L	L	L	M	L	L	M	H	M	L	L	L

H – High, M – Medium, L - Low

Mapping of CO with PSO

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
CO1	H	H	L	L	M	L
CO2	H	H	L	L	M	L
CO3	H	H	L	L	M	L
CO4	H	M	L	L	H	L
CO5	H	M	L	L	H	L

H - High, M – Medium, L – Low

Semester	**II Semester**		
Course Type	**Core Elective Course – 2A**		
Title of the Course	**FOOD MICROBIOLOGY**		
Course Code			
Teaching Hours	**45 Hours/ Semester : 3 Hours/ week**		
	FOOD MICROBIOLOGY	**Credits: 3**	**Max. Marks: 100 (Internal: 25, External**

			75)

Course Prerequisites: The students should have a basic knowledge on food and microorganisms related to food

CODE:	**FOOD MICROBIOLOGY**	**L**	**T**	**P**	**C**
		3	**-**	**-**	**3**

Course Objectives	

Module 1	**Introduction to Food Microbiology**	**9 hours**

The scope of food microbiology, microorganisms and food, food safety, microbiological quality assurance. Micro-organisms and food materials-diversity of habitat, micro-organisms in the atmosphere - airborne bacteria, airborne fungi, micro-organisms of soil, micro-organisms of water, micro-organisms of plants, micro-organisms of animal origin, molds, yeasts and bacteria – general characteristics – classification and importance. Principles of food preservation: Asepsis – removal of microorganisms (anaerobic conditions, high temperature, low temperature & drying), factors influencing microbial growth in food: extrinsic and intrinsic factors- chemical preservatives and food additives- canning, processing for heat treatment-D and F values

Module 2	**Contamination and Spoilage**	**9 hours**

Contamination, preservation and spoilage of cereals & its products, sugar and its products, vegetables & fruits and their products, meat and its products, milk and its products, fish and seafood's and their products; poultry and its products–spoilage of canned foods-Detection of spoilage and characterization

Module 3	**Food Borne Infection and Intoxications**	**9 hours**

Bacterial and non-bacterial with examples of infective and toxic types – *Brucella*, *Bacillus*, *Clostridium*, *E.coli*, *Salmonella*, *Shigella*, *Staphylococcus*, *Vibrio*, *Yersinia*, Nematodes, Protozoa, algae, fungi and viruses. Food borne outbreaks – laboratory testing procedures; prevention measures – food control agencies and their regulations, sanitation – employee's health standards – waste treatment & disposal and their types.

Module 4	**Production of Fermented Dairy Products and Spoilage**	**9 hours**

Cheese, yoghurt, butter milk, sour cream Fermented vegetables; sauerkraut, pickles, olives and soy sauce. Fermented meat, fermented Indian foods – leavening of bread. Food spoilage: Spoilage of fruit and vegetables, spoilage of cereal and cereal products – cereal grains, and bread, spoilage of meat and meat products – Bacon and Ham, spoilage of milk and milk products – butter and frozen desserts. Food borne diseases – indicators of pathogens & food poisoning.		
Module 5	**Food Produced by Microbes**	**9 hours**
Fermented foods, microbial cells as food (Single cell protein), mushroom cultivation. Bioconversions – production of alcohol – fermented beverages (beer and wine), industrial enzymes production (amylases, proteases, and cellulases); amino acid production (glutamic acid and lysine).		
ReferenceBooks	1. Adams, M.R. and Moss, M.O., 2008, Food Microbiology, RSC Publishing, Cambridge, UK. 2. Benwart, G.J., 1987, Basic Food Microbiology, CBS Publishers & Distributors, New Delhi. 3. Blackburn C. de W., 2006, Food Spoilage Microorganisms, Woodhead Publishing, Cambridge, UK 4. Deak, T. and Beuchat, L.R., 1996, Hand Book of Food Spoilage Yeasts, CRC Press, New York. 5. Frazier, W.C., and Westhoff, D.C., 1988, Food Microbiology (Reprint 1995), Tata McGraw Hill Publishing Ltd., New Delhi. 6. Garbutt, J., 1997, Essentials of Food Microbiology, Arnold – International Students Edition, London. 7. Jay J.M., 2000, Modern Food Microbiology, 6th Edition, Chapman & Hall, New York. 8. Prescott, L.M., Harley, J.P. and Helin, D.A., 2008, Microbiology, 5th Edition, McGraw Hill, New York. 9. Ray, B., 2000, Fundamental Food Microbiology, 2nd Edition. CRCPress. New York. 10. Robinson R.K. (ed.), 2002, Dairy Microbiology Handbook, 3rd Edition, Wiley Interscience.	

After the completion of the course, the student will be able to

Course Outcomes	**Cognitive Level**

CO1: Gain knowledge about food as a substrate for various microbes, the role of factors and its importance, understand about the principles and application of different types of food preservation technique, understand the basis of food safety regulations and use of standard methods and procedures for the microbiological analysis of food; Acquire, discover, and apply the theories and principles of food microbiology in practical, real-world situations and problems.	K1, K2, K6
CO2: Understanding the knowledge on various food contamination and spoilage	K1, K2, K3
CO3: Acquire a thorough understanding of food borne diseases, testing methods, and preventive technique.	K1, K2, K3
CO4: Learn about the various fermented products and its various stage spoilage.	K1, K2, K3
CO5: Understand the basic knowledge about the fermentation process and the requirements, designing of fermentation process. Acquire the knowledge about the production of antibiotic and enzymes	K1, K2

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

Mapping of CO with PO

	PO1	**PO2**	**PPO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PO14**	**PO15**
CO1	H	M	H	M	M	L	M	M	M	M	M	M	H	H	M
CO2	H	H	H	M	M	M	M	H	M	M	M	L	L	H	M

CO3	H	H	M	M	L	L	M	M	M	H	M	M	L	H	M
CO4	H	H	H	M	M	L	M	M	M	M	M	M	L	H	M
CO5	H	H	H	M	M	H	M	M	M	M	M	M	M	L	M

H – High, M – Medium, L - Low

Mapping of CO with PSO

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
CO1	M	H	M	M	M	M
CO2	H	M	M	M	M	M
CO3	H	M	L	M	L	L
CO4	H	H	M	M	H	L
CO5	H	M	M	M	H	M

H - High, M – Medium, L – Low

Semester	**II Semester**		
Course Type	**Core Elective Course – 2B**		
Title of the Course	**MARINE MICROBIAL TECHNOLOGY**		
Course Code			
Teaching Hours	**45 Hours/ Semester : 3 Hours/ week**		
	MARINE MICROBIAL TECHNOLOGY	**Credits: 4**	**Max. Marks: 100 (Internal: 25, External 75)**
Course Prerequisites: The students should have a basic knowledge on marine microbiology and techniques used in microbiology			

CODE:	MARINE MICROBIAL TECHNOLOGY	L	T	P	C
		3	-	-	3
Course Objectives	• To get an idea about the vaccination on disease control, role of microbes in industry • Acquire knowledge on microbial probiotics • To get an idea about the microalgal and halobacterial technology				
Module 1	**Gene Technology for Disease Control**			**9 hours**	
Vaccine: Different type of vaccines in microbial control; antiviral immunity and immunogenic proteins in aquatic important pathogens. Transgenic fish: development of transgenic fish and shrimp by gene transfer technology. RNA interference: principle and application of dsRNA, si RNA, mi RNA etc in microbial control.					
Module 2	**Marine Microbes for Industry**			**12 hours**	
Isolation, preservation and maintenance of industrially important microbes from marine environment – A general review of primary and secondary metabolites production – SCP Production – basic concept of industrial production of alcohol, organic solvents, antibiotics, amino acids, and Enzymes by marine microbes.					
Module 3	**Microalgal Production Technology**			**12 hours**	
Culture system-photobioreacter, harvesting of biomass, Bio-fuel production- fats, oils, and hydrocarbons: carotenoid production, Microalgae for aquaculture and waste water treatments, Genetic engineering of microalgae.					
Module 4	**Probiotics**			**12 hours**	
Definition-characteristics of probiotics: Probiotic microbes-production and characterization of probotics-mode of action of probiotics in fish nutrution larval rearing. Immune modulation and disease management					
Module 5	**Halobacterial Technology**			**12 hours**	
Definition-classification – Ecology – structure and functions of complex *Halobacterium salinarum* – Biotechnological potentials of *Halobacterium* – important products and their uses – role of halobacteria in salt purification.					

ReferenceBooks	1. Chandra Bhusan Singh, 2011, Introduction to Microbiology and Biotechnology, Neha Publishers and Distributors. 2. Jonatha M. Gott, 2004, RNA Interface, Editing and Modification: Methods and Protocol (Methods in Molecular Biology), Humana Publisher. 3. Michael A. Borowitzka and Laglay J. Borowitzka (Eds.), Micro algal Biotechnology, University of Cambridge Press, New York. 4. Patel, A.H., 2015, Text book of Industrial Microbiology, 2nd Edition, McMillan, India. 5. Peter Marian, M., John, J.A.C., Immanuel G., and Michael Babu, M., 2002, A Text Book of Marine Natural Products, M.S. University, Tirunelveli.

After the completion of the course, the student will be able to

Course Outcomes	**Cognitive Level**
CO1: Vaccination, techniques used in rDNA technology for the development of transgenic fish	K1, K2, K3
CO2: Understand the role of microbes in industrial production of products such as SCP, alcohol, organic acids, antibiotics etc	K1, K2, K3
CO3: Know about the role of microalgae on biofuel production, aquaculture and waste water treatment	K2, K3, K4
CO4: Role of probiotic microbes in fish nutrition, characterization, mode of action	K2, K3, K4
CO5: Role of halobacteria on salt purification, their structure, potential	K2, K3, K4

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

Mapping of CO with PO

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PO14**	**PO15**
CO1	H	M	M	H	M	M	M	L	M	M	M	M	M	L	L
CO2	H	M	M	M	M	M	M	L	M	M	M	H	M	L	L
CO3	H	M	M	M	M	M	M	L	M	M	M	H	M	L	L
CO4	H	M	M	M	M	M	M	L	H	M	M	H	M	L	L
CO5	H	M	M	M	M	M	M	L	M	M	M	H	M	L	L

H – High, M – Medium, L - Low

Mapping of CO with PSO

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
CO1	H	H	H	L	H	L
CO2	H	H	H	L	H	L
CO3	H	H	H	L	M	L
CO4	H	H	H	L	L	L
CO5	H	H	H	L	L	L

H - High, M – Medium, L – Low

Semester	**III Semester**				
Course Type	**Core Compulsory Paper - 9**				
Title of the Course	**RECOMBINANT DNA TECHNOLOGY**				
Course Code					
Teaching Hours	**60 Hours/ Semester : 4 Hours/ week**				
	RECOMBINANT DNA TECHNOLOGY	**Credits: 4**	**Max. Marks: 100 (Internal: 25, External 75)**		
Course Prerequisites: The student should have a basic knowledge about the biotechnology and biotechnological tools					
CODE:	**RECOMBINANT DNA TECHNOLOGY**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**
Course Objectives	• To understand the principle behind different enzymes and vectors used in recombinant DNA technology • To gain knowledge on gene manipulation using genetic engineering methods and its importance in plant, animal and environmental biotechnology. • To teach students about intellectual property rights (IPRs) and make them understand the process of patent filing • To impart knowledge of safety measures and ethical practices appropriate for transgenic research				
Module 1	**Basics of rDNA Research**				**12 hours**
Introduction to genetic engineering; DNA modifying enzymes – nucleases, polymerases, ligases; Cloning vectors – plasmids, cosmids, phasmids, phagemids, expression vectors, integrating shuttle vector –YAC vectors, viral vectors – SV 40 and adeno virus; Promotors: Lac Z promoter – expression system – Lambda, PL / PR Promoter, T7 promoter, Sp6 promoter, SV – 40 promoter, CaMV 35s promoter.					
Module 2	**Cloning Methodologies**				**12 hours**

Steps in cloning: sticky and blunt end cloning. Gene Transfer methods; Cloning from mRNA – synthesis of cDNA, cloning cDNA– cDNA library. Cloning from genomic DNA – genomic library. Metagenomic library; Shot gun cloning. Screening of recombinants – phenotypic expression of characters--α complementation, – Blotting techniques – Western, Northern and Southern. Mapping of human genes – Human genome project.		
Module 3	**Techniques**	**12 hours**
PCR – gene amplification, primer designing, optimization, variation in the PCR (RAPD, RFLP, RACE, RT-PCR). DNA sequencing – Sanger's method, Maxam Gilbert's method, automated sequencing and micro array, Next generation sequencing; Expression system: Prokaryotic and eukaryotic expression systems and their application in E. coli, Streptomyces, Yeast, Baculovirus and animal hosts.		
Module 4	**Application**	**12 hours**
Cloning of human insulin, interferon in E.coli. Recombinant vaccine development – HBs Ag in yeast. Cloning for commercial production of antibiotics (Penicillin), bio steroid transformation, production of biopolymers – Xanthumgum, melanin biosynthesis in E.coli, adhesive biopolymer in yeast; Gene Therapy; Plant genetic engineering: Ti plasmid, CaMV vector, direct DNA delivery methods – micro projectile bombardment, microinjection and electroporation.		
Module 5	**Advances in Transgenic Technology and IPR**	**12 hours**
Gene silencing; Types and mechanism of gene silencing. genetic factors of silencing, formation of antisense mRNA, inhibition of gene expression by antisense RNA, gene silencing in crop plants: tomato, Si RNA and disease control. Transgenic and GM organisms- guidelines for rDNA and transgenic research; Safety issues and IPR.		
ReferenceBooks	1. Brown, T.A., 2021, Gene Cloning and DNA Analysis: An Introduction, 8th Edition, Wiley- Blackwell Publishing, U.K. 2. Glick, B.R. and Patten, C.L., 2017, Molecular Biotechnology: Principles and Applications of Recombinant DNA, 5th Edition, ASM Press, USA. 3. Glick, B.R., Pasternak, J.J. and Patten, C.L., 2009, Molecular Biotechnology, 4th Edition, ASM Press, USA. 4. Green, M. and J. Sambrook, J., 2012, Molecular Cloning: A Laboratory Manual, 4th Edition, Cold Spring Harbour Laboratory Press, USA. 5. Nicholl, D.S.T., 2008, An Introduction to Genetic Engineering, 3rd Edition, Cambridge University Press. 6. Primrose, S.B. and Twyman, R.M., 2016, Principles of Gene Manipulation	

	and Genomics, 8th Edition, Blackwell Publishing, U.K. 7. Willey, J. M., Sandman, K. and Wood, D. 2019, Prescott's Microbiology, 11th Edition, McGraw Hill Higher Education, USA. 8. Winnacker, E.L., 1986, From Genes to Clones, Reprinted by Panima Publishing Corporation, New Delhi.

After the completion of the course, the student will be able to

Course Outcomes	**Cognitive Level**
CO1: Acquire in-depth understanding of the exploitation of restriction and DNA-modifying enzymes, in recombinant DNA technology, along with the use of linkers and adapters. Gained detailed knowledge of the use of different cloning vectors and different types of expression vectors. Expertise in selection and evaluation of proper tools for rDNA research	K1, K2, K5, K6
CO2: Understand the various steps involved in construction of chimeric molecules and construction of genomic, metagenomic and cDNA libraries, and whole genome sequencing. Gained expertise in development of projects in engineering of genes	K1, K2, K5, K6
CO3: Learn and apply various techniques like PCR and Next generation sequencing technologies for development of research projects. Acquire knowledge on different types of expression vectors used to express heterologous proteins in bacteria, yeast, insect cells and mammalian cells. Evaluate the use of different expression systems.	K1, K2, K4, K6
CO4: Apply the acquired knowledge of genetic engineering for	K3, K4, K5, K6

development of products of human therapeutic interest. Understand gene therapy and plant Genetic engineering to create novel GE crops.	
CO5: Understand and apply transgenic techniques for research and development. Appreciate the potential for safety associated with rDNA research and evaluate and ensure the preventive measures/guidelines to be undertaken. Become aware of the ethics involved in biotechnology research.	K2, K3, K5, K6

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

Mapping of CO with PO

	PO1	**PO2**	**PPO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PO14**	**PO15**
CO1	H	L	L	L	L	M	L	L	L	M	L	L	L	L	L
CO2	H	L	M	L	L	M	L	H	L	L	M	L	L	L	L
CO3	H	H	M	L	L	M	H	H	L	M	M	H	M	L	M
CO4	H	M	M	H	H	H	H	H	M	L	M	M	M	H	H
CO5	H	M	H	H	M	H	H	M	M	M	M	H	H	H	H

H – High, M – Medium, L - Low

Mapping of CO with PSO

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
CO1	H	M	M	H	H	L

CO2	H	M	M	H	H	L
CO3	H	M	M	H	H	H
CO4	H	M	M	H	H	H
CO5	H	H	M	H	H	H

H - High, M – Medium, L – Low

Semester	**III Semester**		
Course Type	**Core Compulsory Paper - 10**		
Title of the Course			
Course Code	**BIOPROCESS TECHNOLOGY**		
Teaching Hours	**60 Hours/ Semester : 4 Hours/ week**		
	BIOPROCESS TECHNOLOGY	**Credits: 4**	**Max. Marks: 100 (Internal: 25; External 75)**

Course Prerequisites: The student should acquire knowledge on general aspects about fermentation technology, which includes microbes responsible for production of bioactive metabolites in confined system. The produced metabolites will be processed by employing various techniques and the industrial and pharmaceutical applications of the identified metabolites will be studied.

CODE:	**BIOPROCESS TECHNOLOGY**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**
Course Objectives	• To understand the basic concepts of fermentation like types of fermentation and its optimized conditions, types of bioreactors and their parts & functions • To know about microbes responsible for production of metabolites, its isolation, preservation and maintenance. Their growth conditions and				

	media required including different nutrients necessary for their growth • Enable to understand the methods of downstream processing of metabolites. Immobilization techniques involved in preservation of metabolites • To understand the elementary idea on production and preservation of industrially important food products.	
Module 1	**General Account on Fermentation**	**12 hours**
Types of fermentation – surface, submerged solid state, adhesive, batch, continuous and fed batch – principle of chemostat and thermostat, Bioreactors – types, parts and their functions – optimization conditions, aeration, agitation, foam control process control equipment's.		
Module 2	**Isolation, Preservation & Maintenance of Industrially Important Microbes**	**12 hours**
Isolation, preservation and maintenance of industrial important microorganisms-Microbial growth kinetics and microbial death kinetics- media for industrial fermentation: Source of nutrients, types of media: synthetic and crude media for industrial fermentation: Source of nutrients, types of media; synthetic and crude media; Advantage and disadvantages.		
Module 3	**Downstream Processing**	**12 hours**
Introduction, removal of microbial cells and solid matter, foam separation, precipitation, filtration, centrifugation, cell disruption, liquid extraction, chromatography, membrane process. Drying and crystallization, effluent treatment -BOD, COD and disposal of effluents.		
Module 4	**Immobilization Technique**	**12 hours**
Whole cell immobilization and their industrial applications, production of chemicals: alcohol (ethanol); acids (citric, acetic and gluconic acids), solvents (glycerol, acetone and butanol), antibiotics (penicillin, streptomycin and tetracycline); amino acids (lysine and glutamic acid); Single Cell Protein.		
Module 5	**Introduction to Food Technology**	**12 hours**
Elementary idea of canning and packing – sterilization and pasteurization of food products – technology of typical food and food products (bread, cheese & idli) – basic food preservation techniques.		
ReferenceBooks	1. Alba, S., Humphrey, A.E. and Millis N.F., 1985, Biochemical Engineering, Univ. of Tokyo press, Tokyo.	

	2. Anton Moser, 1988, Bioprocess Technology, Springer-Verlag, Austria. 3. Baily, J.E. and Ollis, D.F., 2008, Biochemical Engineering Fundamentals, Mc Graw Hill book Co., New York. 4. Berenjian, A., 2019, Essentials in Fermentation Technology, Springer. 5. Kartan, P., 2017, Advances in Bioprocess Technology, Delve Publications. 6. Pogaku Ravindra , 2015, Advances in Bioprocess Technology, Springer-Verlag. 7. Rao, D.G., 2010, Introduction to Biochemical Engineering, 2nd Edition, Tata McGraw Hill education ltd., New Delhi. 8. Svenska, P., 2000, Bioprocess Technology, Fundamentals and Applications, Royal Institute of Technology, Stockholm.

After the completion of the course, the student will be able to

Course Outcomes	**Cognitive Level**
CO1: Understand about the basic concepts of fermentation technology and its types, bioreactors and their types and conditions responsible for fermentation.	K1, K2
CO2: Know about how to isolate industrially important microbes, their preservation, nutrition and media and their types required for the growth of microbes.	K2, K3
CO3: Find out the suitable downstream processing technique to process the metabolites obtained after fermentation for industrial usage.	K3, K4
CO4: Determine the industrial and pharmaceutical applications of produced products	K5, K6

CO5: Make elementary idea on preservation of produced products in large scale level	K4, K5, K6

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

Mapping of CO with PO

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PO14**	**PO15**
CO1	H	M	L	L	L	M	M	L	L	M	M	M	M	L	L
CO2	H	M	L	L	L	M	M	L	L	M	M	M	M	L	L
CO3	H	M	L	L	L	M	M	L	L	M	M	M	M	L	L
CO4	H	M	L	L	L	M	M	L	L	M	M	M	M	L	L
CO5	H	M	L	L	L	M	M	L	L	M	M	M	M	L	L

H – High, M – Medium, L - Low

Mapping of CO with PSO

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
CO1	M	L	L	H	L	L
CO2	M	L	L	H	L	L
CO3	M	L	L	H	L	L
CO4	M	L	L	H	L	L
CO5	M	L	L	H	L	L

H - High, M – Medium, L – Low

Semester	**III Semester**		
Course Type	**Core Compulsory Paper - 11**		
Title of the Course	**MEDICAL MICROBIOLOGY**		
Course Code			
Teaching Hours	**60 Hours/ Semester : 4 Hours/ week**		
	MEDICAL MICROBIOLOGY	**Credits: 4**	**Max. Marks: 100 (Internal: 25, External 75)**

Course Prerequisites: The students should have a basic knowledge on microbiology

CODE:	**MEDICAL MICROBIOLOGY**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**

Course Objectives	It covers all biology of bacteria, viruses and other pathogens related with infectious diseases in humans. The course will provide the conceptual basis for understanding pathogenic microorganisms and particularly address the fundamental mechanisms of their pathogenicity. It will also provide opportunities for a student to develop diagnostic skills in microbiology, Gain knowledge of morphology, cultural characteristics, epidemiology, laboratory diagnosis of emerging and reemerging infectious diseases and the role of the Biosafety professionals in Biomedical Research Laboratories	
Module 1	**Historical Events and Development in Medical Microbiology**	**12 hours**

Medically important microbes – bacteria, fungi, algae, virus and parasites. Laboratory management – safety in containment laboratory, collection and transport of clinical samples, microbiological examination of urine, blood, faeces, cerebrospinal fluid, throat swabs, sputum, pus and wound exudates, normal flora of human systems – skin, respiratory tract, gastrointestinal tract and genitourinary tract, nosocomial infections, common types of hospital infections and their diagnosis and control.

Module 2	**Pathogenic Bacteria**	**12 hours**
Establishment, spreading, tissue damage and anti phagocytic factors; mechanism of bacterial adhesion, colonization and invasion of mucus membranes of respiratory, enteric and urogenital tracts. Role of aggressions, depolymerising enzymes, organotrophism, variation and virulence. Classification of pathogenic bacteria: *Staphylococcus*, *Streptococcus*, *Pneumococcus*, *Neisseria*, *Corynebacterium*, *Bacillus*, *Clostridium*, non-sporing anaerobes, organisms belonging to Enterobacteriaceae. Vibrios, Non-fermenting Gram negative Bacilli, *Yersinia*; *Haemophilus*; *Bordetella*, *Brucella*; *Mycobacterium*, *Spirochaetes*, *Actinomycetes*; *Rickettsiae*, *Chlamdiae*. Sexually transmitted diseases – Syphilis.		
Module 3	**Yeast**	**12 hours**
General characteristics, pathogenesis and laboratory diagnosis and control measures of: Yeast– Cryptococcus neoformans. Yeast like fungus – *Candida* spp. Filamentous fungi – *Aspergillus* and *Penicillium*. Dimorphic fungus – *Blastomyces dermatidis*. Morphology and life cycle: Intracellular parasites– *Cryptosporidium* and *Plasmodium*. Intralumen parasites–*Entameoba histolytica* and *Ascaris lumbricoides*. Parasitic zoonosis– *Toxoplasma* and *Taenia*.		
Module 4	**DNA viruses**	**12 hours**
Morphology, pathogenesis and laboratory diagnosis and control measures of: DNA viruses – Hepatitis B virus. RNA viruses – Flavi virus (dengue), Retrovirus – HIV, viral zoonosis –rabies, classification of antibiotics based on mode of action: antibacterial (penicillin), antiviral (amantidine), antifungal (amphotericin) antiparasitic drugs (quinine and metraindazole). Emerging and re-emerging infections (Chickungunya, Zika virus, H1N1 and Ebola). National programmes in prevention of infectious diseases		
Module 5	**Control of Diseases**	**12 hours**
Laboratory control of antimicrobial therapy; various methods of drug susceptibility testing, antibiotic assay in body fluids. Brief account on available vaccines and schedules; Passive prophylactic measures; medically important parasites – disease diagnosis, control & prevention, protozoan disease, nematode diseases.		
ReferenceBooks	1. Anathanarayan, R., and Jeyaram Panikers, C.K., 2013, Text Book of Microbiology, 9th Edition, Jain Book Depot, New Delhi. 2. Arora, D.R., Brij Bala Arora, 2015, Textbook of Microbiology, CBS, Chennai. 3. Awetz Melnick and Adelberg's Medical Microbiology, 21st Century, 2010.	

	Appleton & Lange. 4. Bhattacharjee, R.N., 2015, Introduction to Microbiology, 1st Edition, Kalyani Publishers, New Delhi. 5. Connie R Mahon, 2010, Textbook of Diagnostic Microbiology, 3rd Edition, Pearson Publishers. 6. David Greenwood, Richard Slack, John Peutherer, 2012, Medical Microbiology, Churchill Livingstone. 7. Myra Wilkinson, 2011, Medical Microbiology, Scion Publishing Ltd. 8. Patrick Murray, Ken Rosenthal and Michael Pfalle, 2015, Medical Microbiology, 8th Edition, Academic Press, New York. 9. Patrick R. Murray, 2015, Medical Microbiology, Elsevier.

After the completion of the course, the student will be able to

Course Outcomes	**Cognitive Level**
CO1: Gain information about the concepts of medical microbiology and gain knowledge on medically important micro-organisms Understanding, knowledge, practical and communication skill on collection of different clinical samples, their transport, culture and examination by microscopy, staining and biochemical methods for the diagnosis of bacterial, fungal and protozoan diseases.	K1, K2, K5, K6
CO2: Gain knowledge of morphology, cultural characteristics, biochemical tests, epidemiology, laboratory diagnosis etc of bacterial pathogens	K2, K7
CO3: Knowledge about the life cycle, pathogenesis, diagnosis and treatment of yeast, fungal and protozoan diseases	K1
CO4: Understanding and knowledge on RNA,DNA viral disease, Mode of action of antibiotics Emerging reemerging infections;	K1

vaccine production and treatment	
CO5: Gain knowledge on various chemotherapeutic agents and their mode of action including alternatives of antibiotics and Alternative and Complimentary medicine	K1

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

Mapping of CO with PO

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PO14**	**PO15**
CO1	H	M	H	M	M	H	M	H	M	H	M	M	H	H	M
CO2	H	H	H	M	H	M	M	H	H	H	M	L	L	H	M
CO3	H	H	M	M	H	M	M	M	M	H	M	M	M	H	M
CO4	H	M	H	M	H	L	M	M	M	H	M	M	L	H	M
CO5	H	M	H	M	H	H	M	M	M	H	M	M	M	L	M

H – High, M – Medium, L - Low

Mapping of CO with PSO

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
CO1	H	H	H	M	H	M
CO2	H	M	M	H	M	M
CO3	H	M	L	M	M	L

CO4	H	H	M	M	H	L
CO5	H	M	M	M	H	M

H - High, M – Medium, L – Low

Semester	**III Semester**				
Course Type	**Core Compulsory Paper - 12**				
Title of the Course	**BIOREMEDIATION**				
Course Code					
Teaching Hours	**60 Hours/ Semester : 4 Hours/ week**				
	BIOREMEDIATION	**Credits: 4**	**Max. Marks: 100 (Internal: 25, External 75)**		
Course Prerequisites: The students should have a basic knowledge on pollution, their causative agents					
CODE:	**BIOREMEDIATION**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**
Course Objectives	• To get an idea about the bioremediation, their types • Acquire knowledge on treatment of industrial waste water, the role of bacteria on waste water treatment and sludge process • To get a knowledge on bioremediation of microbes on heavy metals				
Module 1	**Bioremediation**				**12 hours**
In situ bioremediation, intrinsic bioremediation, engineered *in situ* remediation and *ex situ* bioremediation, solid phase and slurry phase systems and factors affecting slurry phase system.					
Module 2	**Industrial Waste Water Sources and Treatment Strategies**				**12 hours**
Introduction and targets, wastewater flow fractions from industrial plant, waste water from sanitary					

and employee facilities, wastewater from in-plant water preparation, kinds and impacts of wastewater components, hazardous substances, corrosion inducing substances, typical treatment sequence in a wastewater treatment, plant and wastewater composition and treatment strategies in the food processing industry.		
Module 3	**Bacterial Metabolism in Waste Water Treatment Systems**	**12 hours**
Decomposition of organic carbon compounds in natural and man-made ecosystems, basic biology, mass and energy balance of aerobic biopolymer degradation, mass and energy balance for aerobic and anaerobic glucose respiration and sewage sludge stabilization. General considerations for the choice of aerobic and anaerobic wastewater treatment systems, anaerobic degradation of carbohydrates in wastewater, protein, neutral fats and lipids.		
Module 4	**Activated Sludge Process**	**12 hours**
Historical development, single and two stage processes, single sludge carbon, nitrogen and phosphorus removal, waste water characteristics, removal of organic carbon, nitrification, denitrification, phosphorus removal, environmental factors, carbon and nitrogen removal process and post denitrification with external organic carbon.		
Module 5	**Bioremediation of Heavy Metals**	**12 hours**
Xenobiotics, microbial degradation of xenobiotics, microbial leaching – microorganisms used in leaching, chemistry of leaching, direct, indirect leaching, leaching process, examples of bioleaching, genetically modified microorganisms (GMO) in bioremediation and environmental concern.		
ReferenceBooks	1. Agarwal, S.K., 2009, Environmental Microbiology, APH Publishing Corporation, New Delhi. 2. Arvind Kumar, 2004, Environmental Biotechnology. 3. Chatterji, A.K., 2011, Introduction to Environmental biotechnology, PHI Learning Private Limited, New Delhi. 4. Dubey, R.C., 2001, A text book of Biotechnology. 5. Garg, K.L., and Mukherji, K.G., 1993, Recent Advances in Bioremediation and biodegradation, Vol. I & II. 6. Jordening, H.J., and Winter, J., 2005, Environmental Biotechnology. 7. Maier, R.M., Pepper, I.L., and Gerba, C.P., 2000, Environmental Microbiology, Academic Press. 8. Pelczer, M.J., and Chan, E.C.S. 1993, Microbiology, McGraw Hill Education Private Limited, New Delhi.	

After the completion of the course, the student will be able to

Course Outcomes	**Cognitive Level**
CO1: Different types of bioremediation	K1, K2
CO2: Industrial waste water from different sources and their treatment	K1, K2, K3
CO3: Basic biology of aerobic and anaerobic water treatment	K2, K3, K4
CO4: Factors affecting sludge, their treatment	K2, K3, K4
CO5: Role of microorganisms on bioremediation of heavy metals, their treatment	K2, K3, K4, K5

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

Mapping of CO with PO

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PO14**	**PO15**
CO1	H	M	L	L	L	M	M	L	M	M	M	M	M	M	L
CO2	H	M	M	L	L	M	M	L	M	M	H	H	M	M	L
CO3	H	M	M	L	M	M	M	L	M	M	M	M	M	M	M
CO4	H	M	L	L	M	M	M	L	M	M	M	H	M	M	M
CO5	H	M	H	L	H	M	M	M	M	M	H	H	M	M	H

H – High, M – Medium, L - Low

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	M	L	H	L	M	L
CO2	M	L	H	L	M	L
CO3	M	L	H	L	M	L
CO4	M	L	H	L	M	L
CO5	M	L	H	L	M	L

H - High, M – Medium, L – Low

Semester	**III Semester**				
Course Type	**Core Compulsory Course Practical - 5**				
Title of the Course	**RECOMBINANT DNA TECHNOLOGY AND BIOPROCESS TECHNOLOGY**				
Course Code					
Teaching Hours	**60 hours/semester: 4 hours/week**				
	RECOMBINANT DNA TECHNOLOGY AND BIOPROCESS TECHNOLOGY	**Credits: 2**	**Max. Marks: 100 (Internal: 50; External: 50)**		
Course Prerequisites: The students should know the basics of microbes which are having industrial and pharmaceutical importance and also to produce different metabolites (products) through Fermentation technology					
CODE:	**RECOMBINANT DNA TECHNOLOGY AND BIOPROCESS TECHNOLOGY**	**L**	**T**	**P**	**C**
		-	**-**	**4**	**2**
Course Objectives	• To isolate industrially important microbes from different sources. • To determine and optimize the culture conditions for microbial growth. • To utilize the substrates for production of ethanol, citric acid and other commercially important products by the identified microbes				

	• To know the methodology for production of enzymes and antibiotics with the help of microbes • To learn the immobilization technique for long term storage of microbial enzymes.

1. Safety, Reagent preparation and SOP in rDNA lab
2. Plasmid isolation and Restriction analysis
3. Analysis of recombinants- blue & white colony screening
4. PCR analysis of 16s gene
5. Analysis of protein by SDS-PAGE.
6. Demonstration – blotting techniques
7. Isolation of industrially important microorganisms for microbial processes.
8. Determination of thermal death point (TDP) and thermal death time (TDT) of microorganisms for design of a sterilizer.
9. Comparative studies on ethanol production using different substrates.
10. Microbial production of citric acid using different substrates.
11. Microbial production of antibiotics (Penicillin).
12. Production and estimation of alkaline protease.
13. Use of alginate for cell immobilization.

After the completion of the course, the student will be able to

Course Outcomes	**Cognitive Level**
CO1: Understand the techniques of rDNA technology	K2, K3
CO2: Isolate the industrially important microbes from different sources. Determine the culture conditions for microbial growth, especially to know the thermal death point and thermal death time of microbes	K2, K3, K4
CO3: Produce ethanol and citric acid by the identified microbes	K3, K4,K5

by utilizing different substrates	
CO4: Acquire knowledge on microbial production of antibiotics especially Penicillin and enzyme like alkaline protease.	K2, K3, K4, K5
CO5: Apply the immobilization technique for long term storage of microbial enzymes	K2, K3, K4, K5

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

Mapping of CO with PO

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PO14**	**PO15**
CO1	H	M	L	L	H	M	M	L	L	M	M	M	L	L	L
CO2	H	M	L	L	H	M	M	L	L	M	M	M	M	H	L
CO3	H	M	L	L	H	M	M	L	L	M	M	M	M	M	L
CO4	H	M	L	L	H	M	M	L	L	M	M	M	M	L	L
CO5	H	M	L	L	H	M	M	L	L	M	M	M	M	L	L

H – High, M – Medium, L - Low

Mapping of CO with PSO

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
CO1	H	L	L	M	H	L
CO2	H	L	L	M	H	L

CO3	H	L	L	M	H	L
CO4	H	L	L	H	M	L
CO5	H	L	L	H	M	L

H - High, M – Medium, L – Low

Semester	**III Semester**		
Course Type	**Core Compulsory Course Practical - 6**		
Title of the Course	**MEDICAL MICROBIOLOGY AND BIOREMEDIATION**		
Course Code			
Teaching Hours	**60 hours/semester: 4 hours/week**		
	MEDICAL MICROBIOLOGY AND BIOREMEDIATION	**Credits: 2**	**Max. Marks: 100 (Internal: 50; External: 50)**

Course Prerequisites: The students should have a basic practical skill on microbiology and chemistry

CODE:	**MEDICAL MICROBIOLOGY AND BIOREMEDIATION**	**L**	**T**	**P**	**C**
		-	**-**	**4**	**2**

Course Objectives	• To identify microorganisms of relevance to healthcare and the pharmaceutical industry and their sources • To evaluate microbial content testing and sterility testing • To determine the microbial count and Do, COD, BOD in waste water • To determine the role of microorganisms in the degradation of plastics

1. Isolation and identification of normal flora of skin.
2. Isolation and identification of *Streptococci* from teeth.
3. Serological test (WIDAL).
4. Antimicrobial sensitivity test by Kirby – Baur method.
5. Diagnostic Bacteriology: Laboratory diagnosis (isolation & identification) i) Pyogenic infections – *Streptococci* – α, β and γ haemolysis. *Staphylococci* – differentiation – coagulase

test. ii) UTI infection – *E.coli, Proteus, Pseudomonas*

6. Dilution sensitivity test – MIC
7. Isolation of *E. coli* from sewage water samples with the help of EMB agar
8. To determine the Total Dissolved Solids (TDS), Total Suspended Solids (TSS) in given water sample.
9. Quantitative estimation of nitrate in given water sample.
10. To determine the amount of Dissolved Oxygen (DO) present in given water sample.
11. To determine the Biological Oxygen Demand (BOD) of given waste water sample
12. Estimation of pollution load of a natural sample (e.g. river water /industrial waste water)
13. Low density plastic/bioplastic degradation using bacterial isolates

After the completion of the course, the student will be able to

Course Outcomes	**Cognitive Level**
CO1: Technique and skill to isolate pathogenic bacteria in human disease with respect to infections of the respiratory tract, gastrointestinal tract, urinary tract, skin and soft tissue	K1, K2, K3
CO2: Knowledge and skill on serological diagnosis of samples, Recognize the biochemical basis for antibiotic resistance and ways of controlling spread of antibiotic resistance.	K1, K2, K3
CO3: Demonstrate practical skills in fundamental microbiological techniques, opportunities to develop informatics and diagnostic skills, including the use and interpretation of laboratory tests in the diagnosis of infectious diseases	K1, K2, K3, K4, K5
CO4: Understand and get the skill for the determination of TDS, TSS, DO, BOD, COD and *E.coli* in waste water	K3, K4, K5
CO5: Understand the mechanism behind the degradation of	K2, K3, K4

plastics by microorganism	

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

Mapping of CO with PO

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PO14**	**PO15**
CO1	H	M	H	H	H	M	M	M	H	M	H	M	M	L	M
CO2	H	M	H	H	H	M	M	M	H	M	H	M	M	L	M
CO3	H	M	H	H	H	M	M	M	H	M	H	M	M	L	M
CO4	H	M	M	M	H	M	M	M	H	M	H	M	M	L	M
CO5	H	M	M	M	H	M	M	M	H	M	H	M	M	L	M

H – High, M – Medium, L - Low

Mapping of CO with PSO

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
CO1	H	H	H	L	L	L
CO2	H	H	H	L	L	L
CO3	H	H	H	L	L	L
CO4	H	M	H	L	M	L
CO5	H	M	H	L	H	L

H - High, M – Medium, L – Low

Semester	**III Semester**				
Course Type	**Core Elective Paper – 3A**				
Title of the Course	**BIOSAFEY, BIOETHICS & IPR**				
Course Code					
Teaching Hours	**45 Hours/ Semester : 3 Hours/ week**				
	BIOSAFEY, BIOETHICS & IPR	**Credits: 3**	**Max. Marks: 100 (Internal: 25, External 75)**		
Course Prerequisites: Students should have a knowledge on biological regulations					
CODE:	**BIOSAFEY, BIOETHICS & IPR**	**L**	**T**	**P**	**C**
		3	**-**	**-**	**3**
Course Objectives					
Module 1	**Introduction to Bio-safety and Regulations**			**9 hours**	
Bio-safety regulations and definitions, national and international guidelines, rDNA guidelines. Experimental protocol approvals, levels of containment, environmental aspects of biotech applications, degradation of pollutants, Bacterial mining- vaccines- Biological pesticides, use of genetically modified organisms and their release in environment.					
Module 2	**Bioethics**			**9 hours**	
Bioethics: Definition- ethics- norms in India- Licensing of animal house- norms for conducting studies on human and animal subjects- Ethical clearance, ELSI. Bioethics for cosmetics and nano materials development-environmental safety and impact of toxicity- social and ethical issues of nanoparticles- toxicity related to animal models					
Module 3	**IPR – Introduction & Registration**			**9 hours**	
Introduction to IPRs, Basic concepts and need for Intellectual Property - Patents, Copyrights, Geographical Indications, IPR in India and Abroad – Genesis and Development – the way from					

WTO to WIPO –TRIPS, Nature of Intellectual Property, Industrial Property, technological Research, Inventions and Innovations – Important examples of IPR. Meaning and practical aspects of registration of Copy Rights, Trademarks, Patents, Geographical Indications, Trade Secrets and Industrial Design registration in India and Abroad.		
Module 4	**IPR – Agreements, Legislations, Digital Products and Law**	**9 hours**
International Treaties and Conventions on IPRs, TRIPS Agreement, PCT Agreement, Patent Act of India, Patent Amendment Act, Design Act, Trademark Act, Geographical Indication Act. Digital Innovations and Developments as Knowledge Assets – IP Laws, Cyber Law and Digital Content Protection – Unfair Competition – Meaning and Relationship between Unfair Competition and IP Laws – Case Studies. Infringement of IPRs, Enforcement Measures, Emerging issues – Case Studies.		
Module 5	**Enforcement of IPRs and Patents**	**9 hours**
Infringement of IPRs, Enforcement Measures, Emerging issues – Case Studies. Definition of patents- conditions for patent ability: Novelty testing- composition of patent - patenting of biotechnological discoveries - commercialization- Biotech companies - Natures implications- screening and selection of genetic materials for patenting- Public attitude - Genetic counselling.		
ReferenceBooks	1. Cartagena Protocol on Biosafety, 2006, Ministry of Environment and Forest, Government of India, New Delhi 2. Gopalakrishnan, N.S., and Agitha, T.G., 2014, Principles of Intellectual Property, 2nd Edition, Eastern Book Company, Lucknow. 3. Kshitij Kumar Singh, Springer, 2015, Biotechnology and Intellectual Property Mittal, D.P., 1999, Rights: Legal and Social Implications, Indian Patents Law, as amended by Patents (Amendment) Act 1999, Taxman Publication. 4. Laboratory Biosafety Manual, 2004, 3rd Edition, World Health Organization, Geneva. 5. Narayanan, P., 2021, Intellectual Property Law, 3rd Edition, Eastern Law Book House Ltd. 6. Sasson, A., 1988, Biotechnologies and Development, UNESCO Publications. 7. Sasson, A., 1993, Biotechnologies in Developing Countries: Present and Future, UNESCO Publications.	

	8. Singh, K., Intellectual Property Rights on Biotechnology, BCIL, New Delhi. 9. Wadera, B.L., 2010, Law relating to Patents Trade Marks Copyright Designs and Geographical Indications, Delhi University Law Publishing.

After the completion of the course, the student will be able to

Course Outcomes	**Cognitive Level**
CO1: Remember the basic knowledge on biosafety, national and international guidelines and regulations for biosafety. Gain knowledge on organization rDNA guidelines, approval of protocols, Analyze the benefits of degradation of pollutants, bacterial mining, vaccines and biological pesticides. Evaluate the use of environmental aspects of biotech applications, and genetically modified organisms and their release in environment	K1, K2, K3
CO2: Remember the definition of ethics, Gain knowledge on ethical clearance, ELSI (Ethical, Legal and Social Implications, Comprehend the application of ethical principles in India, Analyze the norms of bioethics in India, Acquire knowledge on licensing of animal house and norms for conducting studies on human and animal subjects – regarding ethical clearance	K1, K2, K3
CO3: Understand and remember concepts of IPR, copyrights etc	K1, K2, K3
CO4: Remember the IPRs, Treaties, TRIPS agreement and laws	K1, K2, K3
CO5: Acquire knowledge on obtaining Indian patent and international patents	K1, K2, K3

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

	PO1	PO2	PPO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
CO1	M	H	L	L	L	M	L	L	L	L	L	L	M	L	L
CO2	L	M	L	L	L	1	L	L	L	L	M	L	M	L	L
CO3	M	M	L	L	L	H	M	M	M	L	L	L	M	L	L
CO4	L	L	M	M	M	H	L	M	L	L	L	L	M	L	L
CO5	L	L	L	L	L	L	L	L	L	L	M	M	M	M	M

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	M	L	H	L	M	H
CO2	M	L	M	L	M	H
CO3	H	H	H	L	L	H
CO4	M	M	L	M	M	H
CO5	L	L	M	L	L	H

H - High, M – Medium, L – Low

Semester	**III Semester**
Course Type	**Core Elective Paper – 3B**

Title of the Course	**BIOINFORMATICS**				
Course Code					
Teaching Hours	**45 Hours/ Semester : 3 Hours/ week**				
	BIOINFORMATICS	**Credits: 4**	**Max. Marks: 100 (Internal: 25, External 75)**		
Course Prerequisites: The students should have a basic knowledge on computer and bioinformatics					
CODE:	**BIOINFORMATICS**	**L**	**T**	**P**	**C**
		3	**-**	**-**	**3**
Course Objectives	• To know about the bioinformatics • To know about the protein, their structure and the structure visualization using the bioinformatics tools • To get an idea about the sequence similarity using various tools • To get a gene prediction and proteomics				
Module 1	**Introduction of Bioinformatics**				**9 hours**
Definition and history of bioinformatics, internet and bioinformatics, information networks, EMBnet-, intranet and internet packages, basics, WWW, HTML, URLs browsers, applications of bioinformatics, DNA sequence databases, protein sequence databases.					
Module 2	**Proteins**				**9 hours**
Principles of protein structure; anatomy of proteins – hierarchical organization of protein structure – primary, secondary, super-secondary, tertiary and quaternary structure, protein sequence motif and domain databases, Ramachandran map, prediction of protein structure, secondary structure prediction methods, prediction of 3D structures, homology modelling, visualization of protein structures using Rasmol, SPDBV Viewer.					
Module 3	**Sequence Similarity**				**9 hours**
Basic concepts of sequence similarity, pair-wise sequence alignments, Needleman & Wuncsh, Smith & Waterman algorithms, Scoring matrices, PAM and BLOSUM Matrices, BLAST and FASTA					

algorithm, multiple sequence alignments (MSA), Importance of MSA, Clustal W and Phylip. Definition and description of phylogenetic trees and various types of trees, methods and programs for phylogenetic tree construction.		
Module 4	**Gene Prediction**	**9 hours**
Prediction of genes, gene prediction in prokaryotes and eukaryotes, promoters, splice sites, regulatory regions, Comparative genomics, functional genomics, DNA microarray, basic concepts on identification of disease genes, OMIM database, Pharmacogenomics, Identification of SNPs, SNPs databases (DbSNP), Metabolic pathways, databases such as KEGG, EMP.		
Module 5	**Proteomics**	**9 hours**
Introduction to proteomics, steps in proteomics research, two-dimensional gel electrophoresis, mass spectrometry, MALDI, ESI, protein identification and characterization strategies, 2D Gel maps, applications of proteomics, proteomics in disease diagnosis, protein arrays – basic principles, drug designing, drug designing approaches, chemoinformatics.		
ReferenceBooks	1. Andrew Leach, and Valerie J. Gillet, 2003, An Introduction to Chemoinformatics, Kluwer Academic Publishers. 2. Arthur, M. Lesk, 2003, Introduction to Bionformatics, Oxford University Press, New Delhi. 3. Attwood, T.K., and Parry-Smith, D.J., 2004, Introduction to Bioinformatics, Pearson Education Ltd., New Delhi. 4. Baxevanis, A., and Quellette, B.F., 1998, Bioinformatics : A practical guide to the Analysis of Genes and proteins, Wiley-Interscience, Hoboken, NJ. 5. Baxevanis, A.D., Davison, D.B., Page, R.D.M., and Petsko, G.A., 2004, Current Protocols in Bioinformatics, John Wiley & Sons Inc., New York. 6. Branden, Carl, Tooze & John, 1991, Introduction to Protein Structure, Garland Publishing. 7. Durbin R., Eddy, S., Krogh, A., and Mitchison, G., 1998, Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids, Cambridge University Press. 8. Higgins, D., and Taylor, W., 2000, Bioinformatics – Sequences, Structure and Databanks, Oxford University Press, New Delhi.	

	9. Mount and David, 2004, Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbour Laboratory Press, New York. 10. Swindell, S.R., Miller, R.R., and Myers, G.S.A., 1996, Internet for the Molecular Biologist, Horizon Scientific Press, Wymondham, UK.

After the completion of the course, the student will be able to

Course Outcomes	**Cognitive Level**
CO1: Basci bioinformatics and the tools involved	K1, K2, K3
CO2: Structure of protein and their different structural predictions	K2, K3, K4
CO3: Understand the different methods in sequence similarity	K2, K3, K4
CO4: Understand the knowledge on gene prediction in prokaryotes and eukaryotes, basic concepts of disease genes	K2, K3, K4, K5
CO5: Acquire knowledge on proteomics & chemo-informatics, the techniques involved in protein identification and characterization.	K2, K3, K4, K5

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PO14**	**PO15**
CO1	H	M	M	H	M	M	M	M	L	H	H	M	M	L	M
CO2	H	M	H	H	M	M	M	M	L	H	H	M	M	L	M

CO3	H	M	H	H	M	M	M	M	L	H	H	M	M	L	M
CO4	H	M	H	H	M	M	M	M	L	H	H	M	M	L	M
CO5	H	M	H	H	M	M	M	M	L	H	H	M	M	L	M

H – High, L – Low, M - Medium

Mapping of CO with PSO

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
CO1	H	L	L	L	H	L
CO2	H	L	L	L	H	L
CO3	H	L	L	L	H	L
CO4	H	L	L	L	H	L
CO5	H	L	L	L	H	L

H - High, M – Medium, L – Low