दिल्ली विश्वविद्यालय
UNIVERSITY OF DELHI

Bachelor of Science (Hons) Microbiology

(Effective from Academic Year 2019-20)

Revised Syllabus as approved by

Academic Council

Date: No:

Executive Council

Date: No:

Applicable for students registered with Regular Colleges

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Preamble

The objective of any programme at Higher Education Institute is to prepare their students for the society at large. The University of Delhi envisions all its programmes in the best interest of their students and in this endeavour it offers a new vision to all its Under-Graduate courses. It imbibes a Learning Outcome-based Curriculum Framework (LOCF) for all its Under Graduate programmes.
The LOCF approach is envisioned to provide a focused, outcome-based syllabus at the undergraduate level with an agenda to structure the teaching-learning experiences in a more student-centric manner. The LOCF approach has been adopted to strengthen students' experiences as they engage themselves in the programme of their choice. The Under-Graduate Programmes will prepare the students for both, academia and employability.

Each programme vividly elaborates its nature and promises the outcomes that are to be accomplished by studying the courses. The programmes also state the attributes that it offers to inculcate at the graduation level. The graduate attributes encompass values related to well-being, emotional stability, critical thinking, social justice and also skills for employability. In short, each programme prepares students for sustainability and life-long learning.

1. Introduction to Programme

The Choice-based credit system (CBCS) offers flexibility of programme structure while ensuring that the student gets a strong foundation in the subject and gains in-depth knowledge of all aspects of the field. The Learning outcomes-based curriculum framework is designed around the CBCS and is intended to suit the present day needs of the student in terms of securing their path towards higher studies or employment.

2. Learning Outcome – based Curriculum Framework in Programme B.Sc. (Hons) Microbiology

The Learning Outcomes-based Curriculum Framework (LOCF) for the B.Sc. (Honours) degree in Microbiology is designed to afford a skeletal structure within which the programme can be developed to suit the need of the hour, in keeping with the emergence of new areas of microbiology. The framework is architected to allow for flexibility in programme design and course content development, while at the same time maintaining a basic uniformity in structure in comparison with other universities across the country.

2.1. Nature and extent of the programme in B.Sc. (Hons) Microbiology

Program Duration:
The B.Sc. (Honours) Microbiology programme will be of three years duration. Each year will be called an academic year and will be divided into two semesters. Thus there will be a total of six semesters. Each semester will consists of sixteen weeks.

Design of Program:
The teaching-learning will involve theory classes (Lectures) of one hour duration and practical classes. The curriculum will be delivered through various methods including chalk and talk, power-point presentations, audio, video tools, E-learning/E-content, virtual labs, simulations, field trips/Industry visits, seminars (talks by experts), workshops, projects, models and class discussions. The assessment broadly will comprise of Internal Assessment (Continous Evaluation) and End Semester Examination. Each theory paper will be of 100 marks with 25% marks for Internal Assessment and 75% for End Semester examination. The internal Assessment will be through MCQ, test, assignment, oral presentation, worksheets and short project. Each practical paper will be of 50 marks.

2.2. Aims of Bachelor Degree Programme in B.Sc. (Hons) Microbiology

The B.Sc. (Honours) Microbiology programme covers a wide range of basic and applied microbiology courses as well as courses of interdisciplinary nature. The core courses that are a part of the programme are designed to build a strong microbiology knowledge base in the student, and furthermore, acquaints the students with the applied aspects of this fascinating discipline as well. The student is thus equipped to pursue higher studies in an institution of her/his choice, and to apply the skills learnt in the programme to solving practical societal problems. The programme offers a wide range of elective courses to the student. These include skill enhancement courses that prepare the student for an eventual job in academia or industry.

3. Graduate Attributes in B.Sc. (Hons) Microbiology

Some of the characteristic attributes of an Honors graduate in Microbiology include:

- **Knowledge acquisition:** gathers in-depth knowledge of basic and applied areas of microbiology.
- **Core microbiology laboratory skills**: understands various methods of safe handling, culturing and storage of microorganisms in the laboratory.
- **Interdisciplinary approach:** becomes aware of the role of microbiology in interdisciplinary research as well as in daily life.
- **Environmental literacy**: develops a basic understanding of the microbiological principles that that have environmental implications, and gains an awareness of regulatory requirements and their compliance in biotechnology and microbiological research.
- **Scientific logic**: develops scientific logic and approaches a problem with critical reasoning.
- **Independence in thought**: cultivates independent thinking and is able to integrate knowledge from other disciplines and fit that knowledge into the context of microbiology.
- **Team work:** understands the importance and strengths of interacting with and working alongside people from diverse backgrounds.
- **Global perspective**: becomes acquainted with standard international practices and emerging technologies used to study microbes.
- **Communication skills**: develops effective communication skills through oral presentations of ongoing developments in the field and the compiling of information in the form of reports.
- **Ethics**: acquires an awareness of work ethics and ethical issues in scientific research as well as plagiarism policies.
- **Self-motivation:** develops self-discipline, planning and organization skills, and time management skills.

4. Qualification descriptors for Graduates of B.Sc. (Hons) Microbiology

The qualification descriptors for graduates of B.Sc. (Honours) programme in Microbiology include:

- Demonstration of a clear and exhaustive understanding of the basic concepts of Microbiology, and an awareness of the emerging areas of the field.
- Acquisition of in-depth comprehension of the applied aspects of microbiology in day-to-day life.
- Enhancement of ability to read, assimilate and discuss scholarly articles and research papers showcasing microbiology as well as interdisciplinary areas of life sciences.
- Sharpening of critical thinking skills facilitating the application of knowledge gained in the field of microbiology in the classroom to the practical solving of societal problems.
- Development of intellectual capabilities promoting the ability to formulate and test a hypothesis.

- Acquisition of practical laboratory skills, enabling the accurate design of an experiment and systematic collection of experimental data.
- Exhibition of ability to interprete and quantitatively analyze experimental data and maintain records of the same.
- Development of strong oral and written communication skills promoting the ability to present studies in the field of microbiology using the concepts and knowledge acquired.
- Demonstration of the ability to work effectively and productively, independently or as part of a team.

5. Program Learning Outcomes for B.Sc. (Hons) Microbiology

- Students of the B.Sc. (Honours) Microbiology programme will learn to use scientific logic as they explore a wide range of contemporary subjects spanning various aspects of basic microbiology such as Bacteriology, Virology, Biochemistry, Microbial Physiology, Immunology, Cell Biology, Molecular Biology, Genetics, Systems Biology, Immunology and Molecular biology, in addition to becoming aware of the applied aspects of microbiology such as Industrial Microbiology, Food and Dairy Microbiology, Environmental Microbiology and Medical Microbiology to name just a few.
- Students will appreciate the biological diversity of microbial forms and be able to describe/explain the processes used by microorganisms for their replication, survival, and interaction with their environment, hosts, and host populations. They will become aware of the important role microorganisms play in maintenance of a clean and healthy environment. They will learn of the role of microorganisms in plant, animal and human health and disease.
- Students will gain knowledge of various biotechnological applications of microorganisms and will learn of industrially important substances produced by microorganisms. They will gain familiarity with the unique role of microbes in genetic modification technologies.
- Students will become familiar with scientific methodology**,** hypothesis generation and testing, design and execution of experiments. Sttudents will develop the ability to think critically and to read and analyze scientific literature.
- Students will acquire and demonstrate proficiency in good laboratory practices in a microbiological laboratory and be able to explain the theoretical basis and practical skills of the tools/technologies commonly used to study this field.
- Students will develop proficiency in the quantitative skills necessary to analyze biological problems (e.g., arithmetic, algebra, and statistical methods as applied to biology)
- Students will develop strong oral and written communication skills through the effective presentation of experimental results as well as through seminars.
- Graduates of the B.Sc. (Honours) Microbiology programme will be informed citizens who can understand and evaluate the impact of new research discoveries in the life sciences, and will be able to pursue a wide range of careers, including biological and medical research in higher education institutions as well as careers in public and global health, scientific writing, environmental organizations, and food, pharmaceuticals and biotechnology industries.

6. Structure of Programme

6.1. Credit Distribution for B.Sc. (Hons) Microbiology

The programme will consist of six-credit courses, four-credit courses and two credit courses. All six-credit courses will comprise of theory classes (four credits) and practicals (two credits). Four credit courses will comprise of theory classes (two credits) and practicals (two credits). Two credit courses will comprise of theory classes only (two credits). For theory classes one credit indicates a one hour lecture per week while for practicals one credit indicates a two-hour session per week. Each practical batch will be of fifteen students. A number exceeding fifteen (by at least ten) will be divided into two equal batches.

The programme includes Core Courses (CC) and elective courses. The core courses are all compulsory courses. There are three kinds of elective courses: Discipline-Specific Elective (DSE), Generic Elective (GE) and Skill Enhancement Course (SEC). In addition there are two compulsory Ability Enhancement Courses (AEC).

To acquire a degree in Microbiology a student must study fourteen Core Courses, four Discipline-Specific Electives, four Generic Electives, two Skill Enhancement Courses and two compulsory Ability Enhancement Courses. The Core Courses, Discipline-Specific Electives and Generic Electives are six-credit courses. The Skill Enhancement Courses are four-credit courses while the Ability Enhancement Courses are two credit-courses. A student has to earn a minimum of 144 credits to get a degree in B.Sc. (H) Microbiology.

There will be fourteen Core Courses which are to be compulsorily studied to complete the requirements for an Honours degree in B.Sc. Microbiology. The students will study two Core Courses each in Semesters I and II, three Core Courses each in Semesters III and IV, and two Core Courses each in Semesters V and VI. The Core Courses will be of six credits each (four credits theory and two credits practicals).

The programme offers nine Discipline-Specific Electives (DSEs), of which the student must choose any two in each of the Semesters V and VI. The DSEs will be of six credits each (four credits theory and two credits practicals). A particular option of DSE course will be offered in Semesters V and VI semesters only if the minimum number of students opting for that course is 10. The DSE course that is project work will also carry six credits. The number of students who will be allowed to opt for project work will vary from college to college depending upon the infrastructural facilities and may vary each year. The college shall announce the number of seats for project work well in advance and may select the students for the same based on merit. Project work will involve experimental work and the student will have to do this in the time after their regular theory and practical classes. The final evaluation of the project work will be through a committee involving internal and external examiners. In this regard guidelines provided by University of Delhi for executing and evaluation of project work will be final. Students will be asked their choice for Project work at the end of IV semester and all formalities of topic and mentor selection will be completed by this time.

Different Generic Elective (GE) courses will be offered to the students of the B.Sc. (H) Microbiology programme by other departments of the college and the student will have the option to choose one GE course each in Semesters I, II, III, and IV. The GEs will be of six credits each (four credits theory and two credits practicals). The Department of Microbiology will offer nine GE courses for students of other departments.

The students will undertake two Skill Enhancement (SE) courses of four credits each in Semesters III and IV. which they can choose from the list of SE courses offered by their college. The SE courses will be of four credits each (two credits theory and two credits practicals). The Department of Microbiology is offering eight such courses.

The two compulsory Ability Enhancement Courses (AECs): AE1 (Environmental Sciences) and AE2 (English communication) will be of two credits each (theory only). The student will take one each in Semesters I and II.

COURSES OFFERED UNDER B.SC. (H) MICROBIOLOGY PROGRAMME (CBCS)

Core Courses			
SEMESTER	COURSE CODE	NAME OF THE COURSE	CREDITS
I	MICROB-CC101	Introduction to Microbiology and Microbial Diversity	L=4 P=2
	MICROB-CC102	Bacteriology	L=4 P=2
II	MICROB-CC201	Biochemistry	L=4 P=2
	MICROB-CC202	Cell Biology	L=4 P=2
III	MICROB-CC301	Microbial Physiology and Metabolism	L=4 P=2
	MICROB-CC302	Environmental Microbiology	L=4 P=2
	MICROB-CC303	Molecular Biology	L=4 P=2
IV	MICROB-CC401	Microbial Genetics and Genomics	L=4 P=2
	MICROB-CC402	Virology	L=4 P=2
	MICROB-CC403	Food and Dairy Microbiology	L=4 P=2
V	MICROB-CC501	Industrial Microbiology	L=4 P=2
	MICROB-CC502	Immunology	L=4 P=2
VI	MICROB-CC601	Medical Microbiology	L=4 P=2
	MICROB-CC602	Recombinant DNA Technology	L=4 P=2
Discipline Specific Elective Courses (DSE)			
V	MICROB-DSE501	Bioinformatics	L=4 P=2
	MICROB-DSE502	Instrumentation and Biotechniques	L=4 P=2
	MICROB-DSE503	Principles of Genetics	L=4 P=2
	MICROB-DSE504	Biomathematics and Biostatistics	L=4 P=2
VI	MICROB-DSE601	Microbial Biotechnology	L=4 P=2
	MICROB-DSE602	Advances in Microbiology	L=4 P=2
	MICROB-DSE603	Plant Pathology	L=4 P=2
	MICROB-DSE604	Biosafety and Intellectual Property Rights (IPR)	L=4 P=2
	MICROB-DSE605	Project Work	L=4 P=2
Generic Electives Courses (GE)			
I	MICROB-GE101	Introduction and Scope of Microbiology	L=4 P=2
II	MICROB-GE201	Bacteriology and Virology	L=4 P=2
III	MICROB-GE301	Microbial Metabolism	L=4 P=2
	MICROB-GE302	Microbial Genetics and Molecular Biology	L=4 P=2
	MICROB-GE303	Applications of Microbes in Biotechnology	L=4 P=2
IV	MICROB-GE401	Industrial and Food Microbiology	L=4 P=2
	MICROB-GE402	Microbes in Environment	L=4 P=2
	MICROB-GE403	Medical Microbiology and Immunology	L=4 P=2
	MICROB-GE404	Genetic Engineering and Biotechnology	L=4 P=2
Skill Enhancement Elective Courses (SEC)			
III-IV	MICROB-SE1	Microbial Quality Control in Food and Pharmaceutical Industries	L=2 P=2
	MICROB-SE2	Microbial Diagnosis in Health Clinics	L=2 P=2
	MICROB-SE3	Biofertilizers and Biopesticides	L=2 P=2
	MICROB-SE4	Food Fermentation Techniques	L=2 P=2
	MICROB-SE5	Management of Human Microbial Diseases	L=2 P=2
	MICROB-SE6	Microbiological Analysis of Air and Water	L=2 P=2
	MICROB-SE7	Fundamentals of Bioinformatics	L=2 P=2
	MICROB-SE8	Biostatistics	L=2 P=2

6.2. Semester-wise Distribution of Courses

Semester	CORE COURSE (14)	Ability Enhancement Compulsory Course AECC	Skill Enhancement Course SEC	Discipline Specific Elective DSE	Generic Elective GE
I	Introduction to Microbiology and Microbial Diversity MICROB-CC101	Environmental Science			GE-1
	Bacteriology MICROB-CC102				
II	Biochemistry MICROB-CC201	English communication			GE-2
	Cell Biology MICROB-CC202				
III	Microbial Physiology and Metabolism MICROB-CC301		SEC -1		GE-3
	Environmental Microbiology MICROB-CC302				
	Molecular Biology MICROB-CC303				
IV	Microbial Genetics and Genomics MICROB-CC401		SEC -2		GE-4
	Virology MICROB-CC402				
	Food and Dairy Microbiology MICROB-CC403				
V	Industrial Microbiology MICROB-CC501			DSE-1	
	Immunology MICROB-CC502			DSE-2	
VI	Medical Microbiology MICROB-CC601			DSE -3	,
	Recombinant DNA Technology MICROB-CC602			DSE-4	

7. Teaching Learning Methods

The B.Sc. (Honours) Microbiology programme aims to make the student proficient in microbiology through the transfer of knowledge in the classroom as well as in the laboratory. In the classroom this will be done through blackboard and chalk lectures, charts, powerpoint presentations, and the use of audio-visual resources that are available on the internet such as virtual lab. An interactive mode of teaching will be used. The student will be encouraged to participate in discussions and deliver seminars on some topics. A problem-solving approach will be adopted wherever suitable. In the laboratory the student will first learn good laboartory practices and then get hands-on training on basic microbiological techniques and methods. Emphasis on laboratory work is particularly important keeping in mind the practical nature of the subject, and the time devoted to practicals will enable the student to better understand the applications of the different courses. The student will participate in field trips to industries that will facilitate his/her understanding of the practical aspects of the programme and enable him to gain exposure to future places/areas of employment.

8. Assessment Methods

The student will be assessed over the duration of the programme by many different methods. These include short objectives-type quizzes, assignments, written and oral examinations, group discussions and presentations, problem-solving excercises, case study presentations, experimental design planning, execution of experiments, seminars, preparation of reports, and presentation of

practical records. The wide range of assessment tasks aim to break the monotony of having a single assessment method.

10.Keywords

Microbial Diversity, Microbial Physiology, Industrial microbiology, Environmental Microbiology.

MICROB CC101: INTRODUCTION TO MICROBIAL WORLD AND MICROBIAL DIVERSITY

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:

The main objective of this course is to give students an insight into the world of microorganisms. The paper discusses the historical developments and major milestones leading to the development of microbiology as a separate discipline of science. The students will understand the diversity, structure, evolution and impact of microbes in our day to day life and for the sustenance of life on Earth in general.

Course Learning Outcomes:

Upon successful completion of the course, the students:

CO1: will be acquainted with the historical account and development of microbiology as a scientific discipline.

CO2: will have gained knowledge on different systems of classification. They will also acquire an overview of acellular and cellular microorganisms.

CO3: will have acquired in-depth knowledge of the diversity, distribution, cell structure, life cycles and economic importance of algae.

CO4: will have gathered detailed information on the diversity, distribution, structure, life cycles and economic importance of fungi.

CO5: will be aware of general characteristics of protozoa and their economic importance.

CO6: will have a broad perspective of the scope of microbiology.

Contents:

Unit 1: History of Microbiology: The discovery of microorganisms, controversy of spontaneous generation, golden age of microbiology and developments in the field of medical microbiology, immunology, environmental microbiology with special emphasis on the contributions of Robert Hooke, Antonie von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Edward Jenner, Elie Metchnikoff, Paul Ehrlich, Martinus Beijerinck, Sergei N. Winogradsky, Alexander Fleming, Selman A. Waksman, Ronald Ross, Stanley B. Prusiner and Ananda Mohan Chakraborty. **14**

Unit 2: Systems of Classification: Binomial nomenclature, Whittaker's five kingdom classification and Carl Woese's three kingdom classification systems. Acellular (viruses, viroids and prions) and cellular microorganisms (bacteria, algae, fungi and protozoa). Overview of prokaryotic and eukaryotic microorganisms with respect to differences in their cell structure giving suitable examples. **6**

Unit 3: Microbial diversity (Algae): General characteristics of algae including occurrence, thallus organization. Cell structure: cell wall, vacuoles, eye spot, plastids and pigments, flagella, nucleus, food reserves. Modes of reproduction: vegetative, asexual and sexual modes. Life cycles in algae:

haplontic, diplontic, diplohaplontic, haplobiontic and diplobiontic. Morphology and life cycle of *Chlamydomonas*, *Volvox*, *Spirogyra*. Economic importance of algae. **14**

Unit 4: Microbial diversity (Fungi): General characteristics of fungi distribution, thallus organization and aggregation. Cell wall structure and composition. Modes of reproduction: vegetative, asexual, sexual and parasexual. Morphology and life cycle of *Saccharomyces, Rhizopus and Aspergillus.* Economic importance of fungi. **14**

Unit 5: Microbial diversity (Protozoa): General characteristics of protozoa with special reference to cell structure, reproduction and economic importance. Type studies of *Amoeba*, *Paramecium* and *Giardia*. **6**

Unit 6: An overview on scope and inter-disciplinary aspects of microbiology: brief outline of the role of micro-organisms in human health and medicine, food and dairy industry, agriculture and environment. Emerging aspects of space microbiology. **6**

Practicals:

Marks 50 **Duration: 60 hours (2 credits)**

1. Microbiology good laboratory practices and biosafety.
2. To study the principle, working and applications of important microbiological instruments-biological safety cabinets, autoclave, bacteriological and BOD incubators, hot air oven, compound microscope.
3. Demonstration of aero-microflora by exposing nutrient agar plates.
4. Temporary mount preparation of *Rhizopus*, *Saccharomyces*, *Aspergillus* and *Alternaria* (any two) to study thallus organization and asexual reproductive structures.
5. Temporary mounts of *Chlamydomonas*, *Volvox* and *Spirogyra* (any two) from laboratory specimens.
6. Study of protozoa- *Amoeba*, *Paramecium* and *Giardia* using permanent mounts or photographs.

Suggested Reading:

1. Alexopoulus, C.J., Mims, C.W., Blackwell, C.W. (1996). Introductory Mycology. 4th edition. Wiley and Sons, UK.
2. Atlas, R.M. (1997). Principles of Microbiology. 2nd edition. Brown Publishers, USA.
3. Cappuccino, J. and Welsh, C.T. (2016). Microbiology: A Laboratory Manual. 11th edition. Pearson Education, USA.
4. Lee, R.E. (2008). Phycology. 4th edition. Cambridge University Press, UK.
5. Madigan, M.T. and Martinko, J.M. (2017). Brock Biology of Microorganisms. 15th edition. Prentice Hall International Inc., USA.
6. Pelczar, M.J., Chan, E.C.S. and Krieg, N.R. (1993). Microbiology. 5th edition. McGraw Hill, USA.

7. Stanier, R.Y., Ingrahm, J.I., Wheelis, M.L. and Painter, P.R. (1987). General Microbiology. 5th edition. McMillan Press, UK.

8. Tortora, G.J., Funke, B.R., Case, D., Weber, D. and Bair, W. (2019). Microbiology: An Introduction. 13th edition. Pearson Education, USA.

9. Webster, J. and Weber, R. (2007). Introduction to fungi. 3rd edition. Cambridge University Press, UK.
10. Willey, J. M., Sandman, K. and Wood, D. (2019). Prescott's Microbiology. 11th edition. McGraw Hill Higher Education, USA.
11.

Facilitating the achievement of course learning objectives

Unit no.	**Course learning outcomes**	**Teaching and learning activities**	**Assessment tasks**
1.	Students will be acquainted with the historical account and development of microbiology as a scientific discipline.	Discussion on the discovery of microorganisms, conflict over spontaneous generation, milestones in microbiology with special emphasis on the golden age of microbiology and development of the major fields of applied microbiology.	Quiz, match the following, identification of scientists through photographs related to development of microbiology
2.	Students will have gained knowledge on different systems of classification. They will also acquire an overview of acellular and cellular microorganisms.	Theory classes on different systems of classification. Diagrammatic representation of prokaryotic and eukaryotic cell structure, acellular and cellular microorganisms using visual aids and power point presentations.	Multiple choice questions and student presentations.
3.	Students will have acquired in-depth knowledge of the diversity, distribution, cell structure, life cycles and economic importance of algae.	Theory classes on occurrence, cell structure and reproduction in algae with the help of charts, visual aids, videos, temporary and permanent mounts. Group discussion on the economic importance of algae.	Diagrammatic representations of life cycles and alternation of generation in algae. MCQs on the economic importance of algae.
4.	Students will have gathered detailed information on the diversity, distribution, cell structure, life cycles and economic importance of fungi.	Interactive lectures on distribution, cell structure and reproduction in fungi with the help of charts, visual aids, temporary and permanent mounts. Detailed account on the economic importance of fungi.	Drawing the life cycle of various fungal genera studied. Quiz on economic importance of fungi.
5.	Students will be aware of general characteristics of protozoa and their economic importance.	Detailed discussion on the general characteristics of protozoa and their economic importance.	Class tests focusing on short notes and definitions.
6.	Students will have a broad perspective of the scope of microbiology.	Practical example based teaching on the scope of microbiology and their integration with other fields of science.	Essay writing and poster making on scope of microbiology.

***Assessment tasks listed here are indicative and may vary.**

MICROB-CC102: BACTERIOLOGY

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:
The main objective of this course is to provide in-depth knowledge of bacterial cell structure, its cultivation, growth and reproduction. Further, it gives insight into bacterial diversity and its significance. It will also give hands on training of basic and very important bacteriological techniques which will give the student a strong base in microbiology.

Course learning Outcomes:
Upon successful completion of the course, the student:

CO1: Will gain knowledge about morphology, structure and organisation of different cell components and be able to differentiate between cell walls of Gram positive and Gram-negative bacteria, cell walls and cell membranes of archaea and eubacteria. Will also be able to explain gram and acid-fast staining reactions and effect of antibiotics and enzymes on cell wall structure.

CO2: Will get familiar with various techniques used for isolation, cultivation and preservation of different types of bacterial cultures. Will gain insight into working and importance of compound microscope.

CO3: Will understand nutritional requirements of different types of bacteria and formulation of media for bacterial growth.

CO4: Will be able to briefly explain methods of asexual reproduction in bacteria. Will understand different phases of growth curve and be able to define generation time and growth rate.

CO5: Can define and differentiate various types of classifications. Will gain insight into techniques used in polyphasic bacterial taxonomy.

CO6: Will get acquainted with differences between archaea and eubacteria and can list their important general characteristics along with ecological significance and economic importance.

Contents:

Unit 1: Cell structure and organization: Cell size, shape and arrangement. External cell surface structures: Glycocalyx (capsule and slime layer), S layer, flagella, endoflagella, fimbriae and pili. Cell-wall: Detailed structure and composition of cell wall of eubacterial (Gram-positive and Gram-negative) and archaea. Mechanism of Gram and acid-fast staining, Effect of antibiotics and enzymes on the cell wall and formation of spheroplasts, protoplasts and L-forms. Cell Membrane: Structure, functions and chemical composition of eubacterial and archaeal cell membranes. Cytoplasm: Ribosomes, mesosomes, inclusion bodies (PHB, polyphosphate granules, sulphur globules, cyanophycin, gas vacuoles and magnetosomes), microcompartments (carboxysomes), nucleoid, chromosome and plasmids. Endospore: Structure, formation, stages of sporulation and germination of endospore. **14**

Unit 2: Bacteriological techniques: Pure culture isolation: Streaking, serial dilution and plating methods. Cultivation, maintenance and preservation/stocking of pure cultures. Culture collection centres. Cultivation of anaerobic bacteria and an overview of accessing non-culturable bacteria. Bright Field Microscopy: Principle and functions of compound microscope. Concept of resolving power and magnification. **6**

Unit 3: Bacterial nutrition: Nutritional requirements in bacteria and nutritional categories. Culture media: components of media, natural and synthetic media, chemically defined media, complex media, selective, differential, indicator, enriched and enrichment media. **6**

Unit 4: Reproduction and growth: Asexual methods of reproduction, phases of growth curve in batch culture, generation time and growth rate. **4**

Unit 5: Bacterial systematics: Concepts of systematics, taxonomy, taxa, species, strains, phenetic classification, phylogenetic classification, genotypic classification, polyphasic taxonomy, evolutionary chronometers, rRNA oligonucleotide sequencing and signature sequences. Conventional (classical characteristics, numerical taxonomy), molecular (nucleic acid hybridization, nucleic acid sequencing) and recent approaches (genomic fingerprinting: MLSA, ribotyping) to study polyphasic bacterial taxonomy. **10**

Unit 6: Archaeal and eubacterial diversity: Archaea: General characteristics with reference to genera belonging to Crenarchaeota (*Sulfolobus*) and Euryarchaeota:Methanogens (*Methanobacterium*), thermophiles (*Pyrococcus*), acidophiles (*Picrophilus*) and halophiles (*Halobacterium*). Interesting facts of other groups: Thaumarchaeota, Lokiarchaeota, Nanoarchaeota. **Eubacteria:** Morphology, ecological significance and economic importance of **Gram Negative: Non-proteobacteria**: General characteristics with reference to *Aquifex, Thermotoga, Deinococcus, Mycoplasma, Chlamydia, Chlorobium* and *Spirochaetes,* Cyanobacteria (*Nostoc*, *Spirullina*). **Proteobacteria:** Different classes. **Alphaproteobacteria**: General characteristics with reference to *Rhizobium, Ricketssia.* **Betaproteobacteria**: General characteristics with reference to *Neisseria, Burkholderia.* **Gammaproteobacteria**: General characteristics with reference to *Pseudomonas, Chromatium, Escherichia, Yersinia.* **Deltaproteobacteria**: General characteristics with reference to *Myxococcus* and *Bdellovibrio.* **Epsilonproteobacteria:** General characteristics with reference to *Campylobacter.* **Zetaproteobacteri**a: General characteristics with reference to *Mariprofundus ferrooxydans.* **Gram Positive: Firmicutes (low GC content in DNA)**: General characteristics with reference to *Clostridium, Bacillus, Micrococcus.* **Actinobacteria (high GC content in DNA)**: General characteristics with reference to *Corynebacterium*, *Mycobacterium, Streptomyces.* **20**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Introduction of aseptic techniques: Methods of bacterial control: Mechanical(filtration); Physical (Heat, Radiation); Chemical (Alcohol)

2. Preparation of different media: Synthetic Media (BG11), Complex media (Nutrient Agar, MacConkey agar).

3. Isolation of pure cultures of bacteria by Quadrant streaking method.

4. Enumeration of bacteria by CFU count using spread plate method/pour plate method.

5. To observe size, shape and arrangement of given bacterial sample using simple and negative staining.

6. To differentiate between different types of bacteria using differential staining methods: Gram staining, Capsule staining, Spore staining, Acid fast staining (Permanent slides)

7. Demonstration of motility by hanging drop method.

Suggested Reading:

1. Atlas, R.M. (1997). *Principles of Microbiology*. 2nd edition. Brown Publishers, USA.

2. Black, J.G. and Black, L.J. (2017). *Microbiology: Principles and Explorations*. 10th edition.

3. Cappuccino, J. and Welsh, C.T. (2016). *Microbiology: A Laboratory Manual*. 11th edition. Pearson Education, USA.

4. Madigan, M.T. and Martinko, J.M. (2017). *Brock Biology of Microorganisms.* 15th edition. Prentice Hall International Inc., USA.
5. Pelczar, M.J., Chan, E.C.S. and Krieg, N.R. (1993). *Microbiology.* 5th edition. McGraw Hill, USA.
6. Srivastava, S. and P.S. Srivastava, P.S. (2003). *Understanding Bacteria*. Springer, Netherlands.
7. Stanier, R.Y., Ingrahm, J.I., Wheelis, M.L. and Painter, P.R. (1987). *General Microbiology*. 5th edition. McMillan Press, UK.
8. Tortora, G.J., Funke, B.R., Case, D., Weber, D. and Bair, W. (2019). *Microbiology: An Introduction.* 13th edition. Pearson Education, USA.
9. Willey, J. M., Sandman, K. and Wood, D. (2019). *Prescott's Microbiology.* 11th edition. McGraw Hill Higher Education, USA.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and Learning activity	Assessment Tasks
1.	Will gain knowledge about morphology, structure and organisation of different cell components and be able to differentiate between cell walls of Gram positive and Gram-negative bacteria; cell walls and cell membranes of archaebacteria and eubacteria. Will be able to explain gram and acid -fast staining reactions and effect of enzymes and antibiotics based on cell wall structure.	Video /PowerPoint presentation showing bacterial cells and their components. Explaining differences between Gram +ve and Gram-ve bacteria; eubacterial and archaebacterial structures with the help of diagrams and discuss the role of antibiotic and enzyme on cell wall. Use of graphical representations while teaching.	Quiz on different cell shapes and arrangements with the help of visual aids. Test based on diagrams of various cell components and their differences.
2.	Will get familiar with various techniques used for isolation, cultivation and preservation of different types of bacterial cultures. Will gain insight into working and importance of compound microscope.	Demonstrative lecture showing various techniques used in isolation and cultivation of bacteria and different parts of microscope with emphasis on their principles and applications. Discussion on methods of preservation of bacterial cultures highlighting their advantages and disadvantages.	Evaluation of streaking/ spread plate / pour plate Techniques. Label different parts of microscope and state their functions.
3.	Will understand nutritional requirements of different types of bacteria and formulation of media for bacterial growth.	To study different types of nutritional classes and media with the help of slide presentations.	Match the following based on nutritional classes and media studied.
4.	Will be able to briefly explain methods of asexual reproduction in bacteria. Understand different phases of growth curve and define	Class lecture on methods of asexual reproduction with the help of diagrams. Graphical representation of growth curve and discussion	MCQ /Quiz based on examples of asexual reproduction and growth curve.

	generation time and growth rate	on four phases of growth curve.	
5.	Can define and differentiate various types of classification. Will get insight into techniques used in polyphasic bacterial taxonomy.	Explaining different terms used in taxonomy and to discuss types of classifications and different methods used in taxonomy.	Class test based on definitions of various terms, classification and techniques.
6.	Will get acquainted with differences between archaebacteria and Eubacteria and can list their important general characteristics along with their ecological significance and economic importance.	Enlisting different genera with their unique features and economic importance. Giving insight into differences between archaebacteria and eubacteria with help of tabular chart.	Presentation/project on any one bacterium of their choice highlighting its unique features and ecological and/or economic importance.

*** Assessment tasks are indicative and may vary.**

MICROB-CC201: BIOCHEMISTRY

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:
The major objective of this paper is to help the students develop a clear understanding of the fundamental properties of different biomolecules: carbohydrates, lipids, proteins and nucleic acids and to enable students to understand the principles of thermodynamics, bioenergetics, and their applications to biological systems. The course will provide a foundation for the course on microbial physiology and metabolism and for biotechnology-based courses.

Course Learning Outcomes:
Upon successful completion of the course, the student:

CO1: Will have developed an understanding of the principles of thermodynamics applied to biological systems and will be able to calculate free energy changes accompanying metabolic reactions and comment on their feasibility.

CO2: Will be thoroughly conversant with the structures of carbohydrates and their key properties and be able to detect their presence in samples by performing chemical tests.

CO3: Will be able to explain the properties of storage and membrane lipids. Will be acquainted with different types of lipid aggregates and their applications.

CO4: Will be conversant with the structure and properties of amino acids, formation of polypeptides and protein folding. Will become familiar with the use of spectrophotometer and would have gained practical knowledge of biochemical techniques with proteins.

CO5: Will be familiar with the structures of the building blocks of nucleic acids. Will become conversant with the key conventions used in nucleic acid description.

CO6: Will have learnt the basic concepts of enzyme biochemistry including enzyme kinetics, and will become aware of different variants of enzymes found in living cells.

Contents:

Unit 1: Thermodynamics and Bioenergetics: First and second laws of thermodynamics, enthalpy, entropy, free energy change, standard free energy change, equilibrium constant and spontaneous reactions. Coupled reactions and additive nature of standard free energy change. **6**

Unit 2: Carbohydrates: Monosaccharides: aldoses and ketoses, epimers, mutarotation and anomers of glucose, Haworth projection formulae for pyranose form of glucose, furanose form of fructose, chair and boat forms of glucose, sugar derivatives- glucosamine, galactosamine, muramic acid, N-acetyl neuraminic acid. Disaccharides: concept of reducing and non-reducing sugars, Haworth projections of maltose, lactose, and sucrose. Polysaccharides: storage polysaccharides-starch and glycogen, structural polysaccharides- cellulose, peptidoglycan and chitin. **11**

Unit 3: Lipids: Introduction to storage and structural lipids. Storage lipids: triacylglycerols, building blocks, fatty acids structure and properties, essential fatty acid, saponification. Structural lipids: phosphoglycerides- building blocks, structure of phosphatidylethanolamine and phosphatidylcholine; sphingolipids- building blocks, structure of sphingosine, ceramide, general structure and functions of sphingomyelin, cerebroside and ganglioside. Introduction to lipid micelles, monolayers, bilayers and liposomes. **11**

Unit 4: Proteins: The building blocks-amino acids: classification, biochemical structure and notation of standard protein amino acids, general formula of amino acids. Concept of zwitterion, titration curve of amino acid and its significance. Ninhydrin reaction. Non-protein amino acids: beta-alanine, D-alanine and D- glutamic acid. Oligopeptides: structure and functions of glutathione, aspartame, insulin. Protein structure: primary, secondary- peptide unit salient features, **α** helix, **β** sheet, **β** turn, tertiary and quaternary-human hemoglobin as an example. Forces involved in protein folding. **12**

Unit 5: Nucleic acids: Structures of purines and pyrimidines, nucleosides and nucleotides. Phosphodiester linkage. Double helical structure of DNA. Types of DNA: A, B, Z. Physic-chemical properties of DNA. RNA types-rRNA, mRNA, tRNA. **8**

Unit 6: Enzymes: Introduction to apoenzyme, cofactors, prosthetic group, coenzyme, metal cofactors. Classification of enzymes. Active site and activation energy. Lock and key hypothesis, induced fit hypothesis. Concepts of V_{max} and K_m, enzyme unit, specific activity and turnover number. Significance of hyperbolic and double reciprocal plots. Michaelis-Menten kinetics versus kinetics of allosteric enzymes. Multienzyme complex: pyruvate dehydrogenase. Isozyme: lactate dehydrogenase. Effect of pH and temperature on enzyme activity. Enzyme inhibition: competitive and non-competitive. **12**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Use and calibration of pH meter and preparation of buffers. Preparation of stock and working solutions.

2. Handling of pipettes and micropipettes and checking their accuracy.

3. Qualitative estimation of an enzyme activity (amylase/urease/catalase) Effect of temperature or pH.

4. Qualitative tests for detection of carbohydrates, reducing and non reducing sugars, lipids and proteins.

5. Study of protein secondary and tertiary structures with the help of photographs/models.

6. Quantitative estimation of proteins by Lowry's method.

7. Study of enzyme kinetics : calculation of V_{max}, K_m and K_{cat}

Suggested Reading:

1. Berg, J.M., Tymoczko, J.L., Gatto, G.J., and Stryer, L. (2019). *Biochemistry.* 9th edition. W.H. Freeman and Company, UK.

2. Campbell, M.K., Farrell, S.O. and McDougal, O.M. (2017). *Biochemistry.* 9th edition. Cengage Learning, USA.

3. Nelson, D.L. and Cox, M.M. (2017). *Lehninger Principles of Biochemistry*. 7th edition. W.H. Freeman and Company, UK.

4. Voet, D. and Voet, J.G. (2016). *Biochemistry.* 5th edition. John Wiley and Sons, UK.

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Will have developed an understanding of the principles of thermodynamics applied to biological systems and will be able to calculate free energy changes accompanying metabolic reactions and comment on their feasibility	Classroom lecture on laws of thermodynamics, bioenergetics,numericals on standard free energy changes of coupled reactions	Calculations of free energy change and standard free energy change and determination of equilibrium constant from data provided.
2	Will be thoroughly conversant with the structures of carbohydrates and their key properties and be able to detect their presence in samples by performing chemical tests.	Pictorial presentations of carbohydrates, mono, di-,and polysaccharides, including starch, glycogen, cellulose, and peptidoglycan. Biochemical tests for carbohydrates, reducing and non-reducing sugars, and starch. Use of flow charts for teaching structures and reactions.	Drawing the structures of carbohydrates. Multiple choice questions-type quiz on identification of anomers, epimers, enantiomers of sugars.
3	Will be able to explain the properties of storage and membrane lipids. Will be acquainted with different types of lipid aggregates and their applications.	Lecture on lipids' structure, characteristic features and different types of "formations". Discussion on essential fatty acids and their significance in human nutrition. Chemical tests for fats.	Pictorial quiz on identification of biomolecules forming different types of lipids.
4	Will be conversant with the structure and properties of amino acids, formation of polypeptides and protein folding. Will become familiar with the use of spectrophotometer and would have gained practical knowledge of	Presentation on amino acid structure, their acid base properties and polymerization. Study of primary, secondary, tertiary and quaternary structures of proteins with photographs of different types	Spotting test for identification of amino acids from their biochemical structures. Pictorial quiz for the identification

	biochemical techniques with proteins.	of models. Practical exercises for identification and estimation of protein concentrations by biochemical tests and plotting of standard curve.	of secondary and tertiary structures of proteins from models / photographs. Analysis of results from experimental estimation of proteins.
5	Will be familiar with the structures of the building blocks of nucleic acids. Will become conversant with the key conventions used in nucleic acid description.	Presentations on the structures of nucleic acids and their study with the help of models and photographs.	Multiple choice questions-type quiz on nitrogen bases, nucleosides, nucleotides, DNA and RNA properties.
6	Will have learnt the basic concepts of enzyme biochemistry including enzyme kinetics, and will become aware of different variants of enzymes found in living cells.	Lecture on enzyme structure, classification. Interactive session on mechanism of enzyme action. Study of enzyme kinetics from data by plotting Lineweaver-Burk plot.	Mathematical problems and calculations of enzyme kinetic constants by plotting the data provided.

***Assessment tasks listed here are indicative, and may vary.**

MICROB-CC202: CELL BIOLOGY

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:

The major objective of this course is to educate students about the fundamental concepts in eukaryotic cell biology. The students will be taught the latest developments in cell communication, regulation of cell cycle, and modern tools used to study cell biology. Advances in cancer biology including etiology, diagnosis and therapeutics, as well as the basics of stem cell technology and its applications will be covered.

Course Learning Outcomes:

Upon successful completion of the course, the student:

CO1: Will have gained knowledge about features of the cell wall, plasma membrane, cell transport mechanisms and cytoskeleton.

CO2: Will be able to understand the structures and functions of the nucleus and different cell organelles. The structural organization and function roles of chromatin will be learnt.

CO3: Will have understood the mechanisms of protein sorting, intracellular trafficking, protein export.

CO4: Will have gathered understanding of how cells perceive and respond to various signals from within and outside.

CO5: Will have learnt the mechanisms of cell division and the significance of cell cycle and its regulation. Will become familiar with stem cell technology and its applications.

CO6: Will understand the basics of cancer biology including diagnostic techniques and therapy.

Contents:

Unit 1: Cell envelope, cell interactions and cytoskeleton: Plasma membrane: chemical composition and molecular models. Transport: mechanisms of passive diffusion, facilitated diffusion and active transport. Cell wall: compostion. Extracellular matrix: components. Cell-matrix interactions: focal adhesions, hemi-desmosomes. Cell-cell interactions: adhesion junctions, tight junctions, gap junctions, plasmodesmata (only structural aspects). Cytoskeleton: microtubule structure and functions, outline of structure of cilia, flagella and centrioles, types and functions of intermediate filaments, structure and organization of actin filaments, association of actin filaments with plasma membrane. **12**

Unit 2: **Nucleus and cell organelles:** Structure and function of nuclear envelope, nuclear pore complex, nuclear lamina. Chromatin: C-value paradox, nucleosome organization, euchromatin, heterochromatin. Nucleolus: Structure and function. Structure and function of mitochondrion, chloroplast, ribosome, peroxisome, lysosome. **8**

Unit 3: **Protein Sorting and Transport:** Endoplasmic reticulum: structure, targeting and insertion of proteins in the ER, protein folding, processing and quality control in ER, smooth ER and lipid synthesis, export of proteins and lipids. Golgi Apparatus: organization, protein glycosylation, protein sorting and export from Golgi Apparatus **10**

Unit 4: Cell Signalling: Signalling molecules and their receptors. Function of cell surface receptors. Signalling pathways: cyclic AMP, cyclic GMP and MAP kinase pathways. **10**

Unit 5: Cell Cycle, Cell Death and Cell Renewal: Eukaryotic cell cycle and its regulation, mitosis and meiosis. Cell death: necrosis, apoptosis and autophagy. Stem cells: characteristics and types: somatic stem cells, embryonic stem cells, induced pluripotent stem cells. Therapeutic applications of stem cells. **10**

Unit 6: Cell proliferation abnormalities: Cancer: characteristics, causes (carcinogens and microbes), types, diagnosis and treatment modalities. Bone marrow transplantations in response to cancer therapy and immune cell therapies. **10**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Study of a plant cell and an animal cell through microscopy.
2. Study of the structure of cell organelles (nucleus, plasma membrane, mitochondrion, chloroplast, ribosome, endoplasmic reticulum, golgi bodies) through electron micrographs.
3. Performance of cytochemical staining of DNA by Feulgen stain.
4. Study of polyploidy in onion root tip by colchicine treatment.
5. Studying the different stages of mitosis through temporary mounts.
6. Studying the different stages of meiosis through permanent slides.
7. Demonstration of principles of cell fractionation by density gradient centrifugation, and cell sorting by flow cytometry, using virtual lab.

8. Identification and study of properties of cancerous cells through light and electron micrographs.

Suggested Reading:

1. Alberts, B., Hopkin, K., Johnson, A.D., Morgan, D. and Raff, M. (2019). *Essential Cell Biology*. 5th edition. W.W. Norton & Co, USA.

2. Cooper, G.M. (2018). *The Cell: A Molecular Approach*. 8th edition. Sinauer Associates, UK.

3. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). *Cell and Molecular Biology*. 8th edition. Lippincott,Williams and Wilkins, USA.

4. Hardin, J., Bertoni, G. and Kleinsmith, L. (2015). *Becker's World of the Cell*. 9th edition. Benjamin Cummings, USA.

5. Karp, G. (2013). *Cell and Molecular Biology*. 7th edition. Wiley, USA.

6. Lodish, H., Berk, A., Kaiser, C., Krieger, M., Bretscher, A., Ploegh, H., Amon, A. and Martin, K.C. (2016). *Molecular Cell Biology*. 8th edition. W.H. Freeman, UK.

7. Pollard, T.D., Earnshaw, W.C., Lippincott-Schwartz, J. and Johnson, G.T. (2016). *Cell Biology*. 3rd edition. Elsevier, USA.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks
1	Will have gained knowledge about features of the cell wall, plasma membrane, cell transport mechanisms and cytoskeleton.	Class room lecture and power-point presentation, worksheets	Multiple-choice type quiz, assignment on cytoskeleton.
2	Will be able to understand the structures and functions of the nucleus and different cell organelles. The structural organization and function roles of chromatin will be learnt.	Pictorial representation, use of audio/video resources available online.	Worksheets, and group discussion on importance of chromatin organization
3	Will have understood the mechanisms of protein sorting, intracellular trafficking, protein export.	Lectures on different endomembrane systems, video on protein transportation.	Short quiz, assignment on protein export.
4	Will have gathered understanding of how cells perceive and respond to various signals from	Lectures on different types of cell receptors and steps of signal transduction. Pictorial and video representations of	Class test on cell communications and cascades of signal transduction

	within and outside.	different pathways	
5	Will have learnt the mechanisms of cell division and the significance of cell cycle and its regulation. Will become familiar with stem cell technology and its applications.	Discussion on the Nobel Prize-winning experiments related to these topics. Lectures and interactive classes	Assignment, class test, Short presentations by students in groups on stem cell applications.
6	Will understand the basics of cancer biology including diagnostic techniques and therapy.	Classroom lectures and power-point presenation.	Discussion about the harmful effects of smoking, and increasing cancer incidence in India.

***Assessment tasks listed here are indicative and may vary.**

MICROB-CC301: MICROBIAL PHYSIOLOGY AND METABOLISM

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:
The main objective of this course is to give students a comprehensive insight into various aspects of microbial physiology and metabolism. These include transport mechanisms present in microbes for the uptake of nutrients, bacterial growth and factors affecting it, and diverse metabolic pathways existing in microbes for energy production and carbon and nitrogen assimilation. The course will build the strong foundation needed by the students for further studies in the field of microbiology.

Course Learning Outcomes:
Upon successful completion of the course, the student:

CO1: Will have got acquainted with the diverse physiological groups of bacteria/archaea and microbial transport systems.

CO2: Will have an in-depth knowledge of patterns of bacterial growth, bacterial growth curve, calculation of generation time and specific growth rate, and effect of the environment on growth.

CO3: Will understand the variety of pathways used by bacteria for energy generation and conservation during growth on glucose under aerobic and anaerobic conditions.

CO4: Will become conversant with two important fermentation pathways in microbes.

CO5: Will have an added knowledge on the groups and families of chemolithotrophs and phototrophs, based on their ability to extract energy from inorganic compounds and assimilate carbon from CO_2.

CO6: Will have learnt about a typical capability of prokaryotes to reduce nitrogen gas to ammonia. Will become familiar with the physiology of nitrogen fixation and assimilation of inorganic nitrogen by bacteria.

Contents:

Unit 1: Microbial nutrition and transport: Classification of microorganisms based on nutrient and energy source. Nutrient uptake and transport: passive and facilitated diffusion, primary and secondary active transport, iron uptake, concept of uniport, symport, antiport, group translocation. **9**

Unit 2: Microbial growth and influence of environmental factors: Bacterial growth curve (generation time and specific growth rate), diauxic growth, synchronous growth, batch and continuous cultures. Effect of temperature, pH, oxygen concentration, solute and water activity on growth. **9**

Unit 3: Carbon metabolism and energy generation: Concept of aerobic respiration, anaerobic respiration and fermentation. Glucose degradation/catabolism by microbes via: Embden-Meyerhof-Parnas (EMP) pathway /glycolysis, Entner-Doudoroff (ED) pathway, Pentose phosphate pathway (PPP), Krebs Cycle /Tricarboxylic Acid Cycle, Glyoxylate cycle. Electron transport during aerobic respiration: components of mitochondrial electron transport chain (ETC), chemiosmotic hypothesis, oxidative phosphorylation and ATP generation, uncouplers and inhibitors of respiratory chain, comparison of mitochondrial and bacterial electron transport, branched respiratory chain in bacteria (*E. coli*) under high and low levels of O_2. Anaerobic respiration with nitrate as final electron acceptor: dissimilatory nitrate reduction (denitrification, nitrate /nitrite and nitrate/ammonia respiration). **18**

Unit 4: Bacterial fermentations: Alcohol fermentation and Pasteur effect, lactate fermentation (homofermentative and heterofermentative pathways). Concept of linear and branched fermentation pathways. **4**

Unit 5: Chemolithotrophic and phototrophic metabolism: Definition, physiological groups of chemolithotrophs, aerobic chemolithotrophy with details of H_2 oxidizers and anaerobic chemolithotrophy with details of methanogens. Families of phototrophic bacteria. Anoxygenic photosynthesis with reference to purple and green bacteria and oxygenic photosynthesis with reference to cyanobacteria: photosynthetic pigments and photophosphorylation (cyclic and non-cyclic). C1 metabolism: CO_2 fixation by Calvin cycle, reductive TCA and methanogenesis. **10**

Unit 6: Assimilation of inorganic nitrogen: Biological nitrogen fixation: Diversity, mechanism of nitrogen fixation, nitrogenase activity and its physiological regulation, alternate nitrogenases, ammonia assimilation, assimilatory nitrate reduction. **10**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Study and plot the growth curve of *E. coli* by turbidometric method.

2. Calculations of generation time and specific growth rate of bacteria from the graph plotted with the given data.

3. Effect of temperature and pH on growth of *E. coli* or *Aspergillus*.

4. Demonstration of alcoholic fermentation.

5. Effect of carbon and nitrogen on microbial growth.

Suggested Reading:

1. Cohen, G.N. (2014). *Microbial Biochemistry*. 2nd edition. Springer, Germany.

2. Gottschalk, G. (1986). *Bacterial Metabolis*m. 2nd edition. Springer, Germany.

3. Madigan, M.T. and Martinko, J.M. (2017). *Brock Biology of Microorganisms.* 15th edition. Prentice Hall International Inc., USA.

4. Moat, A.G., Foster, J.W. and Spector, M.P. (2002). *Microbial Physiology*. 3rd edition. John Wiley & Sons, USA.

5. Nelson, D.L. and Cox, M.M. (2017). *Lehninger Principles of Biochemistry*. 7th edition. W.H.

Freeman and Company, UK.

6. Reddy, S.R. and Reddy, S.M. (2005). *Microbial Physiology*. Scientific Publishers, India.

7. Stanier, R.Y., Ingrahm, J.I., Wheelis, M.L. and Painter, P.R. (1987). *General Microbiology*. 5th edition. McMillan Press, UK.

8. White, D., Drummond, J. and Fuqua, C. (2011). *The Physiology and Biochemistry of Prokaryotes*. 4th edition. Oxford University Press, UK.

9. Willey, J. M., Sandman, K. and Wood, D. (2019). *Prescott's Microbiology.* 11th edition. McGraw Hill Higher Education, USA.

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Will have got acquainted with the diverse physiological groups of bacteria/archaea and microbial transport systems.	A classroom lecture on various types of microbes based on nutrient uptake. Detailed discussion along with diagrammatic presentation on diffusion, active transport, group translocation and iron transport.	A quiz on the identification of transport mechanism for specific solutes.
2	Will have an in-depth knowledge of patterns of bacterial growth, bacterial growth curve, calculation of generation time and specific growth rate, and effect of the environment on growth.	Detailed talk on batch and continuous culture, diauxic and synchronous growth, growth curve and calculation of generation time and specific growth rate. Interactive lecture on effect of temperature, pH, oxygen concentration and solute activity on the bacterial growth.	Numerical on calculation of generation time and specific growth rate. Class test on bacterial adaptations under different environmental conditions.
3	Will understand the variety of pathways used by bacteria for energy generation and conservation during growth on glucose under aerobic and anaerobic conditions.	Discussion on bacterial respiration in the presence and absence of oxygen. Detailed lecture on EMP, ED,TCA, PP and Glyoxylate pathways and ETC under aerobic and anaerobic conditions. Teaching of pathways through graphical representations.	Fill in the blanks-type test on the different pathways
4	Will become conversant with two important fermentation pathways in microbes.	Detailed teaching along with diagrammatic display of the fermentation pathways.	An assignment on writing the alcohol and lactic acid fermentation pathways.
5	Will have an added knowledge on the groups and families of chemolithotrophs and phototrophs, based on their ability to extract energy from inorganic compounds and	Class room teaching on chemolithotrophs and phototrophs, the basis of their classification, and their metabolism with respect to ETC and carbon assimilation.	Group presentations on energy production and CO_2 assimilation in hydrogen oxidizers, methanogens, green

	assimilate carbon from CO_2.		bacteria, purple bacteria and heliobacteria.
6	Will have learnt about a typical capability of prokaryotes to reduce nitrogen gas to ammonia. Will become familiar with the physiology of nitrogen fixation and assimilation of inorganic nitrogen by bacteria.	Power point presentation on physiology of nitrogen fixation and assimilation of ammonia and nitrate by bacteria.	Placing processes of nitrogen fixation, assimilation of ammonia and nitrate in the nitrogen cycle.

***Assessment tasks listed here are indicative, and may vary.**

MICROB-302 ENVIRONMENTAL MICROBIOLOGY

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:

The main objective of this paper is to have in-depth knowledge of microbial diversity in different habitats with emphasis on their interactions among themselves and with higher plants and animals. The students will also learn about various environment-related problems and be motivated to think about sustainable and novel ways to solve them.

Course learning outcomes:

Upon successful completion of the course, the students:

CO1: Will get acquainted with natural habitats of diverse microbial population. And be familiar with microbial succession and concept of metagenomics.

CO2: Will understand how microbes interact among themselves and with higher plants and animals with the help of various examples.

CO3: Will become aware of the important role microorganisms play in bio-geochemical cycling of essential elements occurring within an ecosystem and its significance.

CO4: Will gain in-depth knowledge of different types of solid wastes and their management with emphasis on advantages and disadvantages of various methods used for their treatment.

CO5: Will acquire knowledge about composition and strength of sewage and its treatment using primary, secondary and tertiary methods. Will have learnt about treatment and safety of drinking water and be conversant with different methods to test its potability.

CO6: Will get familiar with problems of pollution and applications of clean-up technologies (bioremediation) for the pollutants such as pesticides, oil, e-waste and plastic in the ecosystem and gain insights into the importance of finding sustainable and novel methods for treating such pollutants.

Contents:

Unit 1: Microorganisms in different habitats: Terrestrial environment: Soil texture, profile and its microflora. Aquatic environment: Stratification and microflora of fresh water and marine habitats, Atmosphere: Aeromicroflora and dispersal of microbes. Animal environment: Microbes in/on animal (ruminants) body. Extreme habitats: microbes (extremophiles) thriving at high and low temperatures, pH, high hydrostatic and osmotic pressures, salinity and low nutrient levels. Concept of metagenomics (non-culturable microorganisms). Microbial succession in decomposition of plant organic matter. **14**

Unit 2: Microbial interactions: Microbe-microbe interactions: mutualism, synergism, commensalism, competition, amensalism, parasitism, predation. Microbe-plant interactions: microbes associated with roots and aerial plant surfaces, *Rhizobium* symbiosis, *Anabaena-Azolla* symbiosis, mycorrhizal associations, actinorhizal associations. Microbe-animal interactions: termite gut microflora, nematophagus fungi and symbiotic luminescent bacteria. **12**

Unit 3: Biogeochemical cycling: Carbon cycle: microbial degradation of cellulose, lignin and chitin. Nitrogen cycle: nitrogen fixation, ammonification, nitrification, denitrification and nitrate reduction, nitrate pollution. Phosphorus cycle: phosphate immobilization and solubilisation. Sulphur cycle: microbes involved in sulphur cycle. **10**

Unit 4: Solid waste management: Sources and types of solid waste, methods of solid waste disposal: incineration, sanitary landfill, composting. **6**

Unit 5: Liquid waste management and water potability: Liquid waste management: composition and strength of sewage (BOD and COD). Primary, secondary (aerobic: oxidation ponds, trickling filter, activated sludge process; anaerobic: septic tank, Imhoff tank, anaerobic sludge digestor) and tertiary sewage treatment. Water potability: treatment and safety of drinking (potable) water. Methods to detect potability of water samples: standard qualitative procedure - presumptive test/MPN test, confirmed and completed tests for faecal coliforms; membrane filter technique and Presence/Absence tests for coliforms. **13**

Unit 6: Microbial bioremediation: Bioremediation of contaminated soils and marine oil pollutants. Degradation of pesticides (DDT and Propanil). Role of microbes in e-waste management. Plastic degrading microbes. **5**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. To analysis following characteristics of soil samples- pH, moisture content, water holding capacity, percolation, capillary action. Concept of sterilization and disinfection.

2. To isolate and identify fungi from the soil sample at different temperatures (28ºC & 45ºC).

3. To determine rhizosphere effect by enumerating bacteria present in rhizosphere and root free soil.

4. To assess the microbiological quality of water by standard qualitative procedure.

5. To determine BOD of waste water sample by Dissolved Oxygen Electrode method.

6. To study the presence of microbial activity by detecting (qualitatively) any two enzymes (dehydrogenase, amylase, urease) in soil.

7. To isolate *Rhizobium* from root nodules/ *Azotobacter*/ *Azospirillum*.

Suggested Reading:

1. Atlas, R.M. and Bartha, R. (2000). *Microbial Ecology: Fundamentals and Applications*. 4th edition. Benjamin Cummings, USA.

2. Bergey, D.H. (2019). *Waste Water Microbiology*. 2nd edition. Medtech, India.

3. Madigan, M.T. and Martinko, J.M. (2017). *Brock Biology of Microorganisms.* 15th edition. Prentice Hall International Inc., USA.

4. Okafor, N. (2011). *Environmental Microbiology of Aquatic and Waste Systems.* Springer, USA.

5. Pepper, I.L., Gerba, C.P. and Gentry, T.J (editors). (2014). *Environmental Microbiology.* 3rd edition. Academic Press, USA.

6. Singh, A., Kuhad, R.C. and Ward, O.P. (2009). *Advances in Applied Bioremediation*. Springer-Verlag, Germany.

7. Subba Rao, N.S. (2017). *Soil Microbiology*. 5th edition. Medtech, India.

8. Willey, J. M., Sandman, K. and Wood, D. (2019). *Prescott's Microbiology.* 11th edition. McGraw Hill Higher Education, USA.

Facilitating the achievement of Course Learning Outcomes

Unit no.	**Course Learning Outcomes**	**Teaching and learning Activity**	**Assessment Tasks***
1.	Will get acquainted with natural habitats of diverse microbial population. And be familiar with microbial succession and the concept of metagenomics.	Class lecture on different habitats and microbial diversity with the help of visual aids Discussion on microbial succession and metagenomics.	Class test based on different characteristics of habitats.
2.	Will understand how microbes interact among themselves and with higher plants and animals with the help of various examples.	Video lectures showing interactions between micro and macropopulartions of an ecosystem.	Quiz based on different interactions.
3.	Will become aware of the important role microorganisms play in bio-geochemical cycling of essential elements occurring within an ecosystem and its significance.	Class lecture on the role of different microbes in nutrient cycling. Use of powerpoint presentations to explain biogeochemical cycles.	Test based on flow charts of different bio-geochemical cycles studied.
4.	Will gain in-depth knowledge of different types of solid wastes and their management with emphasis on advantages and disadvantages of various methods used for their treatment.	Power point presentation on different methods used for management of solid waste.	Match the following and MCQs. Problem solving questions based on types of solid waste.
5.	Acquires knowledge about composition and strength of sewage and its treatment using primary, secondary and tertiary methods. Will have learnt about treatment and safety of drinking water and be conversant with different methods to test its potability.	Interactive session with class discussing treatment of sewage with the help of visual aids. Demonstrative lecture on testing potabilty of water.	Problem solving questions based on types of liquid waste. Testing of water samples collected from various sources.
6.	Will become familiar with problems of pollution and applications of clean-up technologies (bioremediation) for the pollutants such as pesticides, oil, e-waste and plastic in the	Class discussion on various environment related problems and their sustainable and novel solutions.	Group discussions and presentations based on environmental related problems and their solutions.

	ecosystem and get insight in importance of finding sustainable and novel methods for treating such pollutants.		

***Assessment tasks listed here are indicative and may vary.**

MICROB-CC303: MOLECULAR BIOLOGY

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:
The major objective of this course is to develop a clear understanding of the basic concepts of molecular biology starting from the structure and function of DNA to its replication. The student will become familiar with the central dogma of molecular biology, and will learn about the conversion of information from DNA to RNA to proteins, by the study of transcriptional and translational processes.

Course Learning Outcomes:
Upon successful completion of the course, the student:

CO1: Will be acquainted with the structure of various types of DNA and RNA as well as their organization as genetic material in various living organisms.

CO2: Will gain an in-depth knowledge of DNA replication mechanisms in prokaryotes and eukaryotes, enzymes and proteins involved in replication.

CO3: Will have learnt the fundamental principles of transcription in prokaryotes and eukaryotes, including the RNA polymerases and general transcription factors involved. Will be able to distinguish between the process in prokaryotes versus eukaryotes.

CO4: Will understand the concept of split genes, introns, exons, spliceosomes and alternative splicing besides learning about other processing events like polyadenylation and capping. Will become familiar with RNA interference and its significance, siRNA and miRNA.

CO5: Will get a clear understanding of translational mechanisms in both prokaryotes and eukaryotes along with the inhibitors of protein synthesis.

CO6: Will understand various mechanisms involved in regulation of gene expression in prokaryotes and eukaryotes at the level of transcription, post-transcriptional processes, and modifications in chromatin structure

Contents

Unit 1: Structures of DNA and RNA: Types of genetic material. DNA Structure: Salient features of double helix, types of DNA. RNA Structure. Denaturation and renaturation, cot curves. DNA topology: linking number, topoisomerases. DNA organization in prokaryotes, viruses, eukaryotes. **12**

Unit 2: Replication of DNA in prokaryotes and eukaryotes: Bidirectional and unidirectional replication, semi-conservative and semi-discontinuous replication. Mechanism of DNA replication: enzymes and proteins involved – DNA polymerases, DNA ligase, primase. Replication of chromosome ends: importance of telomerase. DNA replication modes: rolling circle, D-loop (mitochondrial), Θ (theta) modes. Distinction between prokaryotes versus eukaryotes replication. **10**

Unit 3: Transcription in Prokaryotes and Eukaryotes: Distinction between replication and transcription. Concept of transcription unit. Promoter: structure and role of promoter, strength of

promoter. RNA Polymerases: prokaryotic and eukaryotic. General transcription factors in eukaryotes. Distinction between transcription process in prokaryotes versus eukaryotes. **8**

Unit 4: Post-Transcriptional Processing: Split genes, concept of introns and exons, RNA splicing, spliceosome machinery, concept of alternative splicing, polyadenylation and capping. Processing of rRNA. RNA interference and its significance. microRNAs and their significance. **8**

Unit 5: Translation in prokaryotes and eukaryotes: Translational machinery: ribosome structure in prokaryotes and eukaryotes, tRNA structure and processing. Charging of tRNA, aminoacyl tRNA synthetases. Mechanisms of initiation, elongation and termination of polypeptides in both prokaryotes and eukaryotes. Fidelity of translation. Inhibitors of protein synthesis in prokaryotes and eukaryotes. **10**

Unit 6: Regulation of gene expression in prokaryotes and eukaryotes: Overview of layers of regulation of gene expression. Strategies of transcriptional regulation. Negative versus positive regulation with lac, trp and ara operons as examples. Gene regulation events during sporulation in *Bacillus*. Yeast mating-type switching. Regulation of gene expression by DNA methylation, histone acetylation and histone methylation mechanisms. **12**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Study of different types of DNA and RNA using micrographs and model / schematic representations.

2. Study of semi-conservative replication of DNA through micrographs / schematic representations

3. Isolation of genomic DNA from *E. coli* and analysis by agarose gel electrophoresis.

4. Estimation of salmon sperm / calf thymus DNA using colorimeter (diphenylamine reagent) or UV spectrophotometer (A_{260} measurement).

5. Estimation of RNA using colorimeter (orcinol reagent) or UV spectrophotometer (A_{260} measurement).

6. Resolution and visualization of proteins by polyacrylamide gel electrophoresis (SDS-PAGE).

Suggested Reading:

1. Clark, D., Pazdernik, N. and McGehee, M. (2018). *Molecular Biology*. 3rd edition. Academic Cell Press, USA.

2. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). *Cell and Molecular Biology*. 8th edition. Lippincott,Williams and Wilkins, USA.

3. Gardner, E.J., Simmons, M.J. and Snustad, D.P. (2005). *Principles of Genetics*. 8th edition. Wiley and Sons, UK.

4. Green, M. and J. Sambrook, J. (2012). *Molecular Cloning: A Laboratory Manual*. 4th edition. Cold Spring Harbour Laboratory Press, USA.

5. Hardin, J., Bertoni, G. and Kleinsmith, L. (2011). *Becker's World of the Cell*. 8th edition. Benjamin Cummings, USA.

6. Karp, G. (2013). *Cell and Molecular Biology*. 7th edition. Wiley and Sons, UK.

7. Krebs, J., Goldstein, E. and Kilpatrick, S. (2012). *Lewin's Essential Genes.* 3rd edition. Jones and Bartlett Publishers, USA.

8. Krebs, J., Goldstein, E. and Kilpatrick, S. (2017). *Lewin's Genes XII*. 12th edition. Jones and Bartlett Learning, USA.
9. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2014). *Molecular Biology of the Gene*. 7th edition. Cold Spring Harbour Laboratory Press, USA.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks
1	Will be acquainted with the structure of various types of DNA and RNA as well as their organization as genetic material in various living organisms.	Classroom lecture on DNA and RNA structures and organization of chromatin structure with models and electron micrographs and photographs in practical. Studying the topology of DNA by agarose gel electrophoresis	Multiple choice questions- type quiz on chemical structure of nucleosides and nucleotides, and difference between various types of DNA and RNA.
2	Will gain an in-depth knowledge of DNA replication mechanisms in prokaryotes and eukaryotes, enzymes and proteins involved in replication.	Learning video showing the entire process of replication, coupled to classroom lecture. Experimental details on discovery of semiconservative nature of DNA replication.	Discussion on enzymes and proteins involved in DNA replication in prokaryotes versus eukaryotes. Students will compare and contrast the process in prokaryotes versus eukaryotes.
3	Will have learnt the fundamental principles of transcription in prokaryotes and eukaryotes, including the RNA polymerases and general transcription factors involved. Will be able to distinguish between the process in prokaryotes versus eukaryotes.	Interactive lecture on differences between DNA replication and transcription. Theory class on general transcription mechanism in prokaryotes and eukaryotes. Pictorial presentation showing various protein factors required for transcription in eukaryotes	Short answer quiz on promoters, promoter strength , transcription factors. Interactive discussion on RNA polymerases of eukaryotes, comparative analysis of prokaryotic RNA polymerase with eukaryotic RNA polymerases.
4	Will understand the concept of split genes, introns, exons, spliceosomes and alternative splicing besides learning about other processing events like polyadenylation and capping. Will become familiar with RNA interference and its significance, siRNA and miRNA.	Power point presentation and videos showing splicing mechanisms and product of processing events. Explanation of the concept and mechanism of RNA interference and its applications using power point. Explanation of the importance of microRNAs in gene regulation.	Match the following type of quiz on splicing and transcription factors. Oral quiz on enzymes of the RNA interference pathway.

5	Will get a clear understanding of translational mechanisms in both prokaryotes and eukaryotes along with the inhibitors of protein synthesis.	Classroom lectures using power point presentation followed by videos of the mechanism and the factors involved in translation process. Slides showing structure of inhibitors and their mode of action.	Interactive session on steps involved in translation, Group discussion comparing mechanism of translation in prokaryotes and eukaryotes. Match the following type of questions on inhibitors of protein synthesis and their site of action.
6	Will understand various mechanisms involved in regulation of gene expression in prokaryotes and eukaryotes at the level of transcription, post-transcriptional processes, and modifications in chromatin structure	Lecture on principles of transcriptional regulation, concept of inducible and repressible operons. Differential expression of genes due to use of different promoters under different environmental conditions. Showing the change in chromatin structure by photographs. Explanation of the impact of DNA methylation and histone acetylation using power point presentation.	Assignment on nucleosome structure showing various types of histones and their modifications and the roles of these modifications.

***Assessment tasks listed here are indicative, and may vary.**

MICROB-CC401: MICROBIAL GENETICS AND GENOMICS

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:

The major objective of this course is to develop clear understanding of various aspects of microbial genetics and genomes in relation to microbial survival and propagation and to enable students to better understand courses taught later such as recombinant DNA technology and other allied papers.

Course Learning Outcomes:

Upon successful completion of the course, the student:

CO1: Will be acquainted with the organization of prokaryotic and eukaryotic genomes and organelle genomes in eukaryotes.

CO2: Will get acquainted with basic and applied aspects of mutations and mutagenesis and their importance and the role of mutator genes. Will learn of the use of a microbial test in detecting the carcinogenic potential of chemicals. Will become aware of different repair mechanisms.

CO3: Will have learnt the role of plasmids and their types in microorganisms. Will get acquainted with plasmid replication and partitioning as well as aspects related to plasmid copy number, its regulation and plasmid curing.

CO4: Will be aware of detailed mechanisms of genetic exchange in bacteria. Will be familiarized with molecular aspects and applications of transformation, conjugation, and transduction. Will learn how to map genes using interrupted mating technique and recombination.

CO5: Will be familiar with the lytic/lysogenic switch in phage lambda. Will be able to discuss the role of CRISPR-Cas in bacterial defense mechanisms.

CO6: Will be acquainted with fundamentals and applied aspects of transposons, types and mechanisms of transposition. Will have learnt of various eukaryotic transposons and their uses.

Contents:

Unit 1: Genome Organization: Comparative genome organization in *E. coli*, *Saccharomyces cerevisiae*, *Neurospora crassa, Streptomyces*. Organelle genomes: chloroplast and mitochondrion. **6**

Unit 2: Mutations, mutagenesis and repair: Definition and types of mutations-base substitutions, frameshifts, deletions, insertions, duplications, inversions. Silent, conditional and lethal mutations. Physical and chemical mutagens. Loss and gain of function mutants. *Petite* and *poky* mutants in *Saccharomyces* and *Neurospora* respectively. Reversion and suppression: true revertants, intra- and inter-genic suppression. Mutator genes. Uses of mutations. Ames Test. Photoreactivation, mismatch repair, excision repair, NHEJ repair: basic mechanism and enzymes and proteins involved. **14**

Unit 3: Plasmids: Plasmid replication and partitioning, host range, plasmid incompatibility, plasmid amplification, regulation of plasmid copy number, curing of plasmids. Types of plasmids – R Plasmids, F plasmids, colicinogenic plasmids, metal resistance plasmids, Ti plasmid, linear plasmids, yeast 2 μ plasmid. **10**

Unit 4: Mechanisms of Genetic Exchange: Concept of horizontal transfer of genes. Transformation - Discovery, mechanism of natural competence. Conjugation - Discovery, mechanism, Hfr and F' strains, gene mapping by interrupted mating technique. Transduction - Generalized transduction, specialized transduction, mapping by recombination and co-transduction of markers. **12**

Unit 5: Phage Genetics: Genetic basis and regulation of lytic versus lysogenic switch of lambda phage. CRISPR-Cas system as bacterial defense against invading genetic material. **6**

Unit 6: Transposable elements: Prokaryotic transposable elements – insertion sequences, composite and non-composite transposons. Mechanism of transposition: Replicative and non- replicative transposition. Types of transposons: Mu transposon, eukaryotic transposable elements - yeast (Ty retrotransposon), *Drosophila* (Copia elements and P elements in Hybrid dysgenesis), Maize (Ac/Ds and Spm/dSpm). Uses of transposons. **12**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Replica plating : preparation of master and replica plates.

2. Study of the effect of chemical (nitrous acid) and physical (UV) mutagens on bacterial cells.

3. Study of survival curve of bacteria after exposure to ultraviolet (UV) light.

4. Isolation of plasmid DNA from *E.coli*. Study of different conformations of plasmid DNA through agarose gel electrophoresis.

6. Demonstration of bacterial conjugation.

7. Demonstration of Ames test.

Suggested Reading:

1. Gardner, E.J., Simmons, M.J. and Snustad, D.P. (2005). *Principles of Genetics*. 8th edition. Wiley and Sons, UK.

2. Klug, W.S., Cummings, M.R., Spencer, C. and Palladino, M. (2018). *Concepts of Genetics*. 12th edition. Pearson Education, USA.

3. Krebs, J., Goldstein, E. and Kilpatrick, S. (2012). *Lewin's Essential Genes.* 3rd edition. Jones and Bartlett Publishers, USA.

4. Maloy, S.R., Cronan, J.E. and Friefelder, D. (2004). *Microbial Genetics*. 2nd edition. Jones and Barlett, USA.

5. Pierce, B.A. (2011). *Genetics: A Conceptual Approach*. 4th edition. Macmillan Higher Education Learning, UK.

6. Russell, P.J. (2009). *iGenetics- A Molecular Approach*. Benjamin Cummings, USA.

7. Snyder, L., Peters, J.E., Henkin,T.M. and Champness, W. (2015). *Molecular Genetics of Bacteria*. 4th edition. ASM Press, USA.

8. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2014). *Molecular Biology of the Gene*. 7th edition. Cold Spring Harbour Laboratory Press, USA.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks
1	Will be acquainted with the organization of prokaryotic and eukaryotic genomes and organelle genomes in eukaryotes	Pictorial presentation of the organization of various genomes through the use of internet resources.	Quiz on organization of nuclear genomes *vs* organelle genomes.
2	Will get acquainted with basic and applied aspects of mutations and mutagenesis and their importance and the role of mutator genes. Will learn of the use of a microbial test in detecting the carcinogenic potential of chemicals. Will become aware of different repair mechanisms.	Pictorial and audio-visual presentations on mutations and mutagenesis. Tabular presentation of mutator genes. Practical demonstration on Ames test will be given.	Match the following type quiz on mutagens and mutations they cause. A group discussion on various repair systems will be carried out.
3	Will have learnt the role of plasmids and their types in microorganisms. Will get acquainted with plasmid replication and partitioning as well as aspects related to plasmid copy number, its regulation and plasmid	Properties of various plasmids will be studied using educational charts. A power point presentation on plasmid amplification and regulation of copy number will be used in discussions.	Students will be asked to tabulate the features and roles of different plasmids. Interactive quiz on plasmid features.

	curing.		
4	Will be aware of detailed mechanisms of genetic exchange in bacteria. Will be familiarized with molecular aspects and applications of transformation, conjugation, and transduction. Will learn gene mapping using interrupted mating technique and recombination.	Various mechanisms of genetic exchange in bacteria will be explained pictorially. Various steps in interrupted mating technique will be detailed using web tutorial.	Simple problem- based questions for mapping genes using recombination-based method.
5	Will be familiar with the lytic/lysogenic switch in phage lambda. Will be able to discuss the role of CRISPR-Cas in bacterial defense mechanisms.	Charts will be used, and chalk and talk lecture on lytic vs lysogeny cycle. Research material be given with respect to latest developments on CRISPR-Cas.	Objective type questions for lambda phage gene regulation
6	Will be acquainted with fundamentals and applied aspects of transposons, types and mechanisms of transposition. Will have learnt of various eukaryotic transposons and their uses.	Audio-visual material on transposition and various transposon types will be given.	Interactive and problem-based questions on transposons and their uses.

***Assessment tasks listed here are indicative, and may vary.**

MICROB-CC402: VIROLOGY

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:

The major objective of this course is to acquaint students with the structure of viruses of plants, animals, and bacteria, their genome organization, and replication strategies within the host cell. The student will learn how they evolve, spread and cause disease, and prevention and control methods for the same. The course also includes description of oncogenic viruses and their role in cancers, and emerging viruses in context of threat to public health and their management.

Course Learning Outcomes:

Upon successful completion of the course the student will have acquired the knowledge in the following areas and:

CO1: Will be able to describe the nature, properties and structure of viruses and will also gain knowledge of taxonomy of different groups of viruses.

CO2: Will be familiar with diversity and multiplication of lytic and lysogenic bacteriophages.

CO3: Will be able to describe different ways of viral transmission, and prominent and unusual genomic features of different viruses with their significance.

CO4: Will understand about the replication strategies, maturation and release of important plant, animal and bacterial viruses.

CO5: Will have gained knowledge about strategies to prevent viral infections: interferons, vaccines and antiviral compounds

CO6: Will understand the concept of oncogenesis, DNA and RNA cancer causing viruses and will learn of newly emerging viruses which have the potential to cause serious threats to public health and have become a global concern.

Contents:

Unit 1: Nature and properties of viruses: Introduction: Discovery of viruses, nature and definition of viruses, general properties, concept of viroids, virusoids, satellite viruses, prions, giant viruses (mama and mimi virus), virophages (Sputnik). Theories of viral origin. Structure of Viruses: Capsid symmetry, enveloped and non-enveloped viruses. Isolation, purification and cultivation of viruses. Viral taxonomy: Classification and nomenclature of different groups of viruses. **13**

Unit 2: Bacteriophages: Diversity, one step multiplication curve, lytic and lysogenic phages (lambda phage) concept of early and late proteins. **6**

Unit 3: Viral transmission and salient features of viral nucleic acids: Modes of viral transmission: Persistent, non-persistent, vertical and horizontal. Salient features of viral nucleic acid: unusual bases (T4 phage), overlapping genes (ϕX174, Hepatitis B virus), alternate splicing (HIV), terminal redundancy (T4 phage), terminal cohesive ends (lambda phage), partial double stranded genomes (Hepatitis B), long terminal repeats (retrovirus), segmented (Influenza virus), and non-segmented genomes (picornavirus), capping and tailing (TMV). **12**

Unit 4: Viral replication, maturation and release: Interaction of viruses with cellular receptors and entry of viruses. Replication strategies of viruses: phi X 174, HIV, Vaccinia, Picorna, Assembly with example of Polio virus and T4 phage, maturation and release of Virions. **10**

Unit 5: Prevention and control of viral diseases: Antiviral compounds and their mode of action: AZT, aciclovir, ganciclovir. Interferons and their mode of action. General principles of viral vaccines: live attenuated vaccines, inactivated viral vaccine, subunit vaccine, recombinant viral vaccine, with one example of each. **10**

Unit 6: Oncogenic and emerging viruses: Introduction to oncogenic viruses. Types of oncogenic DNA and RNA viruses: Concepts of oncogenes and proto-oncogenes. Emerging viruses, their management and control strategies: H1N1, Chikungunya, Dengue, Ebola, Zika and Nipah virus.**9**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Study of the structure of important animal viruses (rhabdo, influenza, paramyxo, hepatitis B and retroviruses) using electron micrographs.

2. Study of the structure of important plant viruses (caulimo, Gemini, tobacco ring spot, cucumber mosaic and alpha-alpha mosaic viruses) using electron micrographs.

3. Study of the structure of important bacterial viruses (ϕX 174, T4, λ) using electron micrograph.

4. Isolation and enumeration of bacteriophages (PFU) from water/sewage sample using double agar layer technique.

5. Isolation and propagation of animal viruses by chick embryo technique using photographs.

6. Study of cytopathic effects of viruses using photographs.

7. Performing local lesion technique for assaying plant viruses.

Suggested Reading:

1. Cann, A.J. (2016). *Principles of Molecular Virology*. 6th edition. Academic Press, Elsevier Netherlands.

2. Carter, J. and Saunders, V. (2013). *Virology: Principles and Applications*. 2nd edition. John Wiley and Sons, UK.

3. Dimmock, N.J., Easton, A.L. and Leppard, K.N. (2007). *Introduction to Modern Virology*. 6th edition. Wiley-Blackwell Publishing.

4. Flint, S.J., Enquist, L.W., Krug, R.M., Racaniello, V.R. and Skalka, A.M. (2015). *Principles of Virology, Molecular biology, Pathogenesis and Control*. 4th edition. ASM Press, USA.

5. Hull, R. (2014). *Plant Virology*. 5th edition. Academic Press, USA.

6. Jones, Teri Shors. (2016). *Understanding Viruses*. 3rd edition. Jones and Bartlett Learning, USA.

7. Levy, J.A., Conrat, H.F. and Owens, R.A.(2000). *Virology*. 3rd edition. Prentice Hall, USA.

8. Nayudu, M.V. (2008). *Plant Viruses*. Tata McGraw Hill, India.

9. Wagner, E.K., Hewlett, M.J. and Bloom, D.C. (2007). *Basic Virology*. 3rd edition. Wiley-Blackwell Publishing, USA

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks*
1	Will get acquainted with knowledge about nature, properties and structure of viruses and will also gain knowledge of taxonomy of different groups of viruses.	Classroom lectures with Electron micrographs of different viruses. Comparative discussion of important viral families	Diagrams of viruses depicting structure.'Match the following' questions based on viral classification
2	Will be familiar with diversity and multiplication of lytic and lysogenic bacteriophages.	Classroom lectures with the help of detailed diagrams	Problems related to one step multiplication curve (MOI, PFU, Burst size).
3	Will have learnt the ways of viral transmission, prominent and unusual genomic features of different viruses with their significance.	Comparative discussion on Transmission of viruses. Detailed diagrammatic explanation of genomic features viruses.	Class test/Quiz. Discussion on different modes of viral transmission.
4	Will be conversant with the replication strategies, maturation and release of important plant, animal and bacterial viruses	Classroom teaching supplemented with audio visual aids.	Assessment by flowcharts on replication strategies and packaging of viruses.
5	Will have gained the knowledge about strategies to prevent viral infections: interferons, vaccines and Antiviral compounds	Class interactions with photographs and specific examples of viruses.	Comparison based class test on prevention strategies.
6	Will understand Oncogenesis, DNA and RNA cancer causing viruses, Newly emerging viruses which have potential to cause serious threats to public health and have become a global concern.	Classroom lectures with pictorial presentation showing examples of oncogenic viruses. Teaching with the help of audio visual aids.	Quiz based on oncogenic viruses and emerging viruses. Power point presentation on emerging viruses and their management.

*** Assessment tasks listed here are indicative, and may vary**.

MICROB-CC403: FOOD AND DAIRY MICROBIOLOGY

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:

The main objective of this paper is to acquaint students with the role of microorganisms in association with foods, highlighting both their beneficial and harmful activities and their applications in the food industry.

Course Learning Outcomes:

On successful completion of the course, the student:

CO1: Will be aware of the possible sources of contamination of foods and the parameters affecting microbial growth in foods.

CO2: Will gain insight into the microbial spoilage of some foods

CO3: Will acquire an in-depth knowledge of various physical and chemical methods used for food preservation.

CO4: Will be acquainted with microbial production of fermented dairy and non-dairy food products. Will also be able to understand the health benefits of prebiotics, probiotics and synbiotics.

CO5: Will be conversant with some food-borne diseases and will be able to explain methods for detection of food borne pathogens.

CO6: Will be able to understand the concept of quality control of food.

Contents:

Unit 1: Foods as a substrate for microorganisms: Natural flora and sources of contamination of foods in general. Intrinsic and extrinsic factors affecting growth and survival of microbes in foods. **8**

Unit 2: Microbial spoilage of various foods: Principles, spoilage of vegetables, fruits, meat, eggs, milk, butter, bread, and canned foods. **10**

Unit 3: Principles and methods of food preservation: Principles. Physical methods of food preservation: temperature (low: refrigeration, freezing; high: boiling, blanching, pasteurization), canning (home and commercial), drying, irradiation, hydrostatic pressure, high voltage pulse, microwave processing and aseptic packaging. Chemical methods of food preservation: salt, sugar, organic acids, SO_2, nitrites and nitrates, ethylene oxide, antibiotics and bacteriocins**.** **12**

Unit 4: Fermented foods: Dairy starter cultures, fermented dairy products: yogurt, acidophilus milk, kumiss, kefir, dahi and cheese. Other fermented foods: bread, idli, dosa, kanji, pickles, sauerkraut, soy sauce and tempeh. Fermented meat and fish products. Prebiotics, probiotics and synbiotics: Health benefits and limitations, types of microorganisms used, probiotic foods available in market. Criteria used when designing a probiotic. **10**

Unit 5: Food borne diseases and detection of food borne pathogens: Causative agents, foods involved, symptoms and preventive measures. Food intoxications: *Staphylococcus aureus*, *Clostridium botulinum* and mycotoxins. Food infections: Salmonellosis, Shigellosis; infections of *Bacillus cereus*, *Vibrio parahaemolyticus*, *Escherichia coli*, *Yersinia enterocolitica*, *Listeria monocytogenes* and *Campylobacter jejuni*. Cultural and rapid detection methods of food borne pathogens in foods. **15**

Unit 6: Food quality and control: Total Quality Management (TQM): concepts and approaches. Hazard analysis of critical control point (HACCP) for food safety: principles, limitations and case

study of milk processing and packaging. Indices of food quality: FSSAI standard, ISO certification. **5**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. MBRT of milk samples and their standard plate count.
2. Alkaline phosphatase test to check the efficiency of pasteurization of milk.
3. Isolation of spoilage fungi from spoiled vegetables/fruits.
4. Isolation of spoilage fungi from bread.
5. Preparation of Yogurt/Dahi.

Suggested Reading:

1. Adams, M.R. and Moss, M.O. (2000). *Food Microbiology*. 2nd edition. New Age International Publishers, India.
2. Banwart, G.J. (2004). *Basic Food Microbiology*. 2nd edition. CBS Publishers and Distributors, India.
3. Davidson, P.M., Sofors, J.N. and Branen, A.L. (2005). *Antimicrobials in Foods*. 3rd edition. CRC Press, UK.
4. Dillon, V.M. and Board, R.G. (1994). *Natural Antimicrobial Systems and Food Preservation*. CAB International, UK.
5. Frazier, W.C., Westhoff, D.C. and Vanitha, N.M. (2013). *Food Microbiology*. 5th edition. Tata McGraw-Hill Publishing Company Ltd, India.
6. Gould, G.W. (1995). *New Methods of Food Preservation*. Blackie Academic and Professional, UK.
7. Jay, J.M., Loessner, M.J. and Golden, D.A. (2006). *Modern Food Microbiology.* 7th edition. CBS Publishers and Distributors, India.
8. Lund, B.M., Baird- Parker, A.C and Gould, G.W. (editors). (2000). *The Microbiological Safety and Quality of Foods. Vol. 1-2*. Springer, USA.
9. Tortora, G.J., Funke, B.R., and Case, C.L. (2016). *Microbiology: An Introduction*. 12th edition. Pearson Education, USA.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks*
1	Student will be aware of the possible sources of contamination of foods and the parameters affecting microbial growth in foods.	Discussion on the possible sources of contamination of foods and the parameters affecting microbial growth in foods	Class test
2	Student will gain insight	Lectures on microbial spoilage of	MCQs and Short Objective

	into the microbial spoilage of some food.	some common foods, supported with visual aids and supplemented with class practicals	type questions
3	Students will acquire in-depth knowledge of various physical and chemical methods used for food preservation	Classroom lectures on various food preservative measures supported by relevant online videos	Short notes
4	Will be acquainted with microbial production of fermented dairy and non-dairy food products. Will also be able to understand the health benefits of prebiotics, probiotics and synbiotics	Classroom discussion on different fermentation; products and probiotics with the help of power-point presentations. Practical exercise on production of a fermented dairy product.	Flow charts on microbial production of fermented foods. Market survey on probiotics and their availability
5	Student will be conversant with some food-borne diseases and will be able to list and explain methods for detection of food borne pathogens.	Lectures on food borne diseases and methods used for detection of food borne pathogens with the help of visual aids.	Class test and preparation of charts
6	Student will be able to understand the concept of quality control of food.	Discussion on Total Quality Control management concepts and indices of food quality	Visit to food processing plant to study the implementation of HACCP. Report to be submitted by students on their visit.

***Assessment tasks listed here are indicative, and may vary.**

MICROB-CC501: INDUSTRIAL MICROBIOLOGY

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:

The major objective of this course is to acquaint students with the various aspects of industrial microbiology, different types of fermentation processes, fermenters designs and operations ~~and the design and operation of fermenters.~~ Students will become familiar with mass scale culturing of microorganisms for industrial ~~–~~production of various biomolecules and ~~–biomass~~/metabolites of industrial interest and ~~various~~ different recovery methods in detail. ~~methods used for their extraction and purification would be dealt with in detail.~~Students will also learn about immobilization of enzymes and their applications.

Course Learning Outcomes:

Upon successful completion of the course the student:

CO1:~~-~~ Will understand the development and importance of industrial microbiology and will be conversant with different types of fermentation processes in liquid media as well as solid state substrates media.

CO2: ~~-~~Will learn about ~~have learnt~~ the design, operation and uses of different types of fermenters of laboratory, pilot and industrial scale.

CO3: Will gain insight into the techniques of isolation, screening, preservation and maintenance of industrially important microbial strains and different types of media used in fermentation processes.

CO4: Will be acquainted with principles of techniques used for the extraction and purification of industrial products produced using microbial fermentation processes.

CO5: Will have gained in-depth knowledge of the principles of microbial production and recovery of industrial products ~~on an industrial~~at large scale ~~scale~~.

CO6: Will have an understanding of the methods of enzyme immobilization, its advantages, drawbacks and its applications in the industry.

Contents:

Unit 1:

Introduction to industrial microbiology and fermentation processes:

~~**(No. of Hours: 10)**~~

Brief history and developments in industrial microbiology, Types of fermentation processes: Solid-state and liquid-state (stationary and submerged) fermentations, Batch, fed-batch and continuous fermentations. **10**

Unit 2:

Types of bioreactors and measurement of fermentation parameters:

~~**(No. of Hours: 12)**~~

Components of a typical bioreactor. Types of bioreactors: Laboratory, pilot-scale and production fermenters, ~~Continuously~~continuously stirred tank reactor, a~~a~~ir-lift fermenter. Measurement and control of fermentation parameters: pH, temperature, dissolved oxygen, foaming and aeration.

12

Unit 3:

Isolation of industrially important microbial strains and fermentation media:

~~**(No. of Hours: 10)**~~

Sources of industrially important microbes and ~~methods for~~ their isolation, preservation and maintenance methods ~~of industrially important strains;~~. Crude and synthetic media: ~~m~~Molasses, corn-steep liquor, sulphite waste liquor, whey, yeast extract, soybean meal, peptone and tryptone.

10

Unit 4:

Down-stream processing: ~~**(No. of Hours: 6)**~~

Cell disruption by physical, chemical and biological methods. Membrane filtration and ultrafiltration, centrifugation, solvent-solvent extraction, precipitation, lyophilization and spray drying.

6

Unit 5: ~~**(No. of Hours :18)**~~

Microbial production of ~~i~~industrially relevant products: Microorganisms, fermentation and recovery strategies: ~~**(microorganisms involved, media, fermentation conditions, downstream processing and uses)**~~

citric acid, ethanol, glutamic acid, Vitamin B_{12}. wine, beer, antibiotics (penicillin, streptomycin). Enzymes: amylase, protease, lipase, glucose isomerase and glucose oxidase. **18**

Unit 6:

Enzyme immobilization ~~**(No. of Hours: 4)**~~**:**

Enzymes i~~I~~mmobilization strategies (~~of Enzymes by~~ cross linking, entrapment, adsorption and

covalent bonding~~.~~;) Advantages and applications of immobilization. Large scale applications of immobilized enzymes (e.g. glucose isomerase and penicillin acylase). 4

~~INDUSTRIAL MICROBIOLOGY (PRACTICAL)~~**Practicals:**

Marks: 50 **Duration: 60 hours (2 credits)**~~SEMESTER – V~~

~~TOTAL HOURS: 60 CREDITS: 2~~

1. Microbial production, detection and estimation of enzymes: Amylase /Protease/ Lipase

~~2.~~ Microbial production, detection and estimation of ~~5.~~2. amino acid: Glutamic acid

~~3.~~ Microbial production, detection and estimation of ~~1.~~3. organic acid: Citric acid

~~4.~~ Microbial production, detection and estimation of ~~2.~~4. alcohol: Ethanol

~~5.~~ A visit to any educational institute/industry to see different parts of an ~~3.~~5. industrial fermenter and downstream processing techniques.

Suggested Reading:

1. Casida, L.E. (1991). *Industrial Microbiology*. 1st edition. Wiley Eastern Limited, USA.
2. Clark, W. (2016). *Biotechnology: Industrial Microbiology. A textbook*. CBS Publishers, India.
3. Crueger, W., Crueger, A. and Aneja, K.R. (2017). *Biotechnology: A Textbook of Industrial Microbiology*. 3rd edition. Medtech Publisher, India.
4. Glazer, A.N. and Nikaido, H. (2007). *Microbial Biotechnology: Fundamentals of Applied Microbiology*. 2nd edition. Cambridge University Press, UK.
5. Okafor, N. and Okeke, B.C. (2017). *Modern Industrial Microbiology and Biotechnology*. 2nd edition. CRC press, UK.
6. Patel, A.H. (1996). *Industrial Microbiology*. 1st edition. Macmillan India Limited.
7. Peppler, H.J. and Perlman, D. (editors) (2009). *Microbial technology: Vols I and II*. 2nd edition. Academic Press, USA.
8. Stanbury, P.F., Whitaker, A. and Hall, S.J. (2016). *Principles of Fermentation Technology*. 3rd edition. Elsevier Science, Netherlands.
9. Waites, M.J., Morgan, N.L., Rockey, J.S. and Higton, G. (2001). *Industrial Microbiology: An Introduction*. Wiley –Blackwell, USA.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks
1	The students will understand the	Class room lectures on history and development of industrial microbiology	Make a list of commercially available industrial products produced by

	development and importance of industrial microbiology. The students will be conversant with different types of fermentation processes in liquid media as well as solid state substrates media.~~The students will understand the development and importance of industrial microbiology .The students will be conversant with different types of fermentation processes in liquid media as well as solid state substrates media.~~	Detailed discussion about different types substrates; advantages and drawbacks of solid state and liquid state fermentations; a comparative account of the salient features, applications and drawbacks of batch, fed-batch and continuous fermentations.	microorganisms
2	The students will learn about the design, operation and uses of different types of fermenters of laboratory, pilot and industrial scale.~~The students will have learnt the design, operation and uses of different types of fermenters of laboratory, pilot and industrial scale.~~	Class lectures supplemented with pictorial presentations of fermenters Demonstration of the operation of a Bench-top fermenter in the laboratory or ~~—~~a visit to research institute/laboratory to see the design and operation of a lab-scale and/or pilot-scale and/or industrial-scale fermenters and learn about the measurement and control of various process parameters.	'Draw and design a fermenter' activity
3	The students gain insight into the techniques of isolation, screening, preservation and maintenance of industrially important microbial strains and different types of media used in fermentation processes.~~The students gain insight into the techniques of isolation, screening, preservation and maintenance of industrially important microbial strains and different types of media used in fermentation processes.~~	Theory classes on the isolation, screening and preservation methods.	Practical group assignments to carry out isolation of amylase producing microorganisms (bacteria and fungi) from the environment (soil)
4	The students will be	Demonstration a few techniques of	Oral quiz/class test

	acquainted with principles of techniques used for the extraction and purification of industrial products produced using microbial fermentation processes.~~The students will be acquainted with principles of techniques used for the extraction and purification of industrial products produced using microbial fermentation processes.~~	downstream processing in lab and/or using audio-visual aids:	
5	The students will have gained in-depth knowledge of the principles of microbial production and recovery of industrial products at large scale.~~The students will have gained in-depth knowledge of the principles of microbial production and recovery of industrial products on an industrial scale.~~	Detailed class lectures about the microbial production of industrial products listed out in the syllabus and prescribed practical exercises. Use of pictorial flow charts for production of industrially important products.	Draw the flow chart for the production and recovery of different metabolites with suitable examples discussed in the class .
6	The students will have an understanding of the methods of enzyme immobilization, its advantages, drawbacks and its applications in the industry.~~The students will understand the processes of immobilization of enzymes, its advantages, drawbacks and its application in the industry.~~	Theory classes and pictorial presentations about the methods of enzyme immobilization with an emphasis on the underlying principles and uses.	Quiz based on objective questions (match-the-following, fill in blanks, one-word answers, etc.)

***Assessment tasks listed here are indicative, and may vary**

MICROB-CC502: IMMUNOLOGY

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:

The major objective of this course is to develop a clear understanding about the host immune system and advances in the field of Immunology. The student will become familiar with the cells, tissues,

and organs constituting the immune system and the various mechanisms used to defend host against microorganisms. The student will gain an understanding of the relationship between the immune system, pathogens and the development of immunity, and will learn how the inappropriate immune response can lead to allergy, autoimmunity and other consequences. The course will further the student's understanding of how advances in immunology have changed the face of modern medicine.

Course Learning Outcomes:

Upon successful completion of the course, the student:

CO1: Will be acquainted with the emergence of immunology and how the immune system protects us from infection through various lines of defense.

CO2: Will have gained an in-depth knowledge of characteristics and functions of the cells of the immune system and the organization of organs of the immune system.

CO3: Can understand the characteristics that make the molecules to act as antigens. The students will also be conversant with the types, properties and functions of antibodies made against the antigens. Will be able to outline the production and use of monoclonal antibodies.

CO4: Will understand the cell surface proteins essential for generation of acquired immune response to differentiate self and non-self molecules and the pathways for antigen processing and presentation.

CO5: Will be acquainted with the mechanisms by which the complement system is recruited and enhances (complements) the ability of antibodies and phagocytic cells to clear microbes and damaged cells from an organism, promotes inflammation, and attacks the pathogen's cell membranes.

CO6: Will be acquainted with the generation and the killing mechanisms of humoral and cell mediated immunity. Will have gained in depth knowledge of various immunological techniques. Will be able to outline the immunodeficiency disorders like autoimmunity and hypersensitivity.

Contents:

Unit 1: History and basic concepts of Immunology: Contributions of the following scientists in development of the field of Immunology: Edward Jenner, Karl Landsteiner, Paul Ehrlich, Elie Metchnikoff, Peter Medawar, MacFarlane Burnet, Neils K Jerne, Rodney Porter, Susumu Tonegawa, Tiselius and Kabat, Jules Bordet, Charles Richet, Gerald M. Edelmen, Peter C. Doherty, Rolf M. Zinkernagel, Cesar Milstein and Georges E. Kohler, George Snell, Jean Dausset, Baruj Benacerraf. Concept of non-specific (innate immunity) and specific immunity (adaptive immunity). Phagocytosis, inflammation. Introduction to immunological tolerance. **5**

Unit 2: Immune cells and organs : Structure, functions and properties of immune cells – Stem cell and hematopoeisis, lymphoid lineage cells (T cell, B cell, NK cell), myeloid lineage cells (macrophage, neutrophil, eosinophil, basophil, mast cell, dendritic cell). Central and peripheral immune organs**.** **7**

Unit 3: Antigens and antibodies : Antigens: Properties of a molecule to be an antigen- foreignness, molecular size, heterogeneity. Contribution of the host individual for the functioning of an antigen. Haptens, epitopes of an antigen (T and B cell epitopes), T – dependent and T – independent antigens, adjuvants. Antibodies : Structure, types, functions and properties of antibodies, antigenic determinants on antibodies (isotypic, allotypic, idiotypic), monoclonal and chimeric antibody. Concept of VDJ rearrangement. **10**

Unit 4: Major Histocompatibility Complex: Organization of MHC locus (mouse and human), structure and functions of MHC I and MHC II molecules, cytosolic and endocytic pathway of antigen processing. **5**

Unit 5: Complement system: Components of complement system. Classical, alternative and lectin pathways of complement activation. Biological consequences of complement activation. Complementation fixation test. **6**

Unit 6: Generation and detection of immune response and associated immunological disorders:

Primary and secondary immune response: Generation of humoral immune response, generation of cell-mediated immune response (Self MHC restriction, T cell activation, Co-stimulatory signals), killing mechanisms by CTL and NK cells. **10**
Immunological techniques: Concepts of precipitation, agglutination, immunodiffusion, immunoelectrophoresis, ELISA, ELISPOT, western blotting, immunofluorescence, flow cytometry. **5**
Immunological disorders: Autoimmunity: types, mechanisms. **4**
Hypersensitivity: Concepts of all types of hypersensitivities with examples. **5**
Immunodeficiency: Animal models (nude and SCID mice), SCID, DiGeorge syndrome, Chediak-Higashi syndrome, leukocyte adhesion deficiency, CGD. **3**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Identification of human blood groups by agglutination.
2. Perform Total Leukocyte Count of the given blood sample.
3. Perform Differential Leukocyte Count of the given blood sample.
4. Separate serum from the blood sample (demonstration).
5. Perform immunodiffusion by double diffusion (Ouchterlony method).
6. Perform DOT ELISA.
7. Perform Immunoelectrophoresis.

Suggested Reading:

1. Abbas, A.K., Lichtman, A.H. and Pillai, S. (2017). *Cellular and Molecular Immunology*. 9th edition. Elsevier, USA.

2. Coico, R. and Sunshine, G. (2015). *Immunobiology: A short course*. 7th edition. Wiley-Blackwell Scientific Publication, UK.

3. Delves, P., Martin, S., Burton, D. and Roitt, I.M. (2017). Roitt's Essential Immunology. 13th edition. Wiley- Blackwell Scientific Publication, UK.

4. Murphy, K., Travers, P. and Walport, M. (2007). *Janeway's Immunobiology*. 7th edition. Garland Science Publishers, USA.

5. Peakman, M. and Vergani, D. (2009). *Basic and Clinical Immunology*. 2nd edition. Churchill Livingstone, UK.

6. Punt, J., Stranford, S., Jones, P. and Owen, J. (2018). *Kuby Immunology*. 8 th edition. W.H. Freeman and Company, USA.

7. Richard, C. and Geoffrey, S. (2009). *Immunology*. 6th edition. Wiley- Blackwell Scientific

Publication, UK.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks
1	Will be acquainted with the emergence of immunology And how the immune system protects us from infection through various lines of defence.	Interactive lectures on history of immunology. Detailed lectures on the contributions of major scientists. Descriptive lectures on the types of immunity	Quiz on the contributions. Group discussion on the defence system of the body
2	Will have gained an in-depth knowledge of characteristics and functions of the cells of the immune system and the organization of organs of the immune system	Pictoral presentation and theory lectures on characteristics cells of immune system. Familiarizing students with internal organization of organs of immune system. Class lectures on the localization and function of all the organs of the immune system	Exercise- Identify and name the cells/organs. Match the following exercise for cells / organs
3	Can understand the molecules that can act as antigens and also the antibodies that are made against the antigens. Will be able to outline the production and use of monoclonal antibodies.	Theory class on antigens and its properties. Pictoral demonstration of antigen interactions with the immune system cells. Detailed account on discovery of antibodies. Pictoral presentation of structure of antibodies. Theory class on Function and types and determinants of antibodies. Pictoral presentations of antigen antibody interactions. Class lecture on their discovery, properties and applications of monoclonal antibodies will be discussed	Class test antigens and their properties. Pictorial quiz on antibody structure and types. Group discussion on synthesis and applications of monoclonal antibodies
4	Will understand the cell surface proteins essential for generation of acquired immune response to differentiate self and nonself molecules and the pathways for antigen processing and presentation	Class lectures on structure of MHC molecules and familiarizing students with the function of MHC molecules. Detailed account of antigen processing and presentation using pictoral presentations	Quiz on Structure and function of MHC molecules. Draw the pathways for endocytic and cytosolic pathways
5	Will be acquainted with the mechanisms by which the complement system is recruited and enhances (complements) the ability of antibodies and phagocytic	Lecture on complement system. Pictoral presentation of the three pathways of complement activation. Detailed discussion on the role of	Presentation on complement proteins, activation pathways and biological consequences

	cells to clear microbes and damaged cells from an organism, promotes inflammation, and attacks the pathogen's cell membranes	complement proteins in an immune response. Relevant online videos	
6	Will be acquainted with the generation and the killing mechanisms of humoral and cell mediated immunity. Will have gained in depth knowledge of various immunological techniques. *Will be able to outline the Immunodeficiency* disorders like autoimmunity and hypersensitivity	Lecture on generation of Humoral Immunity. Detailed explanation of generation of cell mediated immune response. Discussion on principles aand applications of different immunotechniques using audio- visual aids. Detailed discussion on types of immunodeficiency disorders	Class test on humoral immunity and cell mediated immunity. Presentation on immunotechniques. Picture based identification activity on Immunotechniques. Group task on immunodeficiency disorders

***Assessment tasks listed here are indicative, and may vary.**

MICROB-CC601: MEDICAL MICROBIOLOGY

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:

The major objective of this course is to introduce and acquaint the students with the key aspects of medical microbiology related to the diverse microbial pathogens, their virulence mechanisms, diagnostic methods and brief outline of the functional aspects of antimicrobial chemotherapy. The paper deals with the recent development of new molecular diagnostic methods and the global spread and re-emergence of infectious diseases.

Course Learning Outcomes:

Upon successful completion of the course, the student:

CO1: Will have understood the diverse nature of the normal microflora of the body and its significance as well. Student will have also acquainted themselves with the terminology and scientific nomenclature used in describing disease causation and pathogenic features of microbial agents of disease.

CO2: Will have gained an in depth knowledge about the spectrum of diseases caused by bacterial pathogens, and an understanding of the course of disease development and accompanying symptoms. Will become familiar with the methods of transmission, epidemiological aspects as well as prevention and control methods.

CO3: Will become acquainted with the spectrum of diseases caused by viral pathogens. Also will understand the course of disease development and symptoms seen in diseases of different organ systems.

CO4: Will understand the causation of fungal and protozoal diseases and methods of prevention and control.

CO 5: Will learn about the current approaches to diagnosis of diseases.

CO 6: Will have learnt basic concepts of handling clinical specimens and approaches used to aid in detection/diagnosis of diseases using immunological and molecular biology based methods. Will also understand the mode of action of different antimicrobial agents and concept of antimicrobial resistance.

Contents:

Unit 1: Microbiota of the human body and introduction to pathogenicity and infection: Microbiota of skin, throat, gastrointestinal tract, urogenital tract. Significance of microbiome. Definitions: Pathogen, infection, invasion, virulence and its determinants, pathogenicity, endotoxins and exotoxins, carriers and their types, opportunistic infections, nosocomial infections. transmission of infection, sepsis and septic shock. **8**

Unit 2: Human diseases caused by bacterial pathogens: List of diseases of various organ systems and their causative agents. Symptoms, mode of transmission, prophylaxis and control of the following diseases: Respiratory diseases- caused by *Streptococcus pyogenes*, *Haemophilus influenzae, Mycobacterium tuberculosis*. Gastrointestinal diseases – caused by *Escherichia coli*, *Salmonella typhi*, *Vibrio cholerae*, *Helicobacter pylori*. Others- caused by *Staphylococcus aureus, Bacillus anthracis, Clostridium tetani*, *Treponema pallidum, Clostridium difficile*. **15**

Unit 3: Human diseases caused by viral pathogens: Polio, Herpes, Hepatitis, Rabies, Dengue, AIDS, Influenza (swine flu and bird flu), Ebola, Chikungunya, Japanese Encephalitis, Rota virus, Zika virus - causes, symptoms, diagnosis and treatments. **15**

Unit 4: Human diseases caused by protozoan and fungal pathogens: Malaria, Kala-azar – causes, symptoms, diagnosis and treatments. Brief description of the following types of mycoses and one representative disease in detail: Cutaneous mycoses- Tinea pedis (Athlete's foot). Systemic mycoses- Histoplasmosis. Opportunistic mycoses - Candidiasis **6**

Unit 5: Current approaches to diagnosis: Collection, transport and culturing of clinical samples. Principles of different diagnostic tests: ELISA (rapid diagnostic kits) and agglutination-based tests (Widal and VDRL test). Specific approaches to diagnose pathogens that are difficult to detec/culture by routine methods: Plasmid fingerprinting (creation of database for a wide collection of circulating strains of bacterial pathogens); indirect immunofluorescence test for syphilis; monoclonal antibody-based detection kits; immunoblotting for HIV, radio-immunoassays and its applications in cardiology, blood banking, diagnosis of allergies and endocrinology; diagnostic use of microarrays; PCR-ELISA test to detect specific serotypes of rotavirus; flow cytometry for analysing heterogeneous microbial populations and for diagnosis of *Legionella pneumophila*. **7**

Unit 6: Anti-microbial chemotherapy: Antimicrobial agents: General characteristics and mode of action. Antibacterial agents: Five modes of action with one example each: Inhibitor of nucleic acid synthesis; Inhibitor of cell wall synthesis; Inhibitor of cell membrane function; Inhibitor of protein synthesis; Inhibitor of metabolism. Antifungal agents: Mechanism of action of Amphotericin B, Griseofulvin. Antiviral agents: Mechanism of action of Amantadine, Tamiflu, Azidothymidine. Antimicrobial resistance: MDR, XDR, TDR. NDM-1. Brief overview of various approaches used for developing vaccines. National immunization schedule and other current vaccines. **9**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Identify bacteria, *E. coli, Salmonella, Pseudomonas, Staphylococcus, Bacillus, Klebsiella* (any three) on the basis of cultural, morphological and biochemical characteristics: IMViC, TSI, nitrate reduction, urease and catalase tests.

2. Study of composition and use of important differential media for identification of bacteria: EMB Agar, Mannitol salt agar, Deoxycholate citrate agar, TCBS.

3. Study of bacterial flora of skin by swab method.[1] Flowchart to describe approach to metagenomics of oral microbiome.

4. Perform antibacterial sensitivity by Kirby-Bauer method.

5. Study symptoms of the diseases with the help of photographs: Polio, anthrax, herpes, chicken pox, HPV warts, AIDS (candidiasis), dermatomycoses (ring worms).

6. Study of various stages of Malarial parasite in RBCs and *Leishmania* using permanent mounts/photomicrographs.

Suggested Reading:

1. Ananthanarayan, R. and Paniker, C.K.J. (2017). *Textbook of Microbiology*. 10th edition. Universities Press, India.

2. Carroll, K.C., Morse, S.A., Mietzner, T.A. and Miller, S. (2016). *Jawetz, Melnick and Adelberg's Medical Microbiology*. 27th edition. McGraw Hill Education.

3. Madigan, M.T. and Martinko, J.M. (2017). *Brock Biology of Microorganisms.* 15th edition. Prentice Hall International Inc., USA.

4. Tortora, G.J., Funke, B.R., Case, D., Weber, D. and Bair, W. (2019). *Microbiology: An Introduction.* 13th edition. Pearson Education, USA.

5. Willey, J. M., Sandman, K. and Wood, D. (2019). *Prescott's Microbiology.* 11th edition. McGraw Hill Higher Education, USA.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks
1	Will have understood the diverse nature of the normal microflora of the body and its significance as well. Student will have also acquainted themselves with the terminology and scientific nomenclature used in describing disease causation and pathogenic features of microbial agents of disease..	Class room lectures on human microbiome, detailed description of terms in relation to disease causation and outcome of infection. Pictorial representation of various organ systems with the corresponding microflora.	Test and quiz on human microbiome and important terms related to infection.
2	Will have gained an in depth knowledge about the spectrum of diseases caused by bacterial pathogens, and an understanding of the	Class room lectures and flow charts on causation of disease by bacterial pathogens. Pictorial representation of various signs and symptoms of diseases.	Test and quiz on virulence markers, symptoms, transmission and epidemiology of

	course of disease development and accompanying symptoms. Will become familiar with the methods of transmission, epidemiological aspects as well as prevention and control methods.	Graphical representation of epidemiological data by pie charts etc.	various bacterial diseases. Match the following type quiz on disease and causative agent. Identification of disease based on photographs of specific disease presentation. MCQs on causation of disease and prevention and control.
3	Will become acquainted with the spectrum of diseases caused by viral pathogens. Also will understand the course of disease development and symptoms seen in diseases of different organ systems.	Class room lectures, Ems of causative agents and photographs of symptoms.	Quiz, MCQs, Match the following questions, Spotting of various viral EMs and disease symptoms.
4	Will understand the causation of fungal and protozoan diseases and methods of prevention and control.	Class room lectures and interactive discussions on current fungal and protozoan diseases.	Class test, quiz and MCQ type questions.
5	Will learn about the current approaches to diagnosis of diseases.	Class room lectures and interactive discussions on recent developments in the area of disease diagnosis	Class test, quiz and MCQ type questions on diagnostic methods.
6	Will have learnt basic concepts of handling clinical specimens and approaches used to aid in detection/ diagnosis of diseases using immunological and molecular biology based methods.	Class room lectures and videos and discussion regarding specific target sites and modes of action of various antibiotics. Detailed account of contemporary diagnostic methods and applications.	MCQs and quiz on mode of action of antibiotics. Surprise quiz and match the following on various diagnostic techniques.

*** Assessment tasks are indicative and may vary.**

MICROB-CC602: RECOMBINANT DNA TECHNOLOGY

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:

The main objective of this paper is to ensure that the student develops a clear comprehension of the concepts of recombinant DNA technology. The student will get acquainted with the tools and techniques used such as the enzymes, vectors, and cloning methods that can be used, and the applications of cloning such as creation of DNA libraries and recombinant products. A final exercise on a suitable strategy towards developing a genetically modified crop is incorporated to empower the student to apply the knowledge gained.

Course Learning Outcomes:
Upon successful completion of the course, the student:

CO1: Will get an overview of developments and contributions of scientists in the field of genetic engineering.

CO2: Will get familiarized with basic cloning tools such as enzymes used to manipulate DNA, and cloning vectors.

CO3: Will have learnt various gene delivery methods and basic essential techniques of DNA, RNA and protein analysis.

CO4: Will gather in-depth knowledge of DNA amplification and sequencing methods.

CO5: Will become conversant with construction and screening of genomic and cDNA libraries.

CO6: Will become aware of the applied aspects of all major techniques being used for the benefit of humankind in the areas of agriculture and pharmaceuticals. Students will design a strategy outlining all the steps of developing a novel recombinant.

Contents:

Unit 1: Introduction to genetic engineering: Milestones in genetic engineering and biotechnology. Contributions of pioneers such as Bolivar and Rodriguez, Messing, Clark, Arber, Smith and Nathans, Boyer and Cohen, Paul Berg, Alec Jeffrey, Craig Venter, Kary Mullis, Sanger, Southern, Alwine, Burnett. **4**

Unit 2: Tools of molecular cloning - enzymes and vectors: Restriction-modification systems: Types I, II and III. Nomenclatures of restriction enzymes. Applications of type II restriction enzymes in genetic engineering, mode of action, generation of blunt versus staggered ends, frequency of recognition sequences in a DNA molecule, analyses of restriction enzyme-mediated cleavage of DNA, star activity, isoschizomers and neoschizomers. Other endonucleases: DNase I, S1 nuclease. DNA modifying enzymes and their applications: DNA polymerases, alkaline phosphatase, T4 polynucleotide kinase, terminal deoxynucleotidyltransferase. DNA ligases. Cloning vectors: Definition, nomenclature and properties, capacity. Plasmid vectors: pBR, pUC and pGEM series. Phage vectors: lambda (insertion and replacement) vectors, M13-based vectors. Phagemids. Cosmids, BACs, YACs. Applications of different vector types. Use of linkers, adaptors, homopolymer tailing, and insertional inactivation (including alpha complementation). Expression vectors: Distinction between cloning and expression vectors. *E. coli* lac and T7 promoter-based vectors, cassettes and gene fusions, yeast vectors (YIp, YEp, YRp and YCp vectors), baculovirus-based vectors, mammalian SV40 based expression vectors. **16**

Unit 3: DNA delivery methods and methods of analysis of DNA, RNA and proteins. Gene delivery by calcium chloride-based chemical method, microinjection, electroporation, biolistics (gene gun), liposome and viral-mediated delivery, *Agrobacterium* - mediated delivery. DNA and RNA analysis by agarose gel electrophoresis, Southern Blotting, Northern Blotting, Dot Blot, DNA microarray analysis. Protein analysis by SDS-PAGE and western blotting. Analysis of DNA-protein interactions by electrophoretic mobility shift assay and DNA Footprinting. Phage display. **16**

Unit 4: DNA amplification and DNA sequencing: PCR: Basics of PCR, primer designing, RT-PCR, Real-Time PCR. Sanger's method of DNA Sequencing, automated DNA sequencing. Primer walking. Hierarchical versus whole genome shotgun sequencing. Human genome sequencing project. Introduction to next generation sequencing methods. **8**

Unit 5: Construction and screening of genomic and cDNA libraries: Preparation and uses of genomic and cDNA libraries. Screening of libraries by colony hybridization and colony PCR. Screening of expression libraries by immunoscreening and bioactivity assays. **4**

Unit 6: Applications of recombinant DNA technology: Gene therapy: types and strategies. Products of human therapeutic interest: Insulin, hGH (somatotropin and somatostatin). Products of agricultural importance: Flavr Savr Tomato, Bt cotton, plants that have been genetically modified to be stress resistant. Forensics: Application of restriction fragment length polymorphisms in DNA fingerprinting methods. Importance of mitochondrial DNA in forensics. Designing a detailed strategy towards developing a genetically modified crop. **12**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Digestion of given DNA by using restriction enzymes and analysis by agarose gel electrophoresis.
2. Ligation of DNA fragments and analysis by agarose gel electrophoresis.
3. Graphical determination of molecular weight of DNA fragments from agarose gel electrophoresis profile.
4. Interpretation of sequencing gel electropherogram (Sanger's method).
5. Designing primers for DNA amplification.
6. Demonstration of DNA amplification by PCR.
7. Demonstration of Southern Blotting.

Suggested Reading:

1. Brown, T.A. (2016). *Gene Cloning and DNA Analysis: An introduction*. 7th edition. Wiley-Blackwell Publishing, U.K.
2. Clark, D.P and Pazdernik, N.J.(2015). *Biotechnology.* 2nd edition. Academic Press, USA.
3. Glick, B.R. and Patten, C.L. (2017). *Molecular Biotechnology: Principles and Applications of Recombinant DNA*. 5th edition. ASM Press, USA.
4. Glick, B.R., Pasternak, J.J. and Patten, C.L. (2009). *Molecular Biotechnology*. 4th edition. ASM Press, USA.
5. Green, M. and J. Sambrook, J. (2012). *Molecular Cloning: A Laboratory Manual*. 4th edition. Cold Spring Harbour Laboratory Press, USA.
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.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks
1	Will get an overview of developments and contributions of scientists in the field of genetic engineering	Chalk and talk sessions, powerpoint presentations and classroom discussions on major milestones of RDT (how and when these took place).	Group discussion on pioneers of recombinant DNA technology. Multiple choice question-type quiz.
2	Will get familiarized with basic cloning tools such as enzymes used to manipulate DNA, and cloning vectors	Detailed discussion on development, maps and characteristics of various cloning and expression vectors, as well as DNA manipulating enzymes.	Class test to evaluate the comprehension of various cloning vectors and other cloning tools.
3	Will learn various gene delivery methods and basic essential techniques of DNA, RNA and protein analysis	Traditional classroom lectures and use of audio-visual resources as well as hands-on exposure to the common analytical techniques.	Analysis through flow charts, assignments and discussion on trouble shooting of these techniques.
4	Will gather in-depth knowledge of DNA amplification and sequencing methods	Classroom lecture followed by audiovisual presentations. Learning videos and virtual laboratory.	Worksheets on primer designing and DNA sequencing, distinguishing various types of PCR from each other.
5	Will become conversant with construction and screening of genomic and cDNA libraries.	Interactive lectures and powerpoint presentations.	Assignment to design a library construction work flow plan.
6	Will become aware of the applied aspects of all major techniques being used for the benefit of humankind in the areas of agriculture and pharmaceuticals. Students will design a strategy outlining all the steps of developing a novel recombinant.	Traditional lectures and power point presentations on strategies of developing genetically modified organisms and useful biotechnological products.	Class tests for RDT strategies. Group discussions on published success stories of recombinant products. Designing a practical for developing a novel recombinant product.

***Assessment tasks listed here are indicative, and may vary.**

MICROB-DSE501: BIOINFORMATICS

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:

The major objective of this paper is to develop a clear understanding and application of the various concepts in bioinformatics which encompasses molecular biology, genetics, genomics, transcriptomics, proteomics, interactomics and their applications in research and development. This will enable students to take up interdisciplinary subjects later.

Course Learning Outcomes:

Upon successful completion of the course, the student:

CO1: Will be acquainted with bioinformatics and its relation with molecular biology, genetics and genomics, understanding of relational databases, various modes of data transfer and simultaneously learning the advantages of encrypted data transfer, gained an in-depth knowledge of primary, secondary and composite databases, organization of diverse types of biological databases.

CO2: Will be familiar with the file formats of sequence ad molecular file formats. This allows students to apply the acquired knowledge in retrieving and analyzing biological information on the web.

CO3: Will have learnt the concept and significance of sequence alignment, use of scoring matrices and gaps penalty, comparative assessment of global and local sequence alignment, approaches and softwares used for pairwise and multiple sequence comparisons and their applications

CO4: Will be conversant with phylogeny, types of phylogenetic trees, and approaches of phylogenetic tree construction and will be able to choose appropriate phylogenetic method for the desired group of sequences

CO5: Will have gathered understanding of diversity of viral, prokaryotic, eukaryotic genomes and their organization, sequencing strategies, also the knowledge of current techniques in genomic and interactomics along with current concepts in gene organization, challenges in gene prediction, primer designing.

CO6: Will understand the details of primary, secondary and tertiary structure of proteins, knowledge of domains, motifs and folds, strategies on protein structure prediction, Protein modeling approaches and rational drug designing and discovery.

Contents:

Unit 1: Introduction to Bioinformatics and biological databases: Aims and Scope of Bioinformatics. Mode of data transfer (FTP, SFTP, SCP), advantage of encrypted data transfer. Challenges in Omics data management, curation and annotation, Biological databases – nucleotide sequence, genome, protein sequence and structure, gene expression, SNP, chemical, metabolic pathways, signalling pathways, general human genetics, cancer gene. **10**

Unit 2: Sequence file formats: File formats - FASTA, Genbank and Uniprot, Data submission and retrieval from NCBI, EMBL, DDBJ, PDB. **6**

Unit 3: Sequence alignments: Basic concepts of sequence similarity, sequence alignment, Hamming distances, Levenstein distances, gap penalty, local and global sequence alignment, BLAST and its types, pairwise and multiple sequence alignment, scoring an alignment, brief introduction to scoring matrices. **8**

Unit 4: Phylogenetic analysis: Representation of phylogeny, types of phylogenetic trees, molecular clocks. Different approaches of phylogenetic tree construction-UPGMA, neighbour joining, maximum parsimony, maximum likelihood, softwares for phylogeny (PHYLIP, MEGA). **8**

Unit 5: Genomics Analysis: Diversity and features of completed genomes: Viral, prokaryotic (*E.coli)* and eukaryotic genomes (*Arabidopsis,* Human). Codon bias and optimization. Primer designing. Gene prediction methods. Techniques used in genomics and transcriptomics: NGS, Microarray, RNAseq. **10**

Unit 6: Protein structure and proteomics: Hierarchy and features of protein structure: primary, secondary, tertiary and quaternary structures. Structural classes, motifs, folds and domains. Modelling of tertiary structure of protein in presence and absence of template. Use of Rasmol and Pymol. Energy minimizations and evaluation by Ramachandran plot. Proteome, interactome, 2-D gel electrophoresis,

MALDI-TOF spectrometry, STRING, MMDB. Computer aided drug discovery. **18**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Introduction to bioinformatics databases (any three): NCBI/PDB/DDBJ, Uniprot, PDB.

2. Sequence retrieval using BLAST.

3. Sequence alignment & phylogenetic analysis using clustal omega & PHYLIP.

4. Picking out a given gene from genomes using Genscan or other softwares (promoter region identification, repeat in genome, ORF prediction). Gene finding tools (Glimmer, GENSCAN), Primer designing, Genscan/Genetool.

5. Protein structure prediction: primary structure analysis, secondary structure prediction using psi-pred.

6. Homology modeling using Swissmodel. Molecular visualization using Jmol/Pymol, Protein structure model evaluation (PROCHECK).

7. Prediction of different features of a functional gene.

8. Virtual screening of drugs using autodoc.

Suggested Reading:

1. Baker, L. (editor). (2018). *Bioinformatics: Tools and Techniques*. 1st edition. Callisto Reference.

2. Ghosh, Z. and Mallick, V. (2015). *Bioinformatics- Principles and Applications*. 1st edition. Oxford University Press, India.

3. Kaushik, A.C., Kumar, A., Bharadwaj, S., Chaudhary, R. (2018). *Bioinformatics Techniques for Drug Discovery: Applications for Complex Diseases*. 1st edition. Springer International. 2018.

4. Lesk, M.A. (2014). *Introduction to Bioinformatics*. 4th edition. Oxford Publication, UK.

5. Malkoff, C. (editor) (2017). *Bioinformatics, Proteomics and Genomics.* Callisto Reference.

6. Mukhopadhyay, C.S., Choudhary, R.K. and Iquebal, M.A. (2017). *Basic Applied Bioinformatics.* 1st edition. Wiley-Blackwell, USA.

7. Rastogi, S.C., Mendiratta, N. and Rastogi, P. (2007). *Bioinformatics: methods and applications, genomics, proteomics and drug discovery*. 4th edition. Prentice Hall India Publication.

8. Selzer, P.M., Marhöfer, R.J. and Koch, O. (2018). *Applied Bioinformatics: An Introduction.* 2nd edition. Springer, USA.

9. Sinha, P.K. and Sinha, P. (2017). *Foundations of Computing*. 6th edition. BPB Publications, India.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks
1 & 2	Will be acquainted with bioinformatics and its relation with molecular biology, genetics and genomics, understanding of relational databases, various modes of data transfer and simultaneously learning the advantages of encrypted data transfer, gained an in-depth knowledge of primary, secondary and composite databases, organization of diverse types of biological databases. Will be familiar with the file formats of sequence ad molecular file formats. This allows students to apply the acquired knowledge in retrieving and analyzing biological information on the web.	Class room lecture on introduction and scope of Bioinformatics, Detailed talk on need for organization ad annotation of biological data. ICT/live session on features of different types of biological databases. Detailed discussion on parts of sequence and molecular file formats. Hands on session/video on tools/softwares for uploading and downloading data from NCBI, EMBL, DDBJ, PDB, UniProt	MCQ on primary, secondary and composite databases, Group task on identify the database with the help of a pictorial quiz. Give one word type of oral quiz on tools and softwares for data submissions and retrieval
3	Will have learnt the concept and significance of sequence alignment, use of scoring matrices and gaps penalty, comparative assessment of global and local sequence alignment, approaches and softwares used for pairwise and multiple sequence comparisons and their applications	Theory class on local and global sequence alignment, pairwise and multiple sequence alignment. Familiarizing students with similarity and homology. Practical example based teaching on calculation of best score using gap penalty, sequence retrieval using BLAST. Interactive lecture on softwares for pairwise (BLAST, FASTA) and Multiple sequence alignment (MEGA)	Mathematical problem on best sequence alignment. Exercise on Sequence retrieval using BLAST. Match the following type of quiz on
4	will be conversant with phylogeny, types of phylogenetic trees, approaches of phylogenetic tree construction and will be able to choose appropriate phylogenetic method for the desired group of sequences	Lecture on different types of phylogenetic tree. Diagrammatic representation of a phylogenetic tree. Detailed steps of phylogenetic tree construction. Class discussion on appropriate tree construction strategies with given sequences	Mathematical problem on construction a phylogenetic tree using the given set of sequences. Pop quiz on Identification of rooted and unrooted tree
5	Will have gathered understanding of diversity of viral, prokaryotic, eukaryotic genomes and their organization, sequencing strategies, also the knowledge of current techniques	Practical example-based teaching on viral, bacterial and eukaryotic genomes. Interactive discussion on genome organization and the recent developments in	MCQ on features of bacterial, viral and eukaryotic genomes. Problem solving question of gene prediction from a genomic sequence. Identify

	in genomics, proteomics and interactomics along with current concepts in gene organization, challenges in gene prediction, primer designing.	genome sequencing and assembly. Detailed explanation of NGS, microarray 2D PAGE, MALDI-TOF techniques. Practical example based primer designing and gene prediction	the technique type of pictorial quiz on MALDI, Microarray and, 2D PAGE, NGS. Exercise on primer design to isolate a mRNA
6	Will understand the details of primary, secondary and tertiary structure of proteins, knowledge of domains, motifs and folds, strategies on protein structure prediction, Protein modelling, approaches to drug discovery	Class lecture on hierarchy of protein structures, discussion on domains, folds and motifs. Practical example based teaching on prediction of protein structure. Practical exercise on evaluation of a model, 3D structure viewers (RasMOL, PyMOL). Hands on comparative modelling using SWISS MODEL. Video lecture on Molecular Docking	Pictorial Quiz on identification of secondary and super secondary structures. Exercise on protein structure prediction from a primary sequence

***Assessment tasks listed here are indicative, and may vary.**

MICROB-DSE502: INSTRUMENTATION AND BIOTECHNIQUES

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:
The major objective of this paper is to develop understanding of the key concepts of basic as well as some advanced experimental techniques used across biological sciences, with a focus on principle and design of the instruments. This will enable the students to connect between theoretical concepts of these techniques and their immense biological applications in diverse fields.

Course Learning Outcomes:
Upon successful completion of the course, the student:

CO1: Will have identified the principle components of a light microscope, fluorescence microscope, phase contrast microscope, confocal and electron microscope, simultaneously learning about their principles and practical applications in visualizing, identifying and measuring cell, its components and biomolecules. The student will be familiar with staining and preparation of samples for microscopy.

CO2: Will have gained an in-depth knowledge of principles and applications of paper chromatography, thin layer chromatography, gel filtration chromatography, ion- exchange chromatography, affinity chromatography, GC, HPLC. This enables the students to apply the acquired knowledge in isolation and separation of biomolecules for analysis.

CO3: Will have learnt basic concepts of various techniques used to resolve and analyze nucleic acids and proteins - agarose gel electrophoresis, native polyacrylamide gel electrophoresis, SDS-polyacrylamide gel electrophoresis, isoelectric focusing, 2D gel electrophoresis, zymogram preparation.

CO4: Will comprehend details of working principle and outline of UV-visible spectrophotometer as well as be able to understand absorption spectra of biomolecules, and will be able to interpret UV-visible and fluorescence spectroscopy outputs.

CO5: Will have clear fundamentals of centrifugation, RCF, sedimentation coefficient, different types of rotors used, principle and working of differential and density gradient centrifugation, preparative and analytical scales of centrifuge, and the specific uses of ultracentrifuge. Students will also be acquainted with limitations of each method.

CO6: Will be introduced to the concepts of advanced techniques like flow cytometry, circular dichroism, surface plasmon resonance and mass spectrometry. Students will also appreciate the applications of these techniques and recent developments that have come about due to these advanced techniques.

Contents:

Unit 1: Microscopy: Concept of reolving power and magnification. Principles and applications of bright-field and dark-field microscopy, fluorescence microscopy, phase contrast microscopy, confocal microscopy, electron microscopy (scanning, transmission and cryo- electron microscopy) and micrometry. **10**

Unit 2: Chromatography: Principles and applications of paper chromatography (including descending and 2-D), thin layer chromatography, column chromatography (gel filtration chromatography, ion-exchange chromatography, affinity chromatography, GLC, HPLC). **12**

Unit 3: Electrophoresis: Principles and applications of agarose gel electrophoresis, polyacrylamide gel electrophoresis: native and SDS-PAGE, isoelectric focusing, 2D gel electrophoresis. **10**

Unit 4: Spectrophotometry: Absorption spectra of biomolecules, colorimetry, turbidometry, UV spectrophotometry, fluorescence spectrophotometry, nanodrop and its applications. **10**

Unit 5: Centrifugation: Preparative and analytical centrifugation, types of rotors, differential centrifugation, density gradient centrifugation, ultracentrifugation. **8**

Unit 6: Advanced tools and techniques: Principles and applications of flow cytometry, circular dichroism, NMR, surface plasmon resonance, mass spectrometry. **10**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Use of micrographs to distinguish between different types of microscopy.
2. Ray diagrams of phase contrast microscopy and electron microscopy.
3. Separation of mixtures by paper / thin layer chromatography.
4. Demonstration of column chromatography.
5. Separation of protein mixtures by Polyacrylamide Gel electrophoresis (PAGE).
6. Determination of λ_{max} for an unknown sample and calculation of extinction coefficient.
7. Separation of components of a given mixture using a laboratory scale centrifuge.
8. Understanding density gradient centrifugation with the help of pictures / virtual labs.

Suggested Reading:

1. Cooper, G.M. (2018). *The Cell: A Molecular Approach*. 8th edition. Sinauer Associates, UK.

2. Freifelder, D. (1982). *Physical Biochemistry- Application to Biochemistry and Molecular Biology*. 2nd edition. W.H. Freemen and Company, USA.

3. Hofmann, A. and Clokie, S. (editors). (2018). *Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology*. 8th edition. Cambridge University Press, UK.

4. Klostermeier, D. and Rudolph, M.G. (2017). *Biophysical Chemistry.* 1st edition. CRC press, UK.

5. Nelson, D.L. and Cox, M.M. (2017). *Lehninger Principles of Biochemistry*. 7th edition. W.H. Freeman and Company, UK.

6. Nigam, A. and Ayyagari, A. (2007). *Lab Manual in Biochemistry, Immunology and Biotechnology*. Tata McGraw Hill, India.

7. Skoog, D.A., Holler, F.J. and Crouch, S.R. (2017). *Principles of Instrumental Analysis by D.A.* 7th edition. Cengage Learning, USA.

8. Willey, J. M., Sandman, K. and Wood, D. (2019). *Prescott's Microbiology.* 11th edition. McGraw Hill Higher Education, USA.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks
1	Students will have identified the main components of a light microscope, fluorescence microscope, phase contrast microscope, confocal and electron microscope, simultaneously learning about their principle and practical applications in visualizing, identifying and measuring cell, its components and biomolecules. The student will be familiar with staining and preparation of samples for microscopy.	Class room lectures on principles of optics and types of microscopy, power point presentations/videos of parts of different types of microscopes, interactive session on applications of bright-field, dark-field microscopy, fluorescence microscopy, phase contrast microscopy, confocal and electron microscopy; Demonstration of sample preparation for electron microscopy; Practical example based teaching in micrometry.	Quiz on identification of parts of a microscope, Group task to identify specific applications of each type of microscopy in environmental and medical applications.
2	Will have gained an in-depth knowledge of principles and applications of paper chromatography, thin layer chromatography, gel filtration chromatography, ion-exchange chromatography, affinity chromatography, GC, HPLC. This enables the students to apply their acquired knowledge in isolation and separation of	Theory class on principles and applications of paper chromatography, thin layer chromatography, gel filtration chromatography, ion- exchange chromatography, affinity chromatography, GC and HPLC; Video on column packing and fraction collection; Interactive session on choice of solvents in paper and TLC Example based teaching on matrix for Gel	Class test as well as discussions to identify and describe the principles and applications of these techniques; An exercise to design a methodology for purification of an enzyme; Selection

	biomolecules for analysis.	filtration , ion exchange and affinity chromatography. Video demonstration of GLC and HPLC.	of material for various forms of chromatographies.
3	Will have learnt basic concepts of various techniques used to separate and analyze nucleic acids and proteins - Agarose gel electrophoresis, Native polyacrylamide gel electrophoresis, SDS-polyacrylamide gel electrophoresis, 2D gel electrophoresis, Isoelectric focusing, Zymogram preparation.	Theory class on principle and techniques of Agarose gel electrophoresis, Native PAGE, SDS- PAGE, 2D gel electrophoresis, Isolelectric point, zwitter ions, IEF and Zymogram; Video/demonstration of horizontal and vertical gel electrophoresis; Interactive session on visialization of DNA, RNA and Proteins in gel; Example based teaching on separation of components and molecular mass determination (eg: myofibrils).	Exercise on determination of molecular weight from the gel using Rf values; pin pointing the roles of all the components used in electrophoresis protocols.
4	Will comprehend details of working principle and outline of UV-Visible Spectrophotometer so as to enable the students to understand absorption spectra of biomolecules, to interpret UV-Visible and fluorescence spectroscopy.	Classroom lectures and power point presentations on parts of spectrophotometer, Beer Lambert's laws, absorption spectra, emission spectra , chromatophores, fluorophores; Detailed account of UV-Visible and fluorescence spectroscopy; experimental demonstartion of determination of λmax and extinction coefficient.	Class tests and group discussions; Practical exercise on determination of λmax and extinction coefficient using absorbance values.
5	Students will have clear fundamentals of centrifugation, RCF, sedimentation coefficient, different types of rotors used, principle and working of differential and density gradient centrifugation, preparative and analytical scales of centrifuge, and the specific uses of ultracentrifuge. Students will also be acquainted with limitations of each method.	Lecture on basic principle of sedimentation, types of centrifuges; Introduction to centrifugal rotors and pictorial representation; Detailed discussion on the concept and applications preparative and analytical centrifuge, density gradient and differential centrifugation; Differential and density gradient centrifugation as well as ultracentrifugation by audiovisual aids; Calculation of RCF, centrifugal field, angular velocity, sedimentation coefficient on blackboard.	Mathematical problems on RCF and angular velocity Test to describe and mutually distinguish density gradient from differential centrifugation.
6	Introduction to the concepts of some of the popular advanced techniques namely Flow cytometry, Circular Dichroism, Surface Plasmon Resonance and MALDI-TOF. Students will also appreciate the recent developments and applications of these techniques.	Lecture on concepts and principle of Flow cytometry, Circular Dichroism, Surface Plasmon Resonance, MALDI-TOF; Detailed discussion on applications of CD, MALDI-TOF in protein characterization; Development of the latest multi-color flow cytometry instruments; Interactive session on analyzing multiple cellular parameters using different fluorescent labels; Problem based	Group task on " to enlist applications of Flow cytometry in medical microbiology and food microbiology" Oral discussion and short test to evaluate the principles and utility of these

		teaching on use of SPR for ligand-protein interactions.	techniques in modern science.

***Assessment tasks listed here are indicative, and may vary.**

MICROB- DSE503: PRINCIPLES OF GENETICS

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:
The major objective of this paper is to develop a clear understanding of various aspects of inheritance biology along with conceptual framework of genetics with emphasis on classical genetics, transmission genetics, quantitative genetics and population genetics in relation to survival and evolution. This will enable the students to better understand courses such as microbial diagnosis in health clinics and biotechnology oriented courses, promoting the understanding of the diagnosis of chromosomal aberrations using karyotyping in human diagnostics.

Course Learning Outcomes:

Upon successful completion of the course, the student:

CO1: Will have learnt the contributions of scientists in the field of inheritance biology and get acquainted with the various model organisms used in studying genetics.

CO2: Will have gained an in-depth knowledge of mendelian and non-mendelian principles.

CO3: Will understand the concept of linkage and crossing over and will learn the cytological basis and molecular mechanism of crossing over and its application to mapping.

CO4: Will have gathered an understanding of structural details of chromosomes. Will become familiar with the genetic consequences of change in structure and number of chromosomes with emphasis on normal and abnormal karyotypes.

CO5: Will get conversant with the various mechanisms and significance of extranuclear inheritance in different organisms with reference to chloroplast, mitochondria and kappa particles. Will also learn about the field of epigenetics.

CO6: Will have learnt of polygenic inheritance, heritability, and its measurement with emphasis on QTL mapping. Will be familiar with Hardy-Weinberg model describing the relationship between allele frequency and genotype frequency.

Contents:

Unit 1: Introduction to Genetics: Historical developments: contributions of G.J. Mendel, William Bateson, R.C. Punnet, Hugo de Vries, T.H. Morgan, Alfred H. Sturtevant, Carl Correns, Tracy Sonneborn, Arthur Boycott, Boris Ephrussi and Mary B Mitchell. Model organisms in genetic analyses and experimentation: *E.coli, Saccharomyces cerevisiae*, *Neurospora crassa, Caenorhabditis elegans, Drosophila melanogaster, Arabidopsis thaliana and Mus musculus.* **6**

Unit 2: Mendelian principles: Mendel's Laws: Dominance, segregation, independent assortment. Rediscovery of Mendel's principles. Deviation from Mendelian inheritance. Chromosome theory of inheritance: allele, multiple alleles, pseudoallele, complementation tests. Extensions and deviations of Mendelian genetics: allelic interactions, incomplete dominance and co-dominance, epistasis,

penetrance and expressivity. Complementation tests. Introduction to pedigree analysis. **12**

Unit 3: Linkage and Crossing over: Linkage and recombination of genes, two point test cross, three point test cross. Cytological basis of crossing over. Crossing over at four-strand stage. Molecular mechanism of crossing over. Introduction to linkage map. **10**

Unit 4: Characteristics of chromosomes: Structural organization of chromosomes: centromeres, telomeres and repetitive DNA. Packaging DNA molecules into chromosomes. Concept of euchromatin and heterochromatin. Normal and abnormal karyotypes of human chromosomes, chromosome banding, Giant chromosomes: polytene and lampbrush chromosomes. Variations in chromosome structure: Mechanism and genetic consequences of deletion, duplication, inversion and translocation. Disorders based on variation in chromosomal number and structural abnormalities: genetic basis and symptoms of Klinefelter syndrome, Turner syndrome and Down syndrome. **14**

Unit 5: Extra-chromosomal inheritance and epigenetics: Introduction and rules of extra-nuclear inheritance. Organelle heredity: chloroplast mutations in *Chlamydomonas* and *Mirabilis jalapa (*4'o clock plant*)*, mitochondrial mutations in *Saccharomyces* and *Neurospora,* maternal effects - shell coiling in *Limnaea peregra.* Infectious heredity: Kappa particles in *Paramecium.* Epigenetics: epigenetic alterations in genome and their impact. **9**

Unit 6: Quantitative and Population Genetics: Polygenic inheritance, heritability and its measurements, QTL mapping. Genetic variation in population. Gene pool. Hardy-Weinberg principle: allele and genotype frequencies in population. **9**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Mendelian deviations in dihybrid crosses.
2. Studying Barr Body with the temporary mount of human cheek cells.
3. Studying *Rhoeo* translocation with the help of slide preparation.
4. Karyotyping with the help of photographs.
5. Chi-Square Analysis through problems.
6. Study of polytene chromosomes using temporary mounts of salivary glands of *Chironomus* / *Drosophila* larvae.
7. Study of pedigree analysis through various problems.
8. Analysis of a representative quantitative trait.

Suggested Reading:

1. Ennis C. (2017). *Introducing Epigenetics : A graphic guide*. Icon Books Ltd, India.
2. Gardner, E.J., Simmons, M.J. and Snustad, D.P. (2005). *Principles of Genetics*. 8th edition. Wiley and Sons, UK.
3. Griffith, A., Wessler, S., Lewontin, R. and Carroll, S. (2007). *Introduction to Genetic Analysis*. 9th edition. W.H. Freeman and Co. USA.

4. Hartl, D.L. and Cochrane, B. (2017). *Genetics: Analysis of Genes and Genomes*. 9th edition. Jones and Bartlett Learning, USA.

5. Klug, W.S., Cummings, M.R., Spencer, C. and Palladino, M. (2018). *Concepts of Genetics*. 12th edition. Pearson Education, USA.

6. Parihar, P. (2018). *A Textbook of Basic and Molecular Genetics*. 1st edition. Agrobios, India.

7. Pierce, B.A. (2011). *Genetics: A Conceptual Approach*. 4th edition. Macmillan Higher Education Learning, UK.

8. Russell, P.J. (2009). *iGenetics- A Molecular Approach*. Benjamin Cummings, USA.

9. Weaver, R.F. and Hedrick, P.W. (1997). *Genetics*. 3rd edition. Brown Publications, USA.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Will learn the contributions of scientists in the field of inheritance biology and get acquainted with various model organisms.	Classroom lecture and powerpoint presentations on model organisms and discussing the discoveries done using them.	Class test based on advantages of different model organisms/ group discussion on model organisms and their importance in genetic analysis. Assignment and quiz on contributions of scientists.
2	Will gain an in-depth knowledge of Mendelian and non-Mendelian principles.	Detailed discussion on Mendel's laws and Extensions of Mendelian genetics. Interactive sessions drawing Punnett square diagrams for each cross. Pictorial presentations of different allelic Interactions.	Test on allelic Interactions by using different seed ratios.
3	Will understand the concept of linkage and crossing over. Also learn the cytological basis and molecular mechanism of crossing over with introduction to mapping.	Online video lectures on mechanisms of linkage and crossing over. Diagrammatic representation and detailed explanation of cytological basis and molecular mechanism of crossing over.	Class test of numericals and multiple problems based on linkage and crossing over.

4	Will gather an understanding of structure details of chromosomes. Also learn genetic consequences of change in structure of chromosomes with reference to deletion, duplication, inversion and translocation with emphasis on normal and abnormal karyotypes.	Pictorial presentations and explanations of different types of chromosomes. By using audio visual aids, classroom lectures on Karyotyping with the help of karyograms.	MCQs and Pictorial Quiz for identification of abnormal karyotypes. (chromosome analysis or Karyotyping)
5	Will get conversant with the mechanisms and significance of extranuclear inheritance in different organisms with reference to chloroplast, mitochondria and kappa particles. Will also learn about the new field of epigenetics.	Detailed discussion on organelle heredity,infectious heredity and maternal effect by Pictorial Presentations, diagrams and crosses.	Class Presentations on Various examples of extrachromosomal inheritance with mechanism and significance.
6	Will have learnt the polygenic inheritance, heritability, its measurement with emphasis on QTL mating. Will be familiar with Hardyweinberg model describing relationship between allele frequency and genotype frequency.	Classroom lecture on polygenic inheritance with examples of polygenic traits from plants and humans. Online videos on Hardy Weinberg theorem/ principle and equation for equilibrium.	Class tests/ MCQs Group discussion on various examples of quantitative traits and problems based on Hardy Weinberg principle.

***Assesment tasks listed here are indicative, and may vary.**

MICROB-DSE504: BIOMATHEMATICS AND BIOSTATISTICS

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:
The primary objective of this course is to understand the basic concepts of calculus and matrices and their applications in biological science with help of simple examples. The prime focus here is to prepare students to handle biological data as well as to draw appropriate conclusions from its analysis.

Course Learning Outcomes:
After completing this course, students will have developed a clear understanding of:

CO1: Functions, limits, continuity and differentiation along with their applications. Solving first order and first degree ordinary differential equation with constant coefficients. Concepts of Integration.

CO2: Sequence and series with examples. Understanding matrices with addition and multiplication operations. System of equations in matrix form.

CO3: Measures of central tendency, dispersion, skewness and kurtosis. Student will learn about discrete and continuous random variable, correlation and regression. Emphasis with examples on how descriptive statistics helps in analysing biological sciences data.
CO4 : Mean and Variance of Discrete namely Binomial, Poisson, Geometric. Fitting of Distributions, In-depth understanding of various Continuous Distributions namely Logistic, Exponential and Normal distribution. Learning Different probability distributions and their implementation in realistic models.

CO5: Different statistical methods: Principles of statistical analysis of biological data. Sampling parameters. Difference between sample and population, sampling errors, difference between parametric and non-parametric statistics. Concept of Sampling Distributions, Standard Error.; Basic concepts of hypothesis testing, including framing of null and alternative hypothesis, level of significance and degrees of freedom. Hypothesis testing based on a single sample and two samples using both classical and p value approach.

CO6: Large Sample Test based on Normal Distribution, Confidence Interval; Application of Chi-square test; Small sample test based on t-test and F test.

Contents:

Unit 1: Sets and their representation, Relation, Functions and graphs of linear and quadratic functions, sine, cosine, exponential and logarithmic functions; Linear inequality; Understanding of limit and continuity through graph and simple problems; Average rate of change, Instantaneous rate of change, derivative of sum and difference of two functions, derivative of product of two functions, derivative of quotient of two functions. Chain rule; Simple problems on rate of change. Increasing and decreasing functions; Integration as reverse process of differentiation. Definite Integral of a function f(x) on [a b]; Solving differential equations of first order and first degree with constant coefficients using the method of separated variables. **10**

Unit 2: Sequences to be introduced through the examples arising in Science beginning with finite sequences, followed by concepts of recursion equations. For instance, the Fibonacci sequence arising from branching habit of trees and breeding habit of rabbits; Intuitive idea of algebraic relationship and convergence; Infinite Geometric Series. Series formula for exp(x). log (1+x). sin x, cos x. Matrices: Type of matrices, examples, sum and product of matrices up to order3. Expressing a system of equations in the matrix form. **10**

Unit 3: Measures of Central Tendency - mathematical and positional; Measures of Dispersion - range, quartile deviation, mean deviation, standard deviation; coefficient of variation, skewness and kurtosis; Discrete and Continuous Random variables. **10**

Unit 4: Correlation and regression; Emphasis on examples from Biological Sciences; Mean and Variance of Discrete and Continuous Distributions namely Binomial, Poisson, Geometric, Logistic, Exponential and Normal distribution; Fitting of Distributions. **10**

Unit 5: Different statistical methods: Principles of statistical analysis of biological data. Sampling parameters. Difference between sample and population, sampling errors, difference between parametric and non-parametric statistics. Concept of Sampling Distributions, Standard Error.; Basic concepts of hypothesis testing, including framing of null and alternative hypothesis, level of significance and degrees of freedom. Hypothesis testing based on a single sample and two samples using both classical and p value approach. **8**

Unit 6: Large Sample Test based on Normal Distribution, Confidence Interval; Applications of Chi-square test; Small sample test based on t-test and F test. **12**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Handling of data using measures of central tendency.
2. Handling of data using measures of dispersion.
3. Problems based on skewness and kurtosis.
4. Finding Karl Pearson's correlation coefficient and interpretation of result.
5. Spearman rank correlation with and without ties.
6. Fitting of binomial distribution for n and p = q = ½ given.
7. Fitting of Poisson's distribution for given value of lambda.
8. Application problems based on binomial distribution.
9. Application problems based on Poisson's distribution.
10. Problems based on area property of normal distribution.
11. To find the ordinate for a given area for normal distribution.
12. Application based problems using normal distribution
13. Problems based on Large Sample Tests and interpretation of result
    a. Estimators of population mean.
    b. Confidence interval for the parameters of a normal distribution (one sample and two sample problems).
    c. Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems.
14. Application of Chi-Square Distribution and interpretation of result on given data set
    a. Chi-square test of proportions.
    b. Chi-square tests of association.
    c. Chi-square test of goodness-of-fit
15. Application of small sample tests and interpretation of result on given data set.

Suggested Reading:

1. Anton, H., Bivens, H. and Davis, S. (2002). *Calculus.* John Wiley and Sons, UK.

2. Daniel, W.W. (2005). *Biostatistics: A Foundation for Analysis in the Health Sciences*. John Wiley, UK.

3. Dass, M.N. and Giri, N.C. (1986). *Design and analysis of experiments.* John Wiley and Sons, UK.

4. Goldstein, A. (1971). *Biostatistics: An introductory text*. The Macmillan, USA.

5. Goon, A.M., Gupta, M. K. and Dasgupta, B. (2002).*Fundamentals of Statistics* Volumes I and II. 8th edition. The World Press, India.

6. Hogg, R.V., Tanis, E.A. and Rao, J.M. (2009). *Probability and Statistical Inference*. 7th edition. Pearson Education, India.

7. Kolman, B. and Hill, D.R. (2001). *Introductory Linear Algebra with Applications*. 7th edition. Pearson Education, India.

8. Miller, I. and Miller, M. (2012). *John E. Freund's Mathematical Statistics with Applications.* 8th edition. Pearson Education, India.

9. Mood, A.M., Graybill, F.A. and Boes, D. C. (2007). *Introduction to the Theory of Statistics*. 3rd edition. Tata McGraw-Hill Publishing Company, India.

10. Ross, S.L. (1984). *Differential equations*. 3rd edition. John Wiley and Sons, UK.

11. Thomas, G.B. and Finney, R.L. (2012). *Calculus.*11th edition. Pearson Education, USA.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks
1	Understanding Functions, limits, continuity and differentiation along with their applications. Solving first order and first degree ordinary differential equation with constant coefficients. Concepts of Integration.	Classroom lectures.	Class Assignments and Class Tests.
2	Sequence and series with examples. Understanding matrices with addition and multiplication operations. System of equations in matrix form.	Classroom lectures.	Class Assignments and Class Tests.
3	Understanding measures of central tendency, measures of dispersion, measures of skewness and kurtosis. Student will learn about Discrete and Continuous Random variables, correlation and regression. Emphasis on examples from Biological Sciences.	Classroom lectures and Practical work using SPSS/Excel.	Participation in class discussion and completion of assignments/MCQ, short quiz.
4	Learn Mean and Variance of Discrete namely Binomial, Poisson, Geometric. Fitting of Distributions; In-depth understanding of various Continuous Distributions namely Logistic, Exponential and Normal distribution. Fitting of Distributions.	Classroom lectures and Practical work using SPSS/Excel.	Participation in class discussion and completion of assignments, MCQ.
5	Different statistical methods: Principles of statistical analysis of biological data. Sampling parameters. Difference between sample and population, sampling errors, difference between	Classroom lectures and Practical work using SPSS/Excel.	Participation in class discussion as well as a test to evaluate their ability to apply concepts in practical examples

	parametric and non-parametric statistics. Concept of Sampling Distributions, Standard Error; Basic concepts of hypothesis testing, including framing of null and alternative hypothesis, level of significance and degrees of freedom. Hypothesis testing based on a single sample and two samples using both classical and p value approach.		
6	Learn about Large Sample Test based on Normal Distribution, Confidence Interval; Applications of Chi-square test; Small sample test based on t-test and F test.	Classroom lectures and Practical work using SPSS/Excel.	Class discussion, identification of appropriate tests based on sample size, interpretation of results & conclusion.

*** Assessment tasks are indicative and may vary.**

MICROB-DSE601: MICROBIAL BIOTECHNOLOGY

Marks: 100 **Duration: 60 hours (4 Credits)**

Course Objectives:

This paper is aimed at providing a clear understanding of the role of microorganisms in the advent of biotechnology, both traditional as well as modern. The student will become aware of the benefits and concerns of using microbe-based procedures/tools such as biosensors, biopesticides, bioplastics, bioleaching as well as genetically modified organisms. Non-traditional vaccines and the promise they hold will be discussed. Lastly, the much-required information about IPR and its main components would empower the students to protect their innovative research work in the future, and yet be able to fruitfully share with the deserving fellow users.

Course Learning Outcomes:

Upon successful completion of the course, the students:

CO1: Will get an overview of the possibility of using microbes in a number of technologies and fields for the direct/indirect benefit of mankind and the environment.

CO2: Will get familiarized with how manipulated producer microbes and/or procedures may yield products of medical/therapeutic value, hence contributing to human longevity.

CO3: Will learn how microorganisms are the mightiest candidates in fighting environmental pollution and minimizing xenobiotics, thereby elevating human living conditions. Biosensors and whole cell/enzyme immobilization would be appealing illustrations to the students as some of the strategies towards this goal.

CO4: Will delve deep into the role of microorganisms in maintaining environmental homeostasis, combating pollution, eliminating xenobiotics and inexpensive energy production from waste natural lignocellulosics.

CO5: Will become familiar with the contribution of specific microorganisms in traditional agriculture practices, and will become acquainted with GM crops, RNA interference and edible vaccines.

CO6: Will obtain information on IPR, its main components, national institutes related to the same, the know-how of start-ups and the importance of innovative research.

Contents:

Unit 1: Scope of Microbial Biotechnology: Role of microbial biotechnology in agriculture, healthcare, environment, genomics and proteomics with suitable examples. Critical assessment of genetically modified organisms (GMOs). Biotechnology trends in India with special reference to the premier biotechnology institutes and industries of our country. **8**

Unit 2: Human therapeutics: Advantages and disadvantages of prokaryotes and eukaryotes as expression systems for heterologous proteins. Production and applications of recombinant microbial products in medicine: Insulin, semi-synthetic penicillins, streptokinase, Hepatitis B vaccine. **8**

Unit 3: Industrial products: Production and applications of microbial polysaccharides and polyesters, biopesticides, bioplastics and role of microbial amylases in production of high fructose corn syrup. Microbial transformation of steroids and sterols. Enzyme/whole cell immobilization strategies for industrial processes and their applications, types of biosensors and their applications.**12**

Unit 4: Microbes for bioenergy and environment: Bioethanol and biodiesel production: commercial production from lignocellulosic waste and algal biomass. Biogas production: methane and hydrogen production using microbial culture. Microorganisms in bioremediation: degradation of xenobiotics, mineral recovery (bioleaching), removal of heavy metals from aqueous effluents, removal of dyes and phenolic compounds. **12**

Unit 5: Role of biotechnology in agriculture: Bio-fertilisers, PGPR's, mycorrhiza, plant tissue, and organ culture. Development of transgenic crops with special emphasis on insect resistance, herbicide resistance and viral resistance: development of Bt-cotton, Bt-brinjal and Golden rice. RNAi and its application in gene silencing and host-pathogen interaction. Production of edible vaccines. **14**

Unit 6: Role of IPR and innovations and Startups in Biotechnology: IPR in biotechnology: Patents, copyrights, trademarks and trade secrets. Purpose and role of different organizations related to IPR: WIPO, GATT, TRIPs. **6**

Practicals

Marks: 50 **Duration: 60 hours (2 credits)**

1. Study yeast cell immobilization and enzyme immobilization by calcium alginate method.
2. To study the activity and reuse of the immobilized enzyme.
3. Screening of soil samples for isolation of hydrolytic enzymes: protease, lipase, xylanase (any two) producing microorganisms using plate assay.
4. Hydrolysis of starch/casein/lignocellulosic residue.
5. Dye decolourization using microorganisms.
6. Expression of Green fluorescent protein (GFP) in *E. coli*.

Suggested Reading:

1. Crueger, W., Crueger, A. and Aneja, K.R. (2017). *Biotechnology: A Textbook of Industrial Microbiology*. 3rd edition. Medtech Publisher, India.

2. Demain, A.L., Davies, J.E. and Atlas, R.M. (1999). *Manual of Industrial Microbiology and Biotechnology*. 2nd edition. ASM Press, USA.

3. Dubey, R.C. (2014). *A Textbook of Biotechnology*. 5th edition. S. Chand and Co, India.

4. Glazer, A.N. and Nikaido, H. (2007). *Microbial Biotechnology: Fundamentals of Applied Microbiology*. 2nd edition. Cambridge University Press, UK.

5. Glick, B.R., Pasternak, J.J. and Patten, C.L. (2009). *Molecular Biotechnology*. 4th edition. ASM Press, USA.

6. P.K. Gupta, P.K. (2009). *Elements of Biotechnology*. 2nd edition. Rastogi Publications, India.

7. Ratledge, C. and Kristiansen, B. (2006). *Basic Biotechnology*. 3rd edition. Cambridge University Press, UK.

8. Stanbury, P.F., Whitaker, A. and Hall, S.J. (2016). *Principles of Fermentation Technology*. 3rd edition. Elsevier Science, Netherlands.

9. Willey, J. M., Sandman, K. and Wood, D. (2019). *Prescott's Microbiology.* 11th edition. McGraw Hill Higher Education, USA.

Facilitating the Achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Students will get an overview of the possibility of using microbes in a number of technologies and fields for direct/indirect benefit of mankind and environment.	Traditional teaching using chalk and board, powerpoint presentations and class discussions.	Brief, topic wise oral presentations on the present and future roles of various microorganisms in various fields touching human life.
2	Students will get familiarized with how manipulated producer microbes and/or procedures may yield products of immense medical/therapeutic value, hence contributing to human longevity.	Conventional chalk and talk lectures followed by slide shows and videos.	Assignments and presentations by the students of the subtopics, followed by interactive sessions in the end.
3	Students will learn how microorganisms are the mightiest candidates in fighting environmental pollution and minimising xenobiotics, thereby elevating human living conditions. Biosensors and whole	Traditional classroom lectures, powerpoint presentations, educational videos as well as hands-on exposure to immobilization by entrapment technique to demonstrate reusability of producer microbial	Analysis through flow charts, assignments, discussions and MCQs.

	cell/enzyme immobilization would be appealing illustrations to the students as some of the strategies towards this goal.	candidates.	
4	Students will dwell deep into the role of microorganisms in maintaining environmental homeostasis, combating pollution, eliminating xenobiotics and inexpensive energy production from waste natural lignocellulosics.	Chalk and talk lectures followed by slide shows.	Worksheets on various strategies and class tests.
5	Students will become conversant with the contribution of specific microorganisms in traditional agriculture practices, followed by acquainting the students with GM crops, RNA interference and edible vaccines.	Conventional blackboard teching, interactive lectures and powerpoint presentations.	Assignments and short oral presentations by the students.
6	Students will obtain information on IPR, its main components, national institutes related to the same, the know how of start-ups and the importance of innovative research.	Traditional lectures and power point presentations on strategies of developing genetically modified organisms and useful biotechnological products.	Interactive sessions on trade secrets, trade arks, copyrights with some famous success stories. Discussion on bioethics and lastly, some feasible start-up ideas in the form of project reports.

***Assessment tasks listed here are only indicative and may vary**

MICROB-DSE602: ADVANCES IN MICROBIOLOGY

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:

The major objective of this paper is to educate, students about newer concepts in microbiology including CRISPR/Cas system, metagenomics, system biology and which enable students to articulate and evaluate significant challenges or questions faced in the research. Moreover, it will develop a framework where students will be able to integrate in-depth knowledge to generate scientific hypothesis and develop theoretical and practical skills in designing and execution of experiments. This will also provide perspective for students who are interested in nanoscale physical and biological systems and their applications in biotechnology.

Course Learning Outcomes:

Upon successful completion of the course, the student:

CO1: Gains knowledge about features of sequenced genomes and ways of DNA transfer in nature and virulence in bacteria.

CO2: Will be able to acquire, articulate, retain and apply specialized knowledge and understanding of the core concept of CRISPR/Cas system for the future implication of research.

CO3: Will have learnt the concepts of metagenomics which circumvents the unculturability and genetic diversity of microbes, the biggest roadblocks to advances in biotechnology.

CO4: Will have gathered understanding of how plants protect them from pathogens and role of biofilms.

CO5: Will have learnt basic concepts of biological networks, their applications and get introduced to the basic principles of synthetic biology.

CO6: Will get acquainted with the basic concepts of nanotechnology, its development and the current applications.

Contents:

Unit 1: Evolution of microbial genomes: Salient features of sequenced microbial genomes. Core genome pool, flexible genome pool and concept of pangenome. Horizontal gene transfer (HGT). Evolution of bacterial virulence: Genomic islands, Pathogenicity islands (PAI) and their characteristics. **10**

Unit 2: **Genome editing using CRISPR-Cas system:** Mechanism, and components of the system. Variables for using CRISPR in mammalian system. Base editing without double-stranded breaks. Applications of CRISPR-Cas in research and disease biology. Ethical implications of CRISPR-based genetic manipulation. Limitations of CRISPR-Cas methodology. **10**

Unit 3: Metagenomics: Brief history and development of metagenomics. Sargasso Sea Project, Acid mine drainage Project, Human Microbiome Projects. Understanding bacterial diversity in soil using metagenomics approach. Prospecting genes of biotechnological importance using metagenomics. Basic knowledge and methods to study the viral metagenome. Brief overview of metatranscriptomics, metaproteomics and metabolomics. **10**

Unit 4: Molecular basis of host-microbe interactions: Gene for Gene hypothesis in plant pathogens. Plant resistance genes and their types. Hypersensitive response (HR) to plant pathogens and its mechanism. Signal transduction between pathogenicity gene and resistance gene. Sec and Tat Pathway. Type three secretion systems (TTSS) of plant and animal pathogens, and their comparison with other secretion systems. **14**

Unit 5: Systems biology and Synthetic biology: Systems Biology: concept and tools. Types of networks in biological systems (metabolic networks, cell signalling networks, protein-protein interaction networks). Systems Microbiology: Quorum sensing and quenching in bacteria, co-ordinated regulation of bacterial virulence factors. Biofilms: types of microorganisms, molecular aspects and significance in environment, health care, virulence and antimicrobial resistance. Synthetic Biology: Basic principles. Synthesis of poliovirus in laboratory. Future implications of synthetic biology with respect to bacteria and viruses. **10**

Unit 6: Introduction to Nanobiotechnology: Definition and developments in field of nanotechnology and nanobiotechnology. Applications: Use of viruses as nanoparticles, nanoprinting of DNA, RNA, and proteins, Biochips in nanoscale detection - Lab-on-a-chip Devices (LOC). Nanostructures in drug discovery, delivery, and controlled release. Nanostructures in cancer: Research and therapy. Environmental monitoring and food contaminant detection. **6**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Extraction of metagenomic DNA from soil, and understanding its analysis through given data.
2. Understand the impediments in extracting metagenomic DNA from soil.
3. PCR amplification of metagenomic DNA using universal 16S ribosomal gene primers.
4. Case study to understand how the poliovirus genome was synthesized in the laboratory.
5. Synthesis and analysis of silver nanoparticles from plants extracts/microbes.

Suggested Reading:

1. Agrios, G.N. (2005). *Plant Pathology*. 5th edition. Elsevier Academic Press, USA.
2. Dhawan, A., Singh, S., Kumar, A. and Shanker, R. (editors). (2018). *Nanobiotechnology: Human Health and the Environment*. CRC Press, USA.
3. Fraser, C.M., Read, T.D. and Nelson, K.E. (editors). (2004). *Microbial Genomes.* Humana Press, Springer, USA.
4. Kisak, P.F. (editor). (2017). *CRISPR Technology: The Revolutionary Breakthrough for Genetics and Evolution*. 1st edition. CreateSpace, USA.
5. Klipp, E., Liebermeister, W., Wierling, C., Kowald, A., Lehrach, H. and Herwig, R. (2009). *Systems Biology: A Textbook.* Wiley –VCH Verlag, Germany.
6. Madigan, M.T. and Martinko, J.M. (2017). *Brock Biology of Microorganisms.* 15th edition. Prentice Hall International Inc., USA.
7. Niemeyer, C.M. and Mirkin, C. A. (editors) (2005). *Nanobiotechnology: Concepts, Applications and Perspectives*. Wiley-VCH, Germany.
8. Voit, E.O. (2017). *A First Course in Systems Biology.* 2nd edition. Garland Science,USA.
9. Wege, C and Lomonsoff, G. (2018). *Virus Derived Nanoparticles for Advanced Technologies-Methods and Protocols.* Humana Press (Springer).
10. Wilson, B.A., Salyers, A.A., Whitt, D.D. and Winkler, M.E. (2010). *Bacterial Pathogenesis: A Molecular Approach*. 3rd edition. ASM Press, USA.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks
1	Student gets knowledge about features of sequenced genomes and ways of DNA transfer in	Class room lecture and PPT, worksheets and discussion on analyses of genome sequences through	Quiz, assignments, formulate a clear answerable questions

	nature and virulence in bacteria	bioinformatics databases	
2	Will be able to acquire, articulate, retain and apply specialized knowledge and understanding of the core concept of CRISPR/Cas system for the future implication of research on therapies for the genetic disorders	Lectures/PPT, pictorial representation, e-content and using audio/video Laboratory sessions, demonstrations	Assignments on Strategies of prospecting specific genes using metagenomics
3	Will have learnt the concepts of metagenomics which circumvents the unculturability and genetic diversity of microbes, the biggest roadblocks to advances in biotechnology	Lectures and laboratory sessions Interactive sessions on various metagenome projects Hands on session/video tools/softwares for analysis of metagenomic data	Assignments on Strategies of prospecting specific genes using metagenomics
4	Will have gathered understanding of how plants protect them from pathogens and role of biofilms.	Class room Lectures on different secretions systems and hypersensitive response and discussion on applications. Interactive lectures on selected organisms including *Yersinia*.	MCQ on cascades of secretion systems, seminar exercises
5	Will have learnt basic concepts of biological networks and their applications. They will understand quorum sensing in bacteria and its implications. Will understand basic principles of synthetic biology.	Lectures and Blended learning approach, PPT, face-to-face lessons with engaging online activities and resources, showing through ppts the various biological networks, biofilms And introduction of concepts of synthetic biology	Assignment, class test, mock viva Worksheets on biological networks
6	Will get acquainted with the basic concepts of Nanotechnology, its development and the current applications	PPTs, classroom lectures, Videos and E-content Discussion of its potential applications Laboratory sessions on synthesis	Presentations on different applications of nanobiotechnology

***Assessment tasks listed here are indicative, and may vary.**

MICROB-DSE603: PLANT PATHOLOGY

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:

The main objective of this course is to provide in-depth knowledge of plant diseases, the causes, symptoms, and the biochemical and genetical aspects of host-pathogen interactions. The student will become conversant with various means by which plants can defend themselves and plant diseases can

be controlled or prevented. This will enable the student to initiate studies in search of novel and eco-friendly means of disease control which would improve the quality and quantity of crops.

Course Learning Outcomes:
Upon successful completion of the course, the student:

CO1: Will be introduced to the concept and importance of plant diseases. Will also get acquainted with contributions of various plant pathologists.

CO2: Will gain in-depth knowledge of stages in the development of a disease which will form the base for further course material.

CO3: Will learn about types of diseases based on life cycles of hosts and pathogens, factors controlling them and how to forecast diseases in an Indian context.

CO4: Will understand how microbes attack plants using enzymes, toxins, growth regulators, etc. thereby affecting their physiological processes. Will also get conversant with the genetics of plant diseases and how plants defend themselves.

CO5: Will gain insight into how these diseases can be prevented and/or cured with various cultural methods, regulatory, physical, chemical and biological means.

CO6: Will acquire knowledge about causes, symptoms, epidemiology, and control of fungal and bacterial diseases.

Contents:

Unit 1: Introduction and history of plant pathology: Concept of plant disease: definitions of disease, pathogenesis and pathogenicity, symptoms associated with microbial plant diseases, types of plant pathogens, economic losses and social impact of plant diseases. Significant landmarks in the field of plant pathology: Contributions of Anton DeBary, Millardet, E. Smith, Ivanowski, Diener, Stakman, H.H. Flor, Van Der Plank, molecular Koch's postulates. Contributions of eminent Indian plant pathologists (K.C. Mehta, Mundkur, Dastur and Sadasivan). **4**

Unit 2: Disease cycle: Stages in the development of disease: Inoculation, penetration, infection, dissemination of pathogens (by air, water, vector, seed and vegetative propagation and humans) and perennation in bacteria and fungi. **4**

Unit 3: Plant disease epidemiology: Concepts of monocyclic, polycyclic and polyetic diseases, disease triangle, disease pyramid. Concept of disease severity, forecasting of plant diseases and its relevance in the Indian context. **6**

Unit 4: Host-pathogen interaction: a). Microbial pathogenicity: virulence factors of pathogens-enzymes (chitinases, cutinases, pectinases, cellulases), toxins (host specific: HV, T-toxin and non-specific: tabtoxin, tentoxin), growth regulators (auxin, gibberellins), virulence factors in viruses (replicase, coat protein, silencing suppressors) and their role in disease development. Effects of pathogens on host physiological processes (photosynthesis, respiration, cell membrane permeability, translocation of water and nutrients, plant growth and reproduction). **b).** Genetics of plant diseases: concept of resistance (R) gene and avirulence (avr) gene, the gene for gene hypothesis. Types of plant resistance: true resistance– horizontal and vertical, apparent resistance-disease escape and tolerance to disease. **c).** Defense mechanisms in plants: concepts of constitutive (pre-existing) defense mechanisms in plants, inducible structural defenses (histological: cork layer, abscission layer, tyloses, gums), inducible biochemical defenses (hypersensitive response (HR), systemic acquired resistance (SAR), phytoalexins, pathogenesis-related (PR) proteins, plantibodies, phenolics, quinones, oxidative bursts). **18**

Unit 5: Control of plant diseases: Principles and practices involved in the management of plant diseases by different methods. Regulatory methods: quarantine, crop certification, avoidance of pathogen, use of pathogen-free propagative material. Cultural methods: host eradication, crop rotation, sanitation, polyethylene traps, and mulches. Chemical methods: protectants and systemic fungicides (metalaxyl, benomyl), antibiotics, resistance of pathogens to chemicals. Biological methods: suppressive soils, antagonistic microbes-bacteria, and fungi, trap plants. Genetic engineering of disease resistant plants- with plant-derived genes and pathogen-derived genes. **10**

Unit 6: Specific plant diseases: Study of some important plant diseases emphasizing their etiological agents, symptoms, epidemiology, and control. **a).** Some important diseases caused by phytopathogenic fungi: White rust of crucifers (*Albugo candida*), Late blight of potato (*Phytophthora infestans*), Ergot of rye (*Claviceps purpurea*), Black stem rust of wheat (*Puccinia graminis tritici*), Red rot of sugarcane (*Colletotrichum falcatum*) **b).** Some important diseases caused by phytopathogenic bacteria: Angular leaf spot of cotton and Crown gall. **18**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Demonstration of Koch's postulates in fungal, bacterial and viral plant pathogens (any two).

2. Study of important diseases of crop plants by cutting sections of infected plant material - A*lbugo, Puccinia, Ustilago, Fusarium, Colletotrichum.*

3. Study of following diseases through photographs: Bacterial leaf blight of rice, angular leaf spot of cotton, crown galls, bacterial cankers of citrus, aster yellow, citrus stubborn, papaya ring spot, tomato yellow leaf curl, banana bunchy top, rice tungro disease, potato spindle tuber, coconut cadang cadang disease.

Suggested Reading:

1. Agrios, G.N. (2005). *Plant Pathology*. 5th edition. Elsevier Academic Press, USA.

2. Lucas, J.A. (1998). *Plant Pathology and Plant Pathogens.* 3rd edition. Blackwell Science, UK.

3. Mehrotra, R.S. and Aggarwal, A. (2017). *Plant Pathology*. 3rd edition. Tata McGraw-Hill Education, India.

4. Rangaswami, G. and A. Mahadevan, A. (2005). *Diseases of Crop Plants in India*. 4th edition. Prentice Hall, India.

5. Singh, R.S. (2018). *Introduction to Principles of Plant Pathology*. 5th edition. MedTech, India.

6. Singh, R.S. (2018). *Plant Diseases*. 10th edition. MedTech, India.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Student will be introduced to concept and importance of plant diseases. Will also get acquainted with contributions of various plant pathologists.	Interactive lecture on importance of plant diseases and how this field developed with emphasis on contributions of various scientists.	MCQ/Match the following based on symptoms and contribution of scientists.

2	Student will get in-depth knowledge of stages in the development of a disease which will form base for further course materials.	Video lecture showing various stages of Disease cycle.	Class test/assignments based on disease cycle of plant pathogens.
3.	Student will learn about types of diseases based on life cycles of hosts and pathogens, factors controlling them and very important how to forecast diseases in an Indian context.	Class lecture with the help of diagrams of disease cycles, pyramid and triangle and discussion on forecasting of diseases.	Class test on differences between different types of disease cycles. Case study on forecasting disease in an Indian context.
4.	Student will understand how microbes attack plants by means of enzymes, toxins, growth regulators etc. thereby affecting their physiological processes. Will also get conversant with genetics of plant diseases and how plants defend themselves.	A detailed lecture explaining different weapons of pathogens and defence mechanisms of plants with the help of diagrams.	Class presentations based on different sub-topics of the unit
5.,	Student will gain insight into how these diseases can be prevented and/or cured with various cultural methods, regulatory, physical, chemical and biological means.	Detailed account of methods of control with interactive session to look for novel and eco-friendly means of controlling these diseases.	Group discussion based on different methods of control of plant diseases. Class project on eco-friendly means of control of plant diseases.
6.	Student will acquire knowledge about causes, symptoms, epidemiology and control of fungal and bacterial disease.	Slide presentation of various diseases.	QUIZ based on various fungal and bacterial diseases

*** Assessment tasks are indicative and may vary.**

MICROB-DSE604: BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS (IPR)

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:

The course is designed to introduce fundamental aspects of Intellectual property Rights to the students to enable them to play major role in contributing to country's economy in terms of innovations and startups. The course covers all aspects of the IPR Acts. The course is designed for raising awareness regarding protection of Intellectual property and includes case studies in law and scientific research to understand the applications of the legal concepts in Science

Course Learning Outcomes:

Upon successful completion of the course, the student:

CO1: Gains knowledge about biosafety issues and compliance with reference to biotechnology research.

CO2: Will be able to acquire thorough insight into national and international guidelines and protocols followed for biosafety.

CO3: Will have learnt the concepts of IPR and its protection.

CO4: Will have gathered understanding of protection of IP through Patents, Copyright and related rights.

CO5: Will have learnt basic concepts of protection of IP through Trademarks, Geographical indications, Industrial designs and New Plant Varieties along with specific biotechnological cases.

CO6:Will get acquainted with Agreements, Treaties and Acts in relation to IP protection

Contents:

Unit 1: Biosafety: Introduction. Biosafety issues in biotechnology. Biological Safety Cabinets and their types. Primary Containment for Biohazards. Biosafety Levels of Specific Microorganisms. Discard of biohazard waste and methods of disinfection **8**

Unit 2: Biosafety guidelines and regulations: National and International Regulations. GMOs/LMOs:Concerns and Challenges. GRAS organisms. Role of Institutional Biosafety Committees (IBSC), RCGM, GEAC etc. for GMO applications in food and agriculture. Environmental release of GMOs, Risk Analysis, Risk Assessment, Risk management and communication. Overview of International Agreements - Cartagena Protocol. AERB/RSD/RES guidelines for using radioisotopes in laboratories and precautions to be taken. Safer Alternatives to the use of radioisotopes: an overview. **8**

Unit 3: Overview of Intellectual Property Rights: Introduction and need for intellectual property right (IPR). IPR in India: Genesis and Development. Some important examples of IPR. Introduction to different types of IPR. Importance of IPR. **8**

Unit 4: Patents, copyright and related rights: Patents: Types of inventions protected by a patent. Need for a patent. Claims. Searching a patent, Drafting of a patent, Filing of a patent, Grant of patent. Patent infringement, Rights and Duties of patent owner. Granted Patents vs Patent Publications. The different layers of the international patent system (national, regional and international options). Utility models: Differences between a utility model and a patent. Trade secrets and know-how agreements. **Copyrights:** Definition, need, coverage and duration. Related rights. Distinction between related rights and copyright. Rights covered by copyright. **12**

Unit 5: Trademarks, Geographical indications, Industrial designs and New Plant Varieties: Trademarks: Definition. Rights of trademark, signs that can be used as trademarks, types of trademark. Protection and registration a trademark. Duration of protection. Well-known trademarks**. Geographical indications**: Definition. Need for Protection. Examples. **Industrial design**: Overview, kind, duration and need for protection provided by industrial designs. **New Plant Varieties:** Requirements, Rights of breeder, Extent and Duration, Examples. Biotechnology Research and Intellectual Property Rights Management, Commercializing Biotechnology Invention, Case studies of Biotechnology. **12**

Unit 6: Agreements, Treaties and Acts: GATT, WTO, TRIPS. Agreements: Role of Madrid Agreement, Hague Agreement, WIPO Treaties, Budapest Treaty on international recognition of the deposit of microorganisms. UPOV and Brene conventions. Patenting life: legal protection of biotechnological inventions – World Intellectual Property Rights Organization (WIPO), Patent Co-operation Treaty (PCT); Indian Patent Act 1970 and recent amendments. **12**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Study of components and design of a BSL-2 and BSL-3 laboratory.
2. Filing applications for approval from biosafety committee (IBSC).
3. Study of steps of a patenting process.
4. Design a suitable strategy to protect a genetically modified organism.
5. Case study of turmeric/ neem/ basmati rice/ BtCotton (any two).

Suggested Reading:

1. Goel, D. and Parashar, S. (2013). *IPR, Biosafety and Bioethics*. 1st edition. Pearson Education, India.
2. Kankanala, C. (2007). *Genetic Patent Law and Strategy*. 1st edition. Manupatra Information Solution Pvt. Ltd., India.
3. Murray, T.M. and Mehlman, M.J. (editors) (2000). *Encyclopedia of Ethical, Legal and Policy issues in Biotechnology*. John Wiley and Sons, UK.
4. Ramakrishna, B. and Anil Kumar, H.S. (2017). *Fundamentals of Intellectual Property Rights: For Students, Industrialist and Patent Lawyers.* 1st edition. Notion Press, India.
5. Singh, K.K. (2015). *Biotechnology and Intellectual Property Rights: Legal and Social Implications*. Springer, India.
6. Wadehra, B.L. (2004). *Law Relating to Patents, Trade Marks, Copyright, Designs and Geographical Indications.* Universal Law Publishing, India.
7. Wooley, D.P. and Byers, K.B. (2017). *Biological Safety: Principles and Practices*. 5th edition. ASM press, USA.
8. http://shodhganga.inflibnet.ac.in/bitstream/10603/205165/7/chapter%20iii.pdf

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks
1	Student gets knowledge about biosafety issues and compliance with reference to biotechnology research.	Class room lecture on biosafety, different types of biosafety cabinets Pictures/videos on their usage	MCQ on ensuring biosafety
2	Will be able to acquire thorough insight into national and international guidelines and protocols followed for biosafety.	Detailed discussion/ppts on various guidelines, environmental concerns of GMO release, safer alternatives and their benefits	Assessment through designing strategies on risk assessment and management.
3	Will have learnt the concepts of IPR and its	Class room Lectures on introduction of concept, need	Presentation of case studies

	protection.	and types of IP protection	
4	Will have gathered understanding of protection of IP through Patents, Copyright and related rights	Engaging in seminar and interactive discussion on Details of patent filing and copyright registration	Steps to file patent and copyrights
5	Will have learnt basic concepts of protection of IP through Trademarks, Geographical indications, Industrial designs and New Plant Varieties along with specific biotechnological cases.	Class room lectures on other forms of IP protection with examples and specific references to biotechnological inventions	Test on types of IPR
6	Will get acquainted with Agreements, Treaties and Acts in relation to IP protection.	Class room lectures on Agreements, Treaties and Acts in relation to IP protection which are in place	Quiz on identifying knowledge of students with regard to various acts and treaties in IP

***Assessment tasks listed here are indicative, and may vary.**

MICROB-DSE605: PROJECT WORK

Marks: 150 marks **Credits: 6**

Continuous evaluation (IA)	45 marks
Experimental work cum project report	75 marks
Presentation and Viva-voce	30 marks

Course Objectives:
The key objective of this paper is to introduce the students to concepts in identification of a research problem and developing a hypothesis. The course will enable students to learn how to carry out survey of literature, perform experiments, and analyse data. The student will learn how to write a scientific project report, and oral presentation of the results.

Course Learning Outcomes:
CO1: Student is able to formulate a hypothesis to be tested.

CO2: Student learns how to collect and read literature related to the hypothesis.

CO3: Student learns how to present a resarch article.

CO4: Student is able to design experiments to test that hypothesis. Student is exposed to the use of a variety of instruments and is able to perform experiments such as making culture media for various microbes, isolating microorganisms from different sources, and identifying the isolated microorganism. Can examine the microorganism's capacity to produce compounds of industrial importance.

CO5: Student learns about ethical issues in conducting research. Student learns how to examine the obtained data and interpret the results.

CO6: Student learns how to discuss their results based on results obtained by other researchers on the same topic.

CO7: Student learns the skill of writing a project report.

CO8: Student learns about ethical issues related to publishing, plagiarism and self-plagiarism.

Contents:

Unit 1: Identification of research problem

Unit 2: Survey of literature

Unit 3: Formulation of hypothesis, experimental design and methodology

Unit 4: Analysis of data and interpretation of results

Unit 5: Discussion and conclusion

Unit 6: Writing a project report

Note:

1. Number of students who will be offered project work will vary from college to college depending upon the available infrastructural facilities and may vary each year.
2. The college shall announce the number of seats for project work well in advance and may select the students for the same based on merit.
3. Project work will involve experimental work and the student will have to do this in the time after their regular theory and practical classes.
4. The final evaluation of the project work will be through a committee involving internal and external examiners.
5. Guidelines provided by University of Delhi for executing and evaluation of project work will be final.
6. Students will be asked their choice for Project work at the end of IV semester and all formalities of topic and mentor selection will be completed by this time.
7. Project work will be offered in lieu of any one Discipline Specific Elective and will be evaluated for 6 credits.

Suggested Reading:

Kothari, C.R. and Garg, G. (2018). *Research Methodology: Methods and techniques*. New Age International, India.

MICROB-GE101: INTRODUCTION AND SCOPE OF MICROBIOLOGY

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:

The major objective of this paper is to introduce students of other disciplines to the fascinating world of microorganisms. The paper discusses the development of microbiology as an important scientific discipline. The diversity among different groups of microorganisms and their impact on various spheres of our life and the environment will be dealt with.

Course Learning Outcomes:

Upon successful completion of the course, the students:

CO1: Will be acquainted with the historical developments and contributions of eminent scientists which led to the development of microbiology as a scientific discipline.

CO2: Will have learned the different systems of classification and would have acquired knowledge on the characteristics and diversity prevalent among different groups of acellular and cellular microorganisms.

CO3: Will be able to list important human diseases and their causative agents. Will also acquire knowledge about the immune system.

CO4: Will be conversant with microbial interactions; the impact of microorganisms on agriculture and environment will also be dealt with.

CO5: Will have gained an insight into the types of fermentation processes, fermenters and the application of microorganisms in the mass-scale production of metabolites/biomass. Will also be able to list microorganisms used as food and food supplements and discuss the desirable and undesirable activities of microorganisms in association with foods.

CO6: Will be aware of the physical and chemical agents of microbial control used for sterilization and disinfection.

Contents:

Unit 1: History of development of Microbiology: Development of microbiology as a scientific discipline. Controversy over theory of spontaneous generation *vs* biogenesis, contributions of Robert Hooke, Antonie von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Edward Jenner, Elie Metchnikoff, Paul Ehrlich, Martinus W. Beijerinck, Sergei N. Winogradsky, Alexander Fleming, Selman A. Waksman and Ananda Mohan Chakraborty. Golden age of Microbiology. **12**

Unit 2: Diversity of Microorganisms: Systems of classification- Binomial nomenclature, Whittaker's five kingdom classification and Carl Woese's three domain classification system and their utility. General characteristics of different groups giving salient features, and citing examples of acellular microorganisms (viruses, virions and prions) and cellular microorganisms (Prokaryotes: archaea and bacteria; Eukaryotes: algae, fungi and protozoa). Life cycle of an alga (*Chlamydomonas*), fungus (*Rhizopus*) and protozoan (*Paramecium*). **10**

Unit 3: Microbes in human health: Definition of immunity, brief account of active and passive immunity, primary and secondary immune responses, antigens, antibodies and their types. List of important human microbial diseases and their causative agents. **6**

Unit 4: Environmental microbiology: Definitions and examples of important microbial interactions (mutualism, commensalism and parasitism), Definitions and examples of microbes used as biopesticides, biofertilisers, in biodegradation, biodeterioration and bioremediation (e.g. hydrocarbon degradation in oil spills). **6**

Unit 5: Industrial, Food and Dairy Microbiology: Industrial Microbiology: Definition of fermentation, primary and secondary metabolites, types of fermentation processes and fermenters. List of microbes producing important industrial products by fermentation. Food and Dairy Microbiology: Microorganisms used as food (SCP) and food supplements (probiotics). Use of microorganisms in production of fermented dairy products (dahi, yogurt, kefir, butter) and non-dairy (soy sauce and bread). Examples of microorganisms causing food spoilage and food borne diseases (infections and intoxications). **20**

Unit 6: Methods of microbial control: Sterilization and disinfection with the help of physical agents: Dry heat (flaming, incineration and hot air oven), moist heat (pasteurization, boiling, autoclaving and Tyndallisation), filtration and UV radiation. Chemical agents: ethanol, phenol and ethylene oxide. **6**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Microbiological good laboratory practices and biosafety.
2. To study the principle, working and applications of important microbiological instruments- hot air oven, autoclave, biological safety cabinets, bacteriological and BOD incubators, pH meter and bright-field compound microscope.
3. Use of autoclave for media sterilization.
4. Use of hot air oven for sterilization of glassware.
5. To study different shapes of bacteria using permanent slides/photographs.
6. To study *Rhizopus* with the help of permanent slides.
7. To study *Chlamydomonas* with the help of permanent slides.
8. To study *Paramecium* using permanent slides or photographs.

Suggested Reading:

1. Atlas, R.M. (1997). *Principles of Microbiology*. 2nd edition. Brown Publishers, USA.
2. Cappuccino, J. and Welsh, C.T. (2016). *Microbiology: A Laboratory Manual*. 11th edition. Pearson Education, USA.
3. Madigan, M.T. and Martinko, J.M. (2017). *Brock Biology of Microorganisms.* 15th edition. Prentice Hall International Inc., USA.
4. Pelczar, M.J., Chan, E.C.S. and Krieg, N.R. (1993). *Microbiology.* 5th edition. McGraw Hill, USA.
5. Stanier, R.Y., Ingrahm, J.I., Wheelis, M.L. and Painter, P.R. (1987). *General Microbiology*. 5th edition. McMillan Press, UK.
6. Tortora, G.J., Funke, B.R., Case, D., Weber, D. and Bair, W. (2019). *Microbiology: An Introduction.* 13th edition. Pearson Education, USA.
7. Willey, J. M., Sandman, K. and Wood, D. (2019). *Prescott's Microbiology.* 11th edition. McGraw Hill Higher Education, USA.

Facilitating the achievement of course learning objectives:

Unit no.	Course learning outcomes	Teaching and learning activities	Assessment tasks*
1.	Will get acquainted with the historical developments and contributions of eminent scientists which led to the development of microbiology as a scientific discipline.	Discussion on the key contributions of eminent scientists leading to the development of microbiology as a scientific discipline. Rejection of theory of spontaneous generation. Major milestones of the golden age of microbiology.	Quiz, MCQs, match the following questions, identification of scientists with the help of photographs.
2.	Will learn the different systems of classification and would have acquired knowledge of the characteristics and diversity prevalent among different groups of acellular and cellular microorganisms.	An overview on different systems of classification and diversity of acellular and cellular microorganisms using visual aids. Study of life cycles of some eukaryotic microbes using descriptive charts, permanent slides/mounts and photographs.	Class tests and short presentations by students.
3.	Can list important human diseases and their causative agents. Will also acquire knowledge of the immune system.	Classroom lectures on the basic terminology used in the field of immunology and medical microbiology. Students to be provided with an exhaustive list of human microbial diseases and their causative agents.	Quiz, MCQs and match the following.
4.	Become aware of the microbial interactions and the impact of microorganisms on agriculture and environment.	Theory classes highlighting different microbial interactions and the impact of microorganisms on agriculture and environment.	Objective type class tests and definition based questions.
5.	Will gain an insight into the types of fermentation processes, fermenters and application of microorganisms in the mass scale production of metabolites/biomass. Will also be able to list microorganisms used as food and food supplements and discuss the desirable and undesirable activities of microorganisms in association with foods.	Classroom lectures supplemented with visual aids on different industrial fermentation processes and their applications. Role of microorganisms in the production of fermented foods and food supplements through classroom teaching. A list of microorganisms involved in food spoilage and food- borne diseases will also be provided.	Preparation of pictorial charts and flow charts by the students on microbial fermentation products. Assignments on food-borne diseases and food spoilage
6.	Will become aware of the physical and chemical agents of microbial control used for sterilization and disinfection.	Discussion on the use of various physical and chemical agents of sterilization and disinfection using suitable examples. Practical exercises on sterilization using dry heat and moist heat.	Class tests

***Assessment tasks listed here are indicative and may vary.**

MICROB-GE201: BACTERIOLOGY AND VIROLOGY

Marks:100 **Duration: 60 hours (4 credits)**

Course Objectives:
The main objective of this course is to introduce the students of other streams to basic concepts of Bacteriology and Virology including structure, multiplication and economic importance.

Course Learning Outcomes:

Upon successful completion of course the student:

CO1: Will have gained knowledge about structure and organisation of different cell components of bacteria. Will be able to differentiate between Gram positive and Gram-negative bacteria; archaebacteria and eubacteria cell wall and cell membrane.

CO2: Will get familiar with various media and techniques used for cultivation and maintenance of different types of bacteria. Will also gain insight into different phases of growth in batch culture and binary fission as a method of reproduction.

CO3: Will understand the concept of different types of classification. Will learn about the morphology, ecological significance and economic importance of the various bacterial genera.

CO4: Will understand morphology of viruses with important examples.

CO5: Will have learnt structure and replication of different groups of viruses. Will get acquainted with the concept of lytic cycle and lysogeny.

CO6: Will become aware of viral pathogens of plant, animal and human diseases. Will also gain knowledge about prevention and control of viral diseases.

Contents:

Unit 1: Cell organization and structure: Cell size, shape and arrangements, capsule, flagella and pili. Composition and detailed structure of gram- positive and gram- negative cell wall and archaeal cell wall. Structure, chemical composition and functions of bacterial and archaeal cell membranes. Ribosomes, inclusion bodies (PHB, gas vacuole, carboxysomes) nucleoid, plasmids. Structure, formation and stages of sporulation. **10**

Unit 2: Bacterial cultivation and growth: Culture media: Components of media, synthetic or defined media, complex media, enriched media, selective media, differential media. Pure culture isolation: Streaking, serial dilution and plating methods. Cultivation, maintenance of pure cultures, cultivation of anaerobic bacteria. Growth: Binary fission, phases of growth. **8**

Unit 3: Bacterial systematics and taxonomy: Types of classifications: Definitions of phenetic classification, phylogenetic classification, genotypic classification and polyphasic taxonomy. Morphology, ecological significance and economic importance of the following groups: Archaea: methanogens, thermophiles and halophiles; Eubacteria: Gram negative and Gram positive bacteria. Gram negative: *E. coli, Salmonella.* Gram positive: *Bacillus, Streptomyces.* **12**

Unit 4: Introduction to Viruses: Definition, capsid symmetry and viral envelopes with examples. Viroids, prions and their significance. **8**

Unit 5: Structure and multiplication of viruses: Lytic cycle and lysogeny. Structure of important viruses- Bacteriophages (T4 and lambda), plant viruses (TMV and CaMV), human (polio virus and

HIV). **12**

Unit 6: Viral diseases and their prevention: Examples of viral pathogens of plant, animal and human diseases. Prevention and control: viral vaccines (live attenuated polio vaccine, inactivated polio vaccine and live recombinant rabies vaccine). Types of interferons, antiviral drugs (Acyclovir and AZT) **10**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. To study colony morphology of bacteria on nutrient agar after exposure to air.
2. To perform simple staining of the bacterial smear.
3. To perform Gram's staining.
4. Isolation of pure cultures of bacteria by streaking method.
5. Study of the morphological structures of DNA and RNA viruses (any two of each) and their important characters using electron micrographs.
6. To study the symptoms of plant viral diseases with the help of photographs. (Mosaic, ring spot and leaf curl: any two).
7. To study the symptoms of animal viral diseases with the help of photographs. (Polio, mumps and measles: any two).

Suggested Reading:

1. Atlas, R.M. (1997). *Principles of Microbiology*. 2nd edition. Brown Publishers, USA.
2. Cappuccino, J. and Welsh, C.T. (2016). *Microbiology: A Laboratory Manual*. 11th edition. Pearson Education, USA.
3. Carter, J. and Saunders, V. (2013). *Virology: Principles and Applications*. 2nd edition. John Wiley and Sons, UK.
4. Dimmock, N.J., Easton, A.L. and Leppard, K.N. (2007). *Introduction to Modern Virology*. 6th edition. Wiley-Blackwell Publishing.
5. Flint, S.J., Enquist, L.W., Krug, R.M., Racaniello, V.R. and Skalka, A.M. (2015). *Principles of Virology, Molecular biology, Pathogenesis and Control*. 4th edition. ASM Press, USA.
6. Jones, Teri Shors. (2016). *Understanding Viruses*. 3rd edition. Jones and Bartlett Learning, USA.
7. Madigan, M.T. and Martinko, J.M. (2017). *Brock Biology of Microorganisms.* 15th edition. Prentice Hall International Inc., USA.
8. Pelczar, M.J., Chan, E.C.S. and Krieg, N.R. (1993). *Microbiology.* 5th edition. McGraw Hill, USA.
9. Stanier, R.Y., Ingrahm, J.I., Wheelis, M.L. and Painter, P.R. (1987). *General Microbiology*. 5th edition. McMillan Press, UK.

10. Tortora, G.J., Funke, B.R., Case, D., Weber, D. and Bair, W. (2019). *Microbiology: An Introduction.* 13th edition. Pearson Education, USA.

11. Willey, J. M., Sandman, K. and Wood, D. (2019). *Prescott's Microbiology.* 11th edition. McGraw Hill Higher Education, USA.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks*
1	Will have gained knowledge about structure and organisation of different cell components of bacteria. Will be able to differentiate between Gram positive and Gram-negative bacteria; archaebacteria and eubacteria cell wall and cell membrane.	Video /PowerPoint presentation showing bacterial cells and their components of different types. Explaining differences between Gram +ve and Gram-ve bacteria; eubacterial and archaebacterial structures with the help of diagrams.	Quiz on different cell shapes and arrangements with the help of visual aids. Test based on diagrams of various cell components and their differences.
2	Will get familiar with media and techniques used for cultivation and maintenance of different types of bacteria. Will also gain insight into different phases of growth in batch culture and binary fission as a method of reproduction.	Demonstrative lecture showing various techniques used in isolation and cultivation of bacteria. Discussion on preservation of bacterial cultures with emphasis on advantages and disadvantages of these methods. Class lecture on binary fission and discussion on four phases of growth curve.	Evaluation of streaking/ spread plate / pour plate Techniques. MCQ /QUIZ based on media, binary fission and phases of growth curve
3	Will understand the concept of different types of classification. Will learn about the morphology, ecological significance and economic importance of the various bacterial genera.	Explaining different terms used in taxonomy and to discuss different types of classifications. Enlisting different genera with their unique features and economic importance. giving insight into differences between archaebacteria and eubacteria with help of tabular chart.	Class test based on definitions of various terms. Presentation/project on any one bacterium of their choice highlighting its unique features and ecological and/or economic importance
4	Will understand morphology of viruses with important examples.	Class room lecture on capsid symmetry and viral envelope	Test based on diagrams of different viruses
5	Will learn about the structure and replication of different groups of viruses. Will get acquainted with the concept of lytic cycle and lysogeny.	Video/power point presentation showing replication of viruses	MCQ on structure of viruses. Test based on differences between lytic cycle and lysogeny.
6	Will become aware of	Discussion on viral pathogens,	Match the following to test

	viral pathogens of plant, animal and human diseases. Will also gain knowledge about prevention and control of viral diseases.	their prevention and control.	viral diseases. Short-answer based questions on vaccines, interferons and anti-viral drugs.

***Assessment tasks listed here are indicative and may vary**

MICROB-GE301: MICROBIAL METABOLISM

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:

The main objective of this paper is to make students acquainted with various aspects of microbial physiology and metabolism. These include types of microbes based on nutrition, basic transport mechanisms present in microbes for the uptake of nutrients, bacterial growth and factors affecting it and diverse metabolic pathways existing in microbes for energy production and carbon and nitrogen assimilation. An understanding of these physiological and metabolic aspects of the microbes will create interest among students for further studies in the field of microbiology.

Course Learning Outcomes:

Upon successful completion of the course, the student:

CO1: Will have got acquainted with the diverse physiological groups of bacteria/archea and transport systems commonly employed by microbes.

CO2: Will have sufficient knowledge of bacterial bacterial growth curve, calculation of generation time and effect of environmental factors on the growth.

CO3: Will understand catabolic pathways of energy generation and conservation used by bacteria during growth on glucose under aerobic and anaerobic conditions. They will also become familiar with the concepts of aerobic respiration and fermentation in microbes.

CO4: Will have got conversant with the groups of microbes having ability to extract energy from inorganic compounds and assimilate carbon from CO_2 (chemolithotrophs).

CO5: Will have an added knowledge on the families of phototrophic microorganisms. Students would also be aware of differences between anoxygenic and oxygenic photosynthesis.

CO6: Will have learnt about basic concepts of assimilation of inorganic nitrogen like nitrogen gas, ammonia and nitrates by bacteria.

Contents:

Unit 1: Classification of microorganism based on nutrient and energy source: Nutritional types of microorganisms. Transport mechanisms: passive and facilitated diffusion. Primary and secondary active transport. Concept of uniport, symport and antiport, Group translocation. **6**

Unit 2: Microbial growth and environment: Bacterial growth curve, generation time, batch culture. Effect of environmental factors on growth: temperature, pH and concentration of oxygen. **8**

Unit 3: Carbon metabolism and energy generation: Concept of aerobic respiration, anaerobic respiration and fermentation. ATP synthesis in *E.coli* during growth on glucose: Embden-Meyerhof-Parnas (EMP) pathway /glycolysis, Krebs Cycle /Tricarboxylic Acid Cycle. Electron Transport during aerobic respiration: components of mitochondrial electron transport chain (ETC), oxidative phosphorylation, comparison of electron transport chain of mitochondria and *E. coli* (branched). Alcohol fermentation by *S. cerevisiae*. **18**

Unit 4: Chemolithotrophy: Introduction to aerobic and anaerobic chemolithotrophy. Physiological groups of aerobic chemolithotrophs. Energy production and generation of reducing power in H_2 oxidizers. Introduction to methanogenic archaea (anaerobic chemolithotrophs). **8**

Unit 5: Phototrophy: Families of phototrophic bacteria. Comparison of photosynthetic apparatus and light reaction of green and cyanobacteria with reference to anoxygenic and oxygenic photosynthesis. Carbon assimilation in phototrophs: Calvin cycle and reductive TCA cycle. **10**

Unit 6: Nitrogen Metabolism: Biological nitrogen fixation, nitrogenase activity and its physiological regulation. Ammonia assimilation and assimilatory nitrate reduction. **10**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Study and plot the growth curve of *E. coli* by turbidometric method.
2. Calculation of generation time from the graph plotted with the given data.
4. Effect of temperature on growth of *E. coli.*
3. Effect of pH on growth of *E. coli.*
5. Demonstration of alcoholic fermentation.

Suggested Reading:

1. Gottschalk, G. (1986). *Bacterial Metabolism*. 2nd edition. Springer, Germany.
2. Madigan, M.T. and Martinko, J.M. (2017). *Brock Biology of Microorganisms*. 15th edition. Prentice Hall International Inc., USA.
3. Nelson, D.L. and Cox, M.M. (2017). *Lehninger Principles of Biochemistry*. 7th edition. W.H. Freeman and Company, UK.
4. Reddy, S.R. and Reddy, S.M. (2005). *Microbial Physiology*. Scientific Publishers, India.
5. White, D., Drummond, J. and Fuqua, C. (2011). *The Physiology and Biochemistry of Prokaryotes*. 4th edition. Oxford University Press, UK.
6. Willey, J. M., Sandman, K. and Wood, D. (2019). *Prescott's Microbiology*. 11th edition. McGraw Hill Higher Education, USA.

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	l have got acquainted with the diverse physiological groups of bacteria/archea and transport systems commonly employed by microbes.	lass room lecture on various nutritional types of microbes. ailed discussion along with diagrammatic presentation on diffusion, active transport, group translocation and iron transport.	uiz on the identification of transport mechanism for specific solutes.
2	l have sufficient knowledge of bacterial bacterial growth curve, calculation of generation time and effect of environmental factors on the growth.	ailed talk on batch and continuous culture, growth curve and calculation of generation time. ractive lecture on effect of temperature, ph, oxygen concentration and solute activity on the bacterial growth.	nerical on calculation of generation time. :st on the bacterial adaptations under different environmental conditions.
3	Will understand catabolic pathways of energy generation and conservation used by bacteria during growth on glucose under aerobic and anaerobic conditions. They will also become familiar with the concepts of aerobic respiration and fermentation in microbes.	Discussion on bacterial respiration in the presence and absence of oxygen. Detailed lecture on EMP, ED,TCA, PP and Glyoxylate pathways and ETC under aerobic and anaerobic conditions. Detailed teaching along with diagrammatic display of the fermentation pathways.	"Fill in the blanks in pathways" test. An assignment on writing the alcohol and lactic acid fermentation pathways.
4	Will have got conversant with the groups of microbes having ability to extract energy from inorganic compounds and assimilate carbon from CO_2 (chemolithotrophs).	Class room teaching on groups of chemolithotrophs, the basis of their classification, and their metabolism w.r.t ETC and carbon assimilation.	Group presentations on energy production and CO_2 assimilation in hydrogen oxidizers, methanogens.
5	Will have an added knowledge on the families of phototrophic microorganisms. Students would also be aware of differences between anoxygenic and oxygenic photosynthesis.	Class room lecture on the families of phototrophs and physiology of anoxygenic and oxygenic photosynthesis.	Group presentations on photosynthesis in green bacteria and cyanobacteria.
6	Will have learnt about basic concepts of assimilation of inorganic nitrogen like nitrogen gas, ammonia and nitrates by bacteria.	Power point presentation on physiology of nitrogen fixation, assimilation of ammonia and nitrate, and dissimilation of nitrate by bacteria.	Placing processes of nitrogen fixation, ammonia assimilation and nitrate reduction in the nitrogen cycle.

***Assessment tasks listed here are indicative, and may vary**

MICROB-GE302: MICROBIAL GENETICS AND MOLECULAR BIOLOGY

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:

The major objective of this paper is to develop clear understanding about the organization and expression of genomes in prokaryotes, in relation to their survival and propagation. Students will also learn basic concepts of molecular biology that will form the basis for courses taught later.

Course Learning Outcomes:
Upon successful completion of the course, the student:

CO1: Will be acquainted with the fine structural details of DNA, and types of RNA. Will gain knowledge on the genome organization in bacteria. Can be able to understand the concept of mutation and its causative agents.

CO2: Will have gained an in-depth knowledge of the mechanism and types of DNA replication in bacteria as well as enzymes involved.

CO3: Will have learnt detailed aspects of mechanism of transcription and as well as various proteins and enzymes involved in this process. Will be aquainted with aspects of gene expression regulation.

CO4: Will have learnt about the genetic code and its role in translation. Will be familiar with knowledge on machinery and various stages involved in protein synthesis, including charging of tRNA.

CO5: Will gain knowledge on characteristic features of plasmids and transposons including bacteriophage Mu transposon. Will be aware of their types and uses.

CO6: Will be conversant with historical developments and various mechanisms of genetic recombination in bacteria *vis* transformation, conjugation and transduction. Will also have learnt to map genes by exploiting the conjugation mechanism.

Contents:

Unit 1: DNA and RNA as genetic material: DNA structure, Types of DNA, genome organization in *E. coli*. Types of RNA. Definition of mutation. Physical and chemical mutagens. Reversion versus suppression. Ames test. **8**

Unit 2: Replication of DNA: Bidirectional and unidirectional replication, semi- conservative, semi-discontinuous replication. Mechanism of DNA replication: Enzymes and proteins involved in DNA replication –DNA polymerases, DNA ligase, primase. DNA proof-reading and its importance. **12**

Unit 3: Transcription and its regulation: Transcription: Definition. Promoter: concept and strength of promoter. DNA elements regulating gene expression. Transcriptional machinery and mechanism of transcription in prokaryotes. Transcriptional regulation with the examples of *lac* operon. **10**

Unit 4: Translation: Genetic code. Translation in prokaryotes: Ribosomes, structure and charging of tRNA, mechanism of initiation, elongation and termination of polypeptides. Different features of peptidyl transferase. **10**

Unit 5: Plasmids and transposable elements: Types of plasmids: F plasmid and R plasmid. Prokaryotic transposable elements – insertion sequences, composite transposons and non-composite transposons. Uses of transposons and plasmids. **8**
Unit 6: Genetic exchange in prokaryotes: Transformation: Discovery, natural competence and mechanism of transformation. Conjugation: Discovery, mechanism: Role of F plasmid, Hfr and F' strains. Gene mapping using interrupted mating technique. Transduction: generalized and specialized transduction. **12**

Practical content:

50 marks: **Duration: 60 hours (2 credits)**

1. Study of different types of DNA and RNA using micrographs and model / schematic representations.

2. Study of semi-conservative replication of DNA through micrographs / schematic representations.

3. Estimation of salmon sperm/calf thymus DNA using colorimeter (diphenylamine reagent) (OR) UV spectrophotometer (A260 measurement).

4. Resolution and visualization of DNA by agarose gel electrophoresis.

5. Study the effect of physical mutagen (UV) on bacterial cells.

6. Study of Ames test.

Suggested Reading:

1. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). *Cell and Molecular Biology*. 8th edition. Lippincott,Williams and Wilkins, USA.

2. Gardner, E.J., Simmons, M.J. and Snustad, D.P. (2005). *Principles of Genetics*. 8th edition. Wiley and Sons, UK.

3. Hardin, J., Bertoni, G. and Kleinsmith, L. (2015). *Becker's World of the Cell*. 9th edition. Benjamin Cummings, USA

4. Karp, G. (2013). *Cell and Molecular Biology*. 7th edition. Wiley, USA..

5. Klug, W.S., Cummings, M.R., Spencer, C. and Palladino, M. (2018). *Concepts of Genetics*. 12th edition. Pearson Education, USA.

6. Krebs, J., Goldstein, E. and Kilpatrick, S. (2017). *Lewin's Genes XII*. 12th edition. Jones and Bartlett Learning, USA.

7. Russell, P.J. (2009). *iGenetics- A Molecular Approach*. Benjamin Cummings, USA.

8. Snyder, L., Peters, J.E., Henkin,T.M. and Champness, W. (2015). *Molecular Genetics of Bacteria*. 4th edition. ASM Press, USA.

9. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2014). *Molecular Biology of the Gene*. 7th edition. Cold Spring Harbour Laboratory Press, USA.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks
1	Will be acquainted with the fine structural details of DNA, and types of RNA. Will gain knowledge on the genome organization in bacteria. Can be able to understand the concept of mutation and its causative agents	Class room lecture using pictorial presentation of DNA and RNA. Physical and chemical properties may be explained through simple laboratory experiments. Mutations will be tabulated and presented.	Analytical and logical quiz on features of DNA and RNA. Students may be asked to prepare 3D models of DNA from waste materials.

2	Will have gained an in-depth knowledge of the mechanism and types of DNA replication in bacteria as well as enzymes involved.	Detailed talk on mechanism of DNA replication, various replication models. Audio visual material may be used to make students understand the complex function of DNA polymerase and accessory proteins.	Assessment through question and answer method. An assignment may be taken on molecular mechanim.
3	Will have learnt detailed aspects of mechanism of transcription and as well as various proteins and enzymes involved in this process. Will be aquainted with aspects of gene expression regulation.	Detailed discussion on mechanism of transcription with audio visual tutorial. A video lecture on regulation of gene expression with examples from *lac* operon.	Match the following type quiz for trasnscription, splicing and translation. A group discussion over the working nature of Lac operon.
4	Will have learnt about the genetic code and its role in translation. Will be familiar with knowledge on machinery and various stages involved in protein synthesis, including charging of tRNA.	Power point presentation on mechanism of translation. Educational charts will be used for tRNA and ribosome structures.	students to tabulate various factors and their functions involved in protein synthesis. Flow chart preparation of stages of protein synthesis.
5	Will gain knowledge on characteristic features of plasmids and transposons including bacteriophage Mu transposon. Will be aware of their types and uses.	Educational charts and pictures of different plasmids and transposons will be used.	Question and answers and Quiz.
6	Will be conversant with historical developments and various mechanisms of genetic recombination in bacteria *vis* transformation, conjugation and transduction. Will also have learnt to map genes by exploiting the conjugation mechanism.	Chalk and talk lectures on genetic exchange in bacteria. Relevant internet resources will be used.	True or false kind of questioning and match the following pattern of questions can be given to assess students.

***Assessment tasks listed here are indicative, and may vary**

MICROB-GE303: APPLICATIONS OF MICROBES IN BIOTECHNOLOGY

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:

The course is aimed at providing a clear understanding of the role of microorganisms in the development of both traditional and modern biotechnology. The students would get a comprehension of the versatile role of microorganisms in production of important industrial products like amylases, development of recombinant vaccines, biosensors, biopesticides, bioplastics and biofuels. They will also appreciate how microorganisms bring about bioremediation and bioleaching. A critical assessment of genetically modified organisms and transgenic plants will be done. Last but not the

least, students will be made aware about the importance of IPR and its main components in protection of precious biotechnology products.

Course Learning Outcomes::

Upon successful completion of the course, the students:

CO1: Will get an overview the versatile role and applications of microbes in biotechnology.

CO2: Will get familiarized with how genetic manipulation of microbes may yield products of immense medical/therapeutic value like vaccines.

CO3: Will learn how microorganisms are used in the production of important industrial products like enzymes, SCP's etc. Whole cell/enzyme immobilization strategies would help the students to understand how fermentation processes can be improved and made commercially feasible.

CO4: Will understand the importance of microorganisms in environmental management and combating pollution through degradation of xenobiotics and bioremediation and in production of renewable energy alternatives like biofuels.

CO5: Will become conversant with the role of microbes in agricultural biotechnology especially in development of transgenic crops with desirable traits like disease resistance etc. The use of microbes in formulation of biopesticides and biofertilisers will also be discussed.

CO6: Will obtain information on IPR and its main components in protection of recombinant products.

Contents:

Unit 1: Scope of Microbial Biotechnology: Role of microbial biotechnology in agriculture, healthcare, environment, genomics and proteomics with suitable examples. Use of *E. coli* and yeast expression systems for heterologous gene expression. Importance and critical assessment of genetically modified organisms (GMOs). **10**

Unit 2: Biotechnology in medicine: Production and applications of important medicinal products: Insulin, Streptokinase, Hepatitis B vaccine and Glucose oxidase biosensor. **8**

Unit 3: Microbial products: Concept of primary and secondary metabolites. Production and applications of microbial polysaccharides, bioplastics and single cell proteins. Use of microbial amylases in production of high fructose syrup. Enzyme/whole cell immobilisation methods and their applications. **12**

Unit 4: Role of microorganisms in bioenergy and bioremediation: Biofuel production from agricultural waste and biogas production. Role of microbes in bioremediation: Degradation of xenobiotics and mineral recovery (bioleaching). Removal of heavy metals and dyes. **10**

Unit 5: Agricultural Biotechnology: Biofertilizers and biopesticides in agriculture. Plant tissue culture and development of transgenic crops with important traits such as resistance to diseases and environmental stress (drought and frost). Brief description of Bt cotton and Golden rice. Antisense RNA technology (Flavr Savr tomato) and role of RNAi in silencing genes **14**

Unit 6: Role of IPR in Biotechnology: Importance of patents, copyrights, trademarks and trade secrets in biotechnology. **6**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. To perform yeast cell immobilization and enzyme immobilization by calcium alginate method.

2. To study the activity and reuse of the immobilized enzyme.

3. Screening of soil samples for isolation of hydrolytic enzymes: protease, lipase, xylanase (any two) producing microorganisms using plate assay.

4. To demonstrate dye decolorisation using bacteria/fungi.

5. Expression of Green fluorescent protein (GFP) in *E. coli*.

Suggested Reading:

1. Crueger, W., Crueger, A. and Aneja, K.R. (2017). *Biotechnology: A Textbook of Industrial Microbiology*. 3rd edition. Medtech Publisher, India.

2. Demain, A.L., Davies, J.E. and Atlas, R.M. (1999). *Manual of Industrial Microbiology and Biotechnology*. 2nd edition. ASM Press, USA.

3. Dubey, R.C. (2014). *A Textbook of Biotechnology*. 5th edition. S. Chand and Co, India.

4. Glazer, A.N. and Nikaido, H. (2007). *Microbial Biotechnology: Fundamentals of Applied Microbiology*. 2nd edition. Cambridge University Press, UK.

5. Glick, B.R., Pasternak, J.J. and Patten, C.L. (2009). *Molecular Biotechnology*. 4th edition. ASM Press, USA.

6. Gupta, P.K. (2009). *Elements of Biotechnology*. 2nd edition. Rastogi Publications, India.

7. Ratledge, C. and Kristiansen, B. (2006). *Basic Biotechnology*. 3rd edition. Cambridge University Press, UK.

8. Stanbury, P.F., Whitaker, A. and Hall, S.J. (2016). *Principles of Fermentation Technology*. 3rd edition. Elsevier Science, Netherlands.

9. Willey, J. M., Sandman, K. and Wood, D. (2019). *Prescott's Microbiology*. 11th edition. McGraw Hill Higher Education, USA.

Facilitating the Achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Will get an overview the versatile role and applications of microbes in biotechnology.	Traditional teaching using chalk and board, powerpoint presentations	Brief oral presentations on present and future roles of various microorganisms in

		and class discussions.	various fields touching human life.
2	Will get familiarized with how genetic manipulation of microbes may yield product of immense medical/therapeutic value like vaccines.	Conventional chalk and talk lectures followed by slide shows and videos.	Preparation of flow charts depicting the production process of important therapeutic products.
3	Will learn how microorganisms are used in the production of important industrial products like enzymes, SCPs etc. Whole cell/enzyme Immobilization strategies would help the students to understand how fermentation processes can be improved and made commercially feasible.	Traditional classroom lectures, powerpoint presentations, educational videos as well as hands-on exposure to immobilization by entrapment technique to demonstrate reusability of producer microbial candidates.	Analysis through flow charts, assignments, discussions and MCQs.
4	Will understand the importance of microorganisms in production of renewable energy alternatives like biofuels as well as in environmental management and combating pollution through bioleaching and degradation of xenobiotics.	Chalk and talk lectures followed by slide shows.	Worksheets on various strategies and class tests.
5	Will become conversant with the role of microbes in agricultural biotechnology, *e.g.*, in development of transgenic crops with desirable traits like disease resistance etc. The use of microbes in formulation of biopesticides and biofertilisers will also be discussed.	Conventional blackboard teaching, interactive lectures and powerpoint presentations.	Assignments and short oral presentations by the students.
6	Will obtain information on IPR and its main components for protection of novel recombinant products.	Conventional blackboard teaching.	Interactive sessions on patenting process, trade secrets, trademarks, copyrights.

***Assessment tasks listed here are only indicative and may vary**

MICROB-GE401: INDUSTRIAL AND FOOD MICROBIOLOGY

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:

The main objective of this paper is to enable students to gain knowledge of microbial fermentation processes and the application of microorganisms in the industrial production of biomass/metabolites of interest. They would also be acquainted with the desirable and undesirable activities of microorganisms in association with foods and their applications in the food industry.

Course Learning Outcomes:

On successful completion of the course, the student:

CO1: Will have acquired knowledge about different types of fermentation processes feasible using both solid and liquid state substrates/media. They will also be acquainted with types of fermenters and the components of a typical fermenter.

CO2: Will have learnt the various techniques involved in the isolation, screening, preservation, and maintenance of industrial strains. They will also be familiar with the ingredients used in a fermentation medium.

CO3: Will have gained in-depth knowledge about the microbial production of various products and enzymes in the industry along with their downstream processing.

CO4: Will have gathered an understanding of important parameters affecting microbial growth in foods. Spoilage of some common foods by microorganisms will also be discussed. and student will acquire knowledge of commonly occurring food borne diseases.

CO5: Will become acquainted with different physical methods and chemicals used in food preservation. The student will also be aware of the concept of quality control of food.

CO6: Will be conversant with the use of microorganisms in the production of fermented foods (dairy and non-dairy), and microorganisms as food supplements.

Contents:

Unit 1: Introduction to Industrial microbiology: Brief history and developments in industrial microbiology. Types of fermentation processes: solid state, liquid state, batch, fed-batch and continuous. Types of fermenters: laboratory and pilot-scale fermenters. Components of a typical continuously stirred tank bioreactor (CSTR). **10**

Unit 2: Isolation of industrial strains and fermentation medium: Primary and secondary screening. Preservation and maintenance of industrial strains. Carbon and nitrogen source used in fermentation medium: molasses, corn steep liquor, whey and yeast extract. **8**

Unit 3: Microbial fermentation processes: Downstream processing: filtration, centrifugation, cell disruption, solvent-solvent extraction. Microbial production of industrially important products: citric acid, ethanol, and penicillin. Industrial production and uses of the enzymes: amylases, proteases, lipases, and cellulases. **12**

Unit 4: Food as a substrate for microbial growth and food-borne diseases: Intrinsic and extrinsic parameters that affect microbial growth in food. Microbial spoilage of food: milk, bread and canned foods. Food intoxication by *Clostridium botulinum*. Food infection by *Salmonella*. Traveller's diarrhea. **13**

Unit 5: Principles and methods of food preservation: Physical methods: high temperature, low temperature, irradiation, aseptic packaging. Chemical methods**:** salt, sugars, benzoates, citric acid, ethylene oxide, nitrate, and nitrite. Food quality control management: HACCP. **9**

Unit 6: Dairy products and probiotics: Fermented dairy products: yogurt, acidophilus milk, kefir, dahi and cheese. Fermented non-dairy products (soy sauce and sauerkraut) Probiotics: definition, examples and benefits. **8**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Microbial fermentation for the production and estimation of amylase.

2. Microbial fermentation for the production and estimation of citric acid.

3. Determination of the microbiological quality of milk sample by MBRT.

4. Isolation of fungi from spoilt bread/fruits

5. Preparation of yogurt/dahi.

Suggested Reading:

1. Adams, M.R. and Moss, M.O. (2000). *Food Microbiology*. 2nd edition. New Age International Publishers, India.

2. Banwart, G.J. (2004). *Basic Food Microbiology*. 2nd edition. CBS Publishers and Distributors, India.

3. Casida, L.E. (2019). *Industrial Microbiology*. 2nd edition. New Age International, India.

4. Crueger, W., Crueger, A. and Aneja, K.R. (2017). *Biotechnology: A Textbook of Industrial Microbiology*. 3rd edition. Medtech Publisher, India.

5. Frazier, W.C., Westhoff, D.C. and Vanitha, N.M. (2013). *Food Microbiology*. 5th edition. Tata McGraw-Hill Publishing Company Ltd, India.

6. Jay, J.M., Loessner, M.J. and Golden, D.A. (2006). *Modern Food Microbiology*. 7th edition. CBS Publishers and Distributors, India.

7. Patel, A.H. (1996). *Industrial Microbiology*. 1st edition. Macmillan India Limited.

8. Stanbury, P.F., Whitaker, A. and Hall, S.J. (2016). *Principles of Fermentation Technology*. 3rd edition. Elsevier Science, Netherlands.

9. Tortora, G.J., Funke, B.R., Case, D., Weber, D. and Bair, W. (2019). *Microbiology: An Introduction*. 13th edition. Pearson Education, USA.

10. Willey, J. M., Sandman, K. and Wood, D. (2019). *Prescott's Microbiology*. 11th edition. McGraw Hill Higher Education, USA.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks*
1	The student will acquire knowledge about different types of fermentation processes feasible using both solid and liquid state substrates/media. They will also be acquainted with types of fermenters and the components of a typical fermenter.	Detailed discussion on different types of fermentation processes, their advantages, disadvantages, and applications. Different types of fermenters and components of a typical fermenter (CSTR).	Class Tests: Well labeled diagrams of CSTR
2	The student will learn the various techniques involved in	Class room lectures on isolation, screening, and preservation of	Class tests and short presentations by

	the isolation, screening, preservation, and maintenance of industrial strains. They will also be familiar with the ingredients used in a fermentation medium.	industrial strains.	students.
3	Students will gain in-depth knowledge about the microbial production of various products and enzymes in the industry along with their downstream processing.	Discussion on various techniques of downstream processing with the help of audio-visual aids. Detailed class lectures on the microbial production of industrial products listed in the syllabus and supplemented with the practical exercises.	Preparation of flowcharts by students on microbial production of industrial products.
4	Will have gathered an understanding of important parameters affecting microbial growth in foods. Spoilage of some common foods by microorganisms will also be discussed. and student will acquire knowledge of commonly occurring food borne diseases.	An overview of various parameters affecting microbial growth in foods and discussion on spoilage of some common foods. Practical exercise on food spoilage. Lectures on food borne diseases.	Quiz, MCQs, Objective type tests.
5	The student will become acquainted with different physical methods and chemicals used in food preservation. The student will also be aware of the concept of food sanitation and control.	Theory classes are discussing the different physical and chemical methods used for food preservation and an overview on food sanitation.	Objective type questions.
6	Will be conversant with the use of microorganisms in the production of fermented foods (dairy and non-dairy), and microorganisms as food supplements.	Lectures are highlighting the use of microorganisms in the production of some fermented dairy and non-dairy foods supplemented with practical exercise. Discussion on microorganisms as health supplements.	Flow charts for preparation of fermented foods, objective type questions and short notes.

***Assessment tasks listed here are indicative, and may vary.**

MICROB-GE402: MICROBES IN ENVIRONMENT

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:

The objective of this paper is to make the students aware of the diverse microbial populations present in different habitats and interaction amongst them. They would also gain knowledge of the nutrient cycling occurring in the ecosystem(s). The students would learn about environmental problems and their management and will motivate them to think of novel ways to solve various environmental problems.

Course Learning Outcomes:

After studying this course, the student:

CO1: Will know about the diverse microbial populations present in various natural habitats (different types).

CO2: Would understand the interaction of microbes with both micro and macro-organisms (plants and animals).

CO3: Would become aware of the importance of microbes in any ecosystem with reference to nutrient cycling/ biogeo-chemical cycling.

CO4: Would become familiar with and gain knowledge about the various methods of waste treatment (solid and liquid) and management.

CO5: Would become aware of the degradable properties of a microbial population present in a habitat/ecosystem.

CO6: Would gain knowledge of the methods used in testing the potability of water.

Contents:

Unit 1: Microorganisms and their habitats: Terrestrial environment (microflora), aquatic environment (microflora of fresh and marine habitats), atmosphere (aeromicroflora and dispersal of microbes), microbes in /on human and animal bodies. Extreme Habitats: extremophiles – microbes thriving at high and low temperatures, pH, hydrostatic and osmotic pressures and salinity; and low nutrients levels. **14**

Unit 2: Microbial interaction: Microbe-microbe interactions (mutualism, synergism, commensalism, competition, amensalism, parasitism, predation). Plant-microbe interactions (symbiotic and non-symbiotic interactions). Microbe-animal interactions (microbes in ruminants, nematophagus fungi, symbiotic luminescent bacteria). **12**

Unit 3: Biogeochemical cycling: Carbon cycle (microbial degradation of cellulose and lignin), nitrogen cycle (nitrogen fixation, ammonification, nitrification, denitrification and nitrate reduction), phosphorus cycle (phosphate immobilization and solubilisation), sulphur cycle (microbes involved in sulphur cycle). **12**

Unit 4: Waste management: Solid waste management : sources and types of solid waste, methods of solid waste disposal like sanitary landfill and composting. Liquid waste management: composition and strength of sewage (BOD & COD), primary, secondary (oxidation pond, trickling filter, activated sludge process, septic tank) and tertiary sewage treatment. **12**

Unit 5: Microbial bioremediation: Microbial degradation of pesticide (DDT). Marine oil spills. **5**

Unit 6: Water potability: Treatment and safety of drinking (potable) water. Methods to detect potability of water samples: Standard qualitative procedure- MPN test, confirmed and completed test. Membrane filter technique. Presence/Absence test for fecal coliforms. **5**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Analysis of soil pH, moisture content, water holding capacity, percolation, capillary action.

2. Isolation of microbes (bacteria & fungi) from the soil.

3. Assessment of microbiological quality of water by presumptive test (MPN)

4. Determination of BOD of the water sample.

5. Study the presence of microbial activity by detecting enzymes (qualitatively—dehydrogenase, amylase, urease (any 2) in soil.

Suggested Reading:

1. Atlas, R.M. and Bartha, R. (2000). *Microbial Ecology: Fundamentals and Applications*. 4th edition. Benjamin Cummings, USA.

2. Madigan, M.T. and Martinko, J.M. (2017). *Brock Biology of Microorganisms.* 15th edition. Prentice Hall International Inc., USA.

3. Martin, A. (1991). *An Introduction to Soil Microbiology*. 2nd edition. John Wiley and Sons Co, UK.

4. Pepper, I.L., Gerba, C.P. and Gentry, T.J (editors). (2014). *Environmental Microbiology.* 3rd edition. Academic Press, USA

5. Singh, A., Kuhad, R.C. and Ward, O.P. (editors) (2009). *Advances in Applied Bioremediation*. Springer-Verlag, Germany.

6. Subba Rao, N.S. (2017). *Soil Microbiology*. 5th edition. Medtech, India.

7. Willey, J. M., Sandman, K. and Wood, D. (2019). *Prescott's Microbiology.* 11th edition. McGraw Hill Higher Education, USA.

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Would know about the diverse microbial population (different types) present in various natural habitats.	Class lecture on different habitats, their microbial populations with the help of visual aids in ecosystem.	Class test based on the characteristics of habitats and their microorganisms.
2.	Would understand the interaction of microbes amongst themselves and with plants /animals.	Lectures with the help of videos showing interaction between microbial population and with macro population.	MCQ's and match the following type questions on different interactions.
3.	Making/creating awareness on the importance of micro –organisms in Bio-geochemical cycling in ecosystem.	Classroom lecture on the role of microbial population in different nutrient cycling.	A flow chart or through graphical presentation test based on the bio-geo-chemical cycles studied .
4.	Would gain knowledge about the various methods of solid & liquid waste treatment and management.	Powerpoint presentation of the waste (solid & liquid) treatment.	Quiz based on the waste management methods.
5.	Making the students aware of the	A discussion on the	Presentations by

	degradative property of the microbes in different ecosystems/habitat.	clean up technology of the environment. Problems faced and their solutions.	students on various environmental problems and their solutions.
6.	Students would gain knowledge of the methods used to test the potability of water.	Lectures demonstrating the different potability test for water.	Testing the potability of the water samples from different sources.

***Assessment tasks listed here are indicative and may vary**

MICROB-GE403: MEDICAL MICROBIOLOGY AND IMMUNOLOGY

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:

The major objective of this paper is to educate non-microbiology students with the fundamentals of medical microbiology and immunology. The students shall study the whole spectrum of infectious diseases caused by different classes of microbes. The knowledge of human immune system, lymphoid organs, immune cells and its functioning will be given. Another objective is to impart practical training in disease diagnosis and the latest immunological techniques.

Course Learning Outcomes:

Upon successful completion of the course, the student:

CO1: Gets introduced to the basic principles and terminology associated with medical microbiology.

CO2: Will be able to understand the different types of pathogenic diseases, symptoms, disease cycle, prevention and cure.

CO3: Will have learnt about the various classes of antimicrobial compounds and their mode of action, and be aware of the problem of antimicrobial resistance.

CO4: Will have learnt about the different immune organs, immune cells and their functioning.

CO5: Will learn about the characteristics of antigens, haptens and adjuvants.

CO6: Will understand how immune response is generated and how the immune system clears the infection.

Contents:

Unit 1: Normal microflora of the human body and host pathogen interaction: Normal microflora of the human body: importance of normal microflora, normal microflora of skin, throat, gastrointestinal tract, urogenital tract. Host pathogen interaction: Definitions - infection, invasion, pathogen, pathogenicity, virulence, toxigenicity, carriers and their types, opportunistic infections, nosocomial infections. Transmission of Infection. **6**

Unit 2: Diseases caused by pathogens (bacteria, viruses, fungi and protozoa): A brief description of various diseases caused by bacteria (tuberculosis, typhoid), viruses (rabies, influenza), fungi (candidiasis), protozoa (malaria): causative organism, symptoms, transmission, diagnosis, prevention and control. Causative agents of the following diseases: Bacterial - Anthrax, Cholera, Diptheria, Gonorrhea, Tetanus, Tuberculosis, Typhoid; Viral - AIDS, Dengue, Hemorrhagic Fever, Hepatitis, Influenza, Polio, Rabies; Protozoan - Amoebiasis, Giardiasis, Kala Azar, Malaria, Toxoplasmosis; Fungal - Aspergillosis, Candidiasis, Coccidiomycosis, Mycosis, Mycotoxicosis. **16**

Unit 3: Antimicrobial agents: General characteristics and mode of action: Antibacterial agents: five modes of action with one example each: inhibitor of nucleic acid synthesis, inhibitor of cell wall synthesis, inhibitor of cell membrane function, inhibitor of protein synthesis, inhibitor of metabolism. Antifungal agents: mechanism of action of amphotericin B. Antiviral agents: mechanism of action of acyclovir, azidothymidine. **10**

Unit 4: Immune Cells and Organs: Structure, functions and properties of: Immune Cells: T cell, B cell, NK cell, macrophage, neutrophil, eosinophil, basophil, dendritic cell. Immune Organs: bone marrow, thymus, lymph node, spleen. **10**

Unit 5: Antigens: Characteristics of an antigen (foreignness, molecular size and heterogeneity). Haptens. Epitopes (T and B cells Epitopes). Adjuvants. **8**

Unit 6: Humoral and cell-mediated immunity: Structure, types and functions of antibodies. Primary and secondary immune response. Generation of humoral immune response (plasma and memory cells). Generation of cell-mediated immune response. **10**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Identify pathogenic bacteria on the basis of cultural, morphological and biochemical characteristics: IMViC, TSI.

2. Study of composition and use of important differential media for identification of pathogenic bacteria: EMB Agar, MacConkey agar, Mannitol salt agar, Deoxycholate citrate agar, TCBS (any two).

3. Perform antibacterial sensitivity by Kirby-Bauer method.

4. To identify different immune cells by microscopy.

5. To study immunodiffusion by Ouchterlony method.

Suggested Reading:

1. Abbas, A.K., Lichtman, A.H. and Pillai, S. (2017). *Cellular and Molecular Immunology*. 9th edition. Elsevier, USA.

2. Ananthanarayan, R. and Paniker, C.K.J. (2017). *Textbook of Microbiology*. 10th edition. Universities Press, India.

3. Carroll, K.C., Morse, S.A., Mietzner, T.A. and Miller, S. (2016). *Jawetz, Melnick and Adelberg's Medical Microbiology*. 27th edition. McGraw Hill Education.

4. Delves, P., Martin, S., Burton, D. and Roitt, I.M. (2017). *Roitt's Essential Immunology*. 13th edition. Wiley- Blackwell Scientific Publication, UK.

5. Punt, J., Stranford, S., Jones, P. and Owen, J. (2018). *Kuby Immunology*. 8 th edition. W.H. Freeman and Company, USA.

6. Richard, C. and Geoffrey, S. (2009). *Immunology*. 6th edition. Wiley- Blackwell Scientific Publication, UK.

7. Willey, J. M., Sandman, K. and Wood, D. (2019). *Prescott's Microbiology.* 11th edition. McGraw Hill Higher Education, USA

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks
1	Student gets knowledge about the basic features of medical microbiology and the associated terminology.	Class room lecture and PPT, worksheets	Quiz, assignment, formulate a clear answerable questions
2	Will be able to understand the diseases caused by different classes of microbial pathogens, their transmission, disease cycles and treatment	PPT, pictorial representation, video classes	MCQs, worksheets assignment and group discussion
3	Will have learnt the various classes of antimicrobials and their mode of action	Lectures on different groups of antimicrobials, PPTs, Video films	Assignment, class test
4	Will have learnt the organs of immune system, immune cells and their functions	Pictorial representation of these topics and Video films for their functioning	MCQ and Assignments
5	Will learn about the characteristics of antigens, haptens and adjuvants.	Classroom lectures.	Assignment, class test,
6	Will have learnt basic concepts of immune response, and various defence pathways	Blended learning approach, PPT, face-to-face lessons with engaging online activities and resources	Quiz, student knowledge application, mock viva.

***Assessment tasks listed here are indicative, and may vary.**

MICROB-GE404: GENETIC ENGINEERING AND BIOTECHNOLOGY

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:

The major objective of this course is to develop a clear understanding of various aspects of genetic engineering and biotechnology and to become familiar with recently developed tools and techniques. The student learns how genes can be manipulated and recombinant proteins produced for therapeutic and agricultural use. The knowledge gained by the student will equip the student to better understand courses as microbial biotechnology, bioengineering, systems biology and synthetic biology-based courses.

Course Learning Outcomes:

Upon successful completion of the course, the student:

CO1: Will be acquainted with historical developments in the field of biotechnology and will gain knowledge as well as hands-on training about of methods of DNA, RNA and protein analyses.

CO2: Will gather in-depth understanding of the exploitation of restriction and DNA-modifying enzymes in recombinant DNA technology, along with the use of linkers and adapters.

CO3: Will have acquired detailed knowledge of the use of different cloning vectors and different types of expression vectors used to express heterologous proteins in bacteria, yeast, insect cells and mammalian cells.

CO4: Will have learnt of amplification and quantification of DNA and RNA, construction of genomic and cDNA libraries, and whole genome sequencing.

CO5: Will be well aquainted with understanding of gene delivery methods in different organisms, thus allowing the student to apply the acquired knowledge of genetic engineering for development of products of human therapeutic interest.

CO6: Will have learnt differences between patents, copyrights and trademarks, and their specific applications. Will become aware of the ethics involved in biotechnology research.

Contents:

Unit 1: Introduction to genetic engineering and techniques of DNA, RNA and protein analysis: Milestones in genetic engineering and biotechnology. Methods of DNA, RNA and protein analysis: Agarose gel electrophoresis and SDS-PAGE analysis. Southern, Northern and Western blotting techniques, dot/slot blot analysis. DNA microarray analysis. **8**

Unit 2: Enzymes used in genetic engineering: Restriction modification systems: Mode of action, and applications of Type II restriction enzymes in genetic engineering. DNA modifying enzymes and their applications: DNA polymerases, terminal deoxynucleotidyltransferase, T4 polynucleotide kinase, alkaline phosphatase, DNA ligases. **8**

Unit 3: Vectors: Cloning Vectors: Definition and Properties. Applications of different types of cloning vectors: plasmid vectors, phage vectors, cosmids, BACs, YACs. Use of linkers and adaptors in cloning. Difference between cloning and expression vectors. *E.coli* lac and T7 promoter-based expression systems. **12**

Unit 4: Gene delivery methods: Transformation of DNA: by chemical method. Gene delivery: Microinjection, electroporation, biolistic method (gene gun), liposome and viral-mediated delivery, Agrobacterium- mediated delivery. **8**

Unit 5: DNA amplification and DNA sequencing: PCR: Basics of PCR, RT-PCR, Real-Time PCR. Preparation of genomic and cDNA libraries. Sanger's method of DNA Sequencing: traditional and automated. Whole genome sequencing. Overview of next generation sequencing methods. **10**

Unit 6: Applications of genetic engineering and biotechnology: Products of human therapeutic interest - insulin, hGH. Products of agricultural importance – Bt cotton, golden rice, flavr savr tomato. Gene therapy, recombinant vaccine, protein engineering. **14**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Digestion of DNA using restriction enzymes and analysis by agarose gel electrophoresis.
2. Ligation of DNA fragments and visualization by agarose gel electrophoresis.

3. Interpretation of sequencing gel electropherogram.
4. Designing of primers for DNA amplification and amplification of DNA by PCR.
5. Developing a flowchart for the production of a recombinant product.

Suggested reading:

1. Brown, T.A. (2016). *Gene Cloning and DNA Analysis: An introduction*. 7th 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. Green, M. and J. Sambrook, J. (2012). *Molecular Cloning: A Laboratory Manual*. 4th edition. Cold Spring Harbour Laboratory Press, USA

4. Primrose, S.B. and Twyman, R.M. (2004). *Genomics: Applications in Human Biology.* 8th edition. Blackwell Publishing, U.K.

5. Primrose, S.B. and Twyman, R.M. (2016). *Principles of Gene Manipulation and Genomics*. 8th edition. Blackwell Publishing, U.K.

6. Willey, J. M., Sandman, K. and Wood, D. (2019). *Prescott's Microbiology.* 11th edition. McGraw Hill Higher Education, USA.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks
1	Will be acquainted with historical developments in the field of biotechnology and will gain knowledge as well as hands-on training about of methods of DNA, RNA and protein analyses	Students can understand historical development in the field of biotechnology through power point presentation. Class room lecture on different techniques involved in the analysis of DNA, RNA and proteins, along with execution of the methods by the students in practicals.	Execution of experiments related to DNA, RNA and protein analysis and analysis of results obtained.
2	Will gather in-depth understanding of the exploitation of restriction and DNA-modifying enzymes in recombinant DNA technology, along with the use of linkers and adapters.	Pictorial presentations of different types of restriction enzymes and various DNA modifying enzymes along with their applications.	Group discussion on the use of restriction enzymes in genetic engineering. Multiple choice question-type quiz on DNA modifying enzymes and their applications.
3	Will have acquired detailed knowledge of the use of different cloning vectors and different types of expression vectors used to express heterologous proteins in bacteria, yeast,	Detailed discussion on different series of cloning vectors and also focus on the advantages and disadvantages of vectors during cloning and expression of particular genes.	Comparison of different series of vectors. Student will be given a simple cloning problem for which they must select the appropriate vector system and explain their

	insect cells and mammalian cells.		choice.
4	Will have learnt of amplification and quantification of DNA and RNA, construction of genomic and cDNA libraries, and whole genome sequencing.	Theory class on amplification and quantification of DNA and RNA especially by use of PCR, RT-PCR and qRT-PCR. Pictorial presentations on the construction of genomic and cDNA libraries.	Quiz on enzymes involved in PCR and RT-PCR, and in the construction of genomic and cDNA libraries. Simple analysis of a bacterial genome sequence to gain an understanding of the encoded information.
5	Will be well aquainted with understanding of gene delivery methods in different organisms, thus allowing the student to apply the acquired knowledge of genetic engineering for development of products of human therapeutic interest.	Practical example-based teaching on development of products of human therapeutic interest, recombinant vaccine, Bt transgenic crops.	Group presentations on development of specific genetically modified crops.
6	Will have learnt differences between patents, copyrights and trademarks, and their specific applications. Will become aware of the ethics involved in biotechnology research.	Theory class on concepts of patents, copyrights and trademarks	Group discussion on the ethics of biotechnology research with specific examples.

Assessment tasks listed here are indicative, and may vary.

MICROB-SE1: MICROBIAL QUALITY CONTROL IN FOOD AND PHARMACEUTICAL INDUSTRIES

Marks: 50 **Duration: 30 hours (2 credits)**

Course Objectives:

This course is designed specifically to impart skills to students in the area of Quality Control. This is essential for food and pharmaceutical industries to ensure that their final products are consistent, safe, effective and predictable. Hence it is important for students to become familiar with various methodologies for detection of different micro-organisms (qualitative and quantitative methods) and compliance with standards.

Course Learning Outcomes:

Upon successful completion of the course, the student:

CO1: Will have knowledge about Good Laboratory Practices and biosafety.

CO2: Will have understanding of the various tests used in food and pharmaceutical industries to detect and assess microbial load.

CO3: Will have learnt the concepts of TQM and will understand the checks that can be performed to manage microbiological issues. Will become familiar with various standards and certifications for food and pharmaceutical products.

Contents:

Unit 1: Microbiological laboratory and safe practices: Good Laboratory Practices, Good Microbiological Practices. Biosafety cabinets: Working principle and use of biosafety cabinets. Use of protective clothing. Design and specification for BSL-1, BSL-2, BSL-3 facilities. Discard of biohazard waste and methods of disinfection. **5**

Unit 2: Microbiological monitoring and detection in food and pharmaceutical samples: Collection and processing samples for testing. Pathogenic microorganisms in food and water. Detection of microorganisms: culture and microscopic methods - standard plate count (nutrient agar and Sabouraud agar), direct microscopic counts (fluorescence-based). Detection of specific microorganisms through differential and selective media: XLD agar, Salmonella-Shigella agar, Mannitol salt agar, EMB agar, McConkey agar. Most probable number (MPN) method. Molecular methods: nucleic acid probes, PCR-based detection. Biosensors. Biochemical and immunological methods: endotoxin testing by Limulus lysate test, pyrogen testing, rapid detection methods by Clot on Boiling Test **(**COB), Resazurin assay. Sterility testing of food and pharmaceutical products: importance and objectives, microbial limits. **15**

Unit 3: Microbial quality and safety: Total Quality Management (TQM): concepts and approaches, SOP, Quality Assurance and Quality Control**.** Hazard analysis of critical control point (HACCP) for food safety: principles, flow diagrams, limitations and case study of milk processing and packaging. BIS standards. FSSAI standards. ISO certification. **10**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Detection of microorganisms in food samples through differential and selective media
2. Analysing the milk sample provided by Standard Plate Count and Direct Microscopic count.
3. TTC Test for microbial content of milk.
4. Alkaline phosphatase test to test the effectiveness of pasteurization of milk.
5. Resazurin test and COB test.
6. Sterility testing of canned food, tetrapak drink, and one drug formulation (eyedrops/injection ampoule).

Suggested Reading:

1. Akers, M.J. (2016). *Sterile Drug products: Formulation, Packaging, Manufacturing and Quality.* 1st edition. CRC Press, USA.

2. Baird, R.M., Hodges, N.A and Denyer, S.P. (2005). *Handbook of Microbiological Quality control in Pharmaceutical and Medical Devices.* Taylor and Francis Inc., USA.

3. Cooper, M.S. (editor). Quality Control in the Pharmaceutical Industry Vol.2. Academic Press, USA.

4. Garg, N., Garg, K.L and Mukerji, K.G. (2010*). Laboratory Manual of Food Microbiology*. I K International Publishing House, India.

5. Harrigan, W.F. (1998). *Laboratory Methods in Food Microbiology*. 3rd edition. Academic Press, USA.

6. Jay, J.M., Loessner, M.J. and Golden, D.A. (2006). *Modern Food Microbiology*. 7th edition. CBS Publishers and Distributors, India.

7. Law, J.W., Mutalib, N.A., Chan, K.G. and Lee, L.H. (2014). *Rapid methods for the detection of foodborne bacterial pathogens: principles, applications, advantages and limitations* in *Frontiers in Microbiology*. 5: 770, 2014.

8. Mathur, P. (2018). *Food Safety and Quality Control*. Orient Blackswan, India.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks
1	Student gets knowledge about Good laboratory practices and biosafety	Class room lecture and Hands on in the lab	MCQ based assessment
2	Will have understanding of the various tests used in Food and Pharmaceutical industries to detect and assess microbial load	Detailed discussion on strategies to detect particular microorganisms in food and pharmaceutical samples. Hands on in the lab on detection of microbes in food samples	Assessment based on interpretation of results from hands on activities
3	Will have learnt the concepts of TQM, understand the checks that can be performed to manage microbiological issues and various standards and certifications	Lectures on TQM, and interaction with students on various certifications,	Assessment through Case studies of HACCP

***Assessment tasks listed here are indicative, and may vary.**

MICROB-SE2: MICROBIAL DIAGNOSIS IN HEALTH CLINICS

Marks: 50 **Duration: 30 hours (2 credits)**

Course Objectives:

The major objective of this course is to introduce the students to the importance of diagnosis of pathogens in controlling diseases. The student will become familiar with various approaches used for diagnosis along with their advantages and limitations. The importance of antimicrobial resistance and methods to determine it are also covered in this course.

Course Learning Outcomes:

Upon successful completion of the course, the student:

CO1: Will have understood the importance and challenges in detecting pathogens. Will have a fair understanding of various methods used for collection, transport and storage of clinical samples.

CO2: Will have been acquainted with the principles of various classical and newer approaches for the identification of microbial pathogens such as microscopy, culturing, biochemical tests, serological and molecular methods.

CO3: Will have an understanding of the applicability of various detection methods in the form of kits for rapid detection of pathogens. Will have learnt various methods for determination of antimicrobial resistance in bacterial pathogens.

Contents:

Unit 1: General principles of diagnosis and collection of clinical samples: Importance of diagnosis of infectious diseases. Challenges in diagnosis (Interference from normal microflora, mixed infections, specificity and sensitivity issues). Choice of clinical samples for diagnosis of infectious diseases. Methods for collection of clinical samples (Blood, CSF, Urine, Faeces). Sample collection from oral cavity, throat and skin, biopsies). Methods of transport of clinical samples to laboratory and their storage. **6**

Unit 2: Approaches for identification of pathogens: Microscopic examination: Examination of clinical sample by microscopy, Ziehl-Neelson staining of sputum sample for detection of tuberculosis, Giemsa staining of blood film for detection of malaria. **Cultural Methods:** Enrichment Culture, Preparation and use of culture media - Blood agar, Chocolate agar, Lowenstein-Jensen medium, MacConkey agar, TCBS agar, Salmonella Shigella agar; Microbial detection using chromogenic media. Distinct colony properties of various bacterial pathogens on relevant culture media (*Streptococcus pyogenes, Mycobacterium tuberculosis, Salmonella, Shigella, E. coli, Vibrio*). **Biochemical Methods:** Sugar fermentation profiling, TSI, IMViC. **Serological and Molecular methods:** Serological Methods – Agglutination, ELISA, Western blot, Immunofluorescence, Lateral flow Immunoassays, Nucleic acid based methods – PCR: Real Time and Multiplex, Nucleic acid probes: Dot Blot and Colony Hybridization. **15**

Unit 3: Rapid Detection of bacterial pathogens and antibiotic sensitivity of bacteria: Laboratory guidance and diagnostic testing for rapid detection of pathogens**:** Typhoid, Dengue and HIV, Swine flu, Zika virus. Testing for Antibiotic sensitivity in Bacteria**:** Importance, Determination of resistance/sensitivity of bacteria using disc diffusion method, Determination of minimal inhibitory concentration (MIC) of an antibiotic by serial double dilution method. **9**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. To study methods of collection of various clinical specimens *i.e.* oral cavity, throat, skin, blood, CSF, urine and faeces for disease diagnosis through virtual lab.

2. To study the composition and importance of various selective/differential/enriched media (Blood agar, Chocolate agar, Lowenstein-Jensen medium, MacConkey agar, Salmonella Shigella agar) for diagnosis of pathogens from clinical specimens.

3. To study diagnosis of Typhoid with the help of a slide agglutination kit.

4. To determine the Minimal Inhibitory Concentration of the given antibiotic by Serial Dilution method.

5. Demonstration of a lateral flow immunoassay based kit for analyte detection in sample.

6. To prepare a flow chart for diagnosis of microbial pathogens for any two diseases prevalent in India.

Suggested Reading:

1. Ananthanarayan, R. and Paniker, C.K.J. (2017). *Textbook of Microbiology*. 10th edition. Universities Press, India.

2. Cappucino, J. and Sherman, N. (2014). *Microbiology: A Laboratory Manual*. 10th edition. Pearson Education, India.

3. Carroll, K.C., Morse, S.A., Mietzner, T.A. and Miller, S. (2016). *Jawetz, Melnick and Adelberg's Medical Microbiology*. 27th edition. McGraw Hill Education.

4. Collee, J.G., Fraser, A.G., Marmion, B.P. and Simmons, A. (2007). *Mackie and Mccartney*

5. Madigan, M.T. and Martinko, J.M. (2017). *Brock Biology of Microorganisms.* 15th edition. Prentice Hall International Inc., USA.

6. Randhawa, V.S., Mehta, G. and Sharma, K.B. (2009). *Practicals and Viva in Medical Microbiology*. 2nd edition. Elsevier, India.

7. Tille, P. (2013). *Bailey's and Scott's Diagnostic Microbiology*. 13th edition. Mosby, USA.

8. Willey, J. M., Sandman, K. and Wood, D. (2019). *Prescott's Microbiology.* 11th edition. McGraw Hill Higher Education, USA.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks
1	Will have understood the importance and challenges in detecting pathogens. Will have a fair understanding of various methods used for collection, transport and storage of clinical samples.	Class room lectures on importance and relevance of diagnosis of infectious diseases. Pictorial representation of various methods for collection of clinical samples. Visit to pathology lab to observe various containers/tubes used for collection of clinical samples.	Test and Quiz on methods of sample collection. Identification of various containers used for sample collection
2	Will have been acquainted with the principles of various classical and newer approaches for the identification of microbial pathogens such as microscopy, culturing, biochemical tests, serological and molecular methods.	Detailed discussion on the principles of various detection approaches. Lecture on composition of various media highlighting the selective and differential agents. Pictorial representations of various bacteria growing on relevant media. Use of flowcharts to teach various steps in diagnosis of disease. Use of relevant videos available online.	MCQs and Match the following type questions on media compositions (with reference to targeted microorganism, selective and differential agents). Tentative identification of various bacterial pathogens based on the cultural characteristics on different media through pictures. Test on principles of various techniques.

3	Will have an understanding of the applicability of various detection methods in the form of kits for rapid detection of pathogens. Will have learnt various methods for determination of antimicrobial resistance in bacterial pathogens.	Discussion on commercially available kits for detection of pathogens. Class room lectures on calculation of MIC.	Identification of positive, negative, false positive/ negative results based on pictures of kits. Calculation of MIC based on given data/ pictures.

*** Assessment tasks are indicative and may vary**

MICROB-SE3: BIOFERTILIZERS AND BIOPESTICIDES

Marks: 50 **Duration: 30 hours (2 credits)**

Course Objectives:

The major objective of this paper is to develop clear understanding of different types of biofertilizers, their benefits and limitations in their uses over chemical fertilizers. Being one of the skill enhanced elective course, the main focus will be on production of different types of biofertilizers at commercial level for the distribution to the end users. Various aspects of microbial biopesticides will also be discussed in this paper to enable the students learn the eco friendly ways to control agricultural pests and pathogens.

Course Learning Outcomes:

Upon successful completion of the course, the students:

CO1: Will be familiar with the commonly used bacterial, fungal and cyanobacterial biofertilizers for different crops. Students will be able to compare biofertilizers with chemical fertilizers in increasing crop productivity and will become familiar with the isolation, mass culturing and field applications of symbiotic nitrogen fixers.

CO2: Will gain in depth knowledge of isolation, characteristics, and mass production of non symbiotic nitrogen fixers and phosphate-solubilising microorganisms.

CO3: Will understand production and field applications of bacterial, fungal and viral biopesticides in controlling pests population.

Contents:

Unit 1: Symbiotic biofertilizers: General account of the microbes used as biofertilizers for various crop plants and their advantages over chemical fertilizers. Symbiotic nitrogen fixers: *Rhizobium* - Isolation, characteristics, mass production and field application, legume/pulses plants. *Frankia:* Isolation, characteristics, non-leguminous crop symbiosis. *Acetobacter diazotrophicus*: Isolation, characteristics, association with sugarcane crop. Blue green algae: *Anabaena*-Isolation, characteristics, association with *Azolla,* mass multiplication, role in rice cultivation, and field

application. Mycorrhizal associations and their applications as biofertilizers with special emphasis on VAM/AM fungi. **14**

Unit 2: Non-symbiotic biofertilizers: Free living nitrogen-fixing bacteria (*Azospirillum, Azotobacter*), phosphate-solubilising microorganisms: isolation, characteristics, mass inoculum production and field applications. A brief account of PGPR and their role as biofertilizers. Overview of compost formulation. **8**

Unit 3: Biopesticides: General account of microbes used as biopesticides, their mode of action, and advantages over synthetic pesticides. Mass production and field applications of *Bacillus thuringiensis*, *Baculoviruses*, *Beauveria bassiana* and *Trichoderma harzianum*. **8**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Isolation of symbiotic nitrogen fixer- *Rhizobium*

2. Isolation of asymbiotic nitrogen fixers-*Azotobacter* and *Azospirillum*

3. Isolation of phosphate-solubilising microorganisms and blue green algae.

5. Demonstration of composting process.

Suggested Reading:

1. Aggarwal, S.K. (2005). *Advanced Environmental Biotechnology*. APH publication, India.

2. Anwer, M.A. (editor) (2017). *Biopesticides and Bioagents: Novel tools for pest management*. CRC Press, USA.

3. Atlas, R.M. and Bartha, R. (2000). *Microbial Ecology: Fundamentals and Applications*. 4th edition. Benjamin Cummings, USA.

4. Kannaiyan, S. (editor) (2003). *Biotechnology of Biofertilizers*. edited by S. Kluwer Academic Publishers, UK.

5. Mahendra, K.R. (2005). *Hand book of Microbial Biofertilizers*. The Haworth Press, USA. Publisher, India.

6. Reddy, S.M. (2002). *Bioinoculants for Sustainable Agriculture and Forestry.* Scientific Publishers, India.

7. Saleem, F. and Shakooori, A.R. (2012). *Development of Bioinsecticides*. Lap Lambert Academic Publishing, European Union.

8. Subba Rao, N.S. (2019). *Biofertilizers in Agriculture and Forestry*. 4th edition. Biogreen

9. Subba Rao, N.S.. (2017). *Soil Microbiology*. 5th edition. Medtech, India.

10. Willey, J. M., Sandman, K. and Wood, D. (2019). *Prescott's Microbiology.* 11th edition. McGraw Hill Higher Education, USA.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks

1	Students will be familiar with the commonly used bacterial ,fungal and cyanobacterial biofertilizers for diffferent crops. Students will be able to compare biofertilizers with chemical fertilizers in increasing crop productivity. The isolation and mass culturing and field applications of symbiotic nitrogen fixers will be discussed	Class room lecture on different types of biofertilizers and their benefits over chemical fertilizers. Detailed talk on symbiotic fertilizers-*Rhizobium, Acetobacter diazotrophicus, Azolla – Anaebena*	Students to collect and compile data about commercially available biofertilizers Class test
2	Students will gain in depth knowledge of isolation, characteristics , mass production of non symbiotic nitrogen fixers and Phosphate solubilising microorganisms	Lecture on asymbiotic nitrogen fixers-(*Azotobacter* and *Azospirillum*) and phosphate solubilising microorganisms. Use of relevant content available online	Prepare flow chart for the production of different types of biofertilizers
3	Students will understand production and field applications of bacterial, fungal and viral biopesticides in controlling pests population .	Theory class on mass production of biopesticides –*Bacillus thuringiensis*, *Baculoviruses Beauveria bassiana* and *Trichoderma* harzianum Interactive lectures on the field applications of the biopesticides	Draw the scheme for cultivation of bacterial,fungal and viral biopesticides.

***Assessment tasks listed here are indicative, and may vary.**

MICROB – SE4: Food Fermentation Techniques

Marks: 100 **Duration: 30 hours (2 credits)**

Course Objectives:

The major objective of this paper is to develop clear understanding about fermented foods, their types, benefits, process involved and limitations of their use. Being one of the skill enhancement elective courses, the main focus will be on the production of various fermented foods at commercial level. Probiotic, prebiotic and synbiotics foods will also be discussed to enable students to learn about their health benefits.

Course learning outcomes:

Upon successful completion of the course, the students:

CO1: Will be familiarized with the fermented foods, types and their health benefits.

CO2: Will gain in-depth knowledge on the types of microbes involved in food fermentation.

CO3: Will be acquainted with the process involved in the production of various fermented foods.

Contents:

Unit 1: Introduction to food fermentation: Definition of fermentation and fermented foods. Types of food fermentations: acid food fermentations and yeast fermentations. Oriental and indigenous foods. Nutritional and health benefits of fermented foods. Prebiotics, probiotics and synbiotics: Definition and examples. **4**

Unit 2: Microbial cultures for food fermentation: Microbial food culture (MFC): Definition and applications. Starter culture: Definition, selection, maintenance, preparation and their inhibition. Bacterial starter cultures: lactic acid bacteria (LAB), propionic acid and acetic acid bacteria. Yeast starter cultures: Top and bottom fermenting yeast. Overview of other micro-organisms involved in food fermentation: Molds and Non starter lactic acid bacteria (NSLAB). **8**

Unit 3: Microbiology of fermented foods and their production strategies: Nutritional benefits, defects and micro-organisms involved in the production of: Fermented dairy products (Yogurt, Kefir, Koumiss, Acidophilus milk, Different Cheese types and preparation of cheddar cheese). Cereal and pulse based fermented foods (Tempeh, Koji process and Soya sauce). Vegetable and fruit based fermented products (pickles and Sauerkraut). Traditional Indian fermented foods (Dahi, Dosa, Idli, Ziang Dui, Sinki, Ngari, Kinema, Soidon, Ennog). Beverages (beer, sake and wine). Fermented meat (sausages). **18**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Preparation of cheese using rennet.
2. Preparation of kefir/kumiss.
3. Demonstration of sauerkraut fermentation.
4. Preparation of dahi and isolation, culturing and microscopic examination of LAB.
5. Demonstration of Vinegar – Brine pickling technique.
6. Checking the viability of inoculum: percentage yeast viable cells using methylene blue vital stain.

Suggested Reading:

1. Cogan, T.M., Beresford, T.P., Steele, J., Broadbent, J., Shah, N.P. and Ustunol, Z. (2007). *Advances in Starter Cultures and Cultured Foods* in *Journal of Dairy Science*. 90:4005–4021.
2. Edward, F.R. (2016). *Handbook of fermented functional foods*. 2nd edition. CRC press, USA.
3. Frazier, W.C., Westhoff, D.C. and Vanitha, N.M. (2013). *Food Microbiology*. 5th edition. Tata McGraw-Hill Publishing Company Ltd, India.
4. Garbut, J. (1997). *Essentials of Food Microbiology*. CRC press, USA.
5. Holzapfel, W. (2014). *Advances in Fermented Foods and Beverages.* 1st edition. Woodhead Publishing, UK.
6. Jay, J.M., Loessner, M.J. and Golden, D.A. (2006). *Modern Food Microbiology.* 7th edition. CBS Publishers and Distributors, India.
7. Safety Demonstration of Microbial Food Cultures (MFC) in Fermented Food Products. Bulletin of the International Dairy Federation 455/ 2012.
8. Y.H. Hui, L. Meunier-Goddik, J. Josephsen, W.K. Nip and P.S. Stanfield. (2004). *Handbook of food and beverage fermentation technology*. 1st edition. CRC Press, UK.

Facilitating the achievement of course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Students will be familiarized with the fermented foods, types and their health benefits.	Class Room lecture on the fermented foods and their types. Interactive session on the use of probiotic, prebiotic and synbiotic and their health benefits.	Students to collect samples of various fermented foods available commercially and do market survey on their consumption.
2	Students will gain in-depth knowledge on the types of microbes involved in food fermentation.	Detailed discussion on types and use of starter cultures in food fermentations.	Class test / Assignment on MFC and types of starter cultures.
3	Students will be acquainted with the process involved in the production of various fermented foods.	Teaching of various fermentation processes through flow charts, powerpoint presentations and relevant online videos	Quiz and MCQs on the microorganisms and the process involved in the production of fermented foods.

***Assessment tasks listed here are indicative and may vary.**

MICROB-SE5: MANAGEMENT OF HUMAN MICROBIAL DISEASES

Marks: 50 **Duration: 30 hours (2 credits)**

Course Objectives:

The major objective of this course is to develop a clear understanding of the wide spectrum of human diseases caused by different micro-organisms and to introduce the students to the diverse antibiotics used for therapy, as well as familiarize them with the epidemiological aspects of the disease with respect to transmission and preventive methods.

Course Learning Outcomes:

Upon successful completion of the course, the student:

CO1: Will be introduced to the microbial diseases of various organ systems, their causative agents, symptoms as well as modes of transmission. Will have also gained a brief insight into newly emerging microbial diseases, their geographical distribution, factors responsible for their spread, and their control measures.

CO2: Will learn about the mode of action of different anti- microbial agents, concept of anti-microbial resistance, and updates on current therapeutics.

CO3: Will be familiarized with the methods of disease prevention and types of immunization methods and vaccines being used currently.

Contents:

Unit 1: Human microbial diseases: Introduction: Definition and concept of health, disease,

infection, pathogen. Types of human microbial diseases and their causative agents. Symptoms and mode of transmission of respiratory diseases, gastrointestinal diseases, nervous system diseases, urinary tract diseases, skin diseases, sexually transmitted diseases, mosquito-borne diseases, microbial mediated cancers, and nosocomial infections. Recently emerging microbial diseases: SARS, Swine flu, Ebola and Zika virus. **10**

Unit 2: Therapeutics of microbial diseases: Mechanism of action of different antibiotics: penicillins, cephalosporins, aminoglycosides, tetracyclines, fluoroquinolones, carbapenems, macrolides. Antiviral agents: acyclovir, amantadine, Tamiflu. Concept and importance of antibiotic regimen. DOTS. Drug resistance: MDR, XDR, TDR, NDM-1. Brief update on phage therapy. **10**

Unit 3: Prevention of microbial diseases: General preventive measures, importance of personal hygiene and environmental sanitation. Immunization: active and passive immunization, bacterial and viral vaccines, concept of live and killed vaccines, vaccination schedule. Tracing source of infections using epidemiological markers. **10**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. To study the antibiotic susceptibility patterns of clinically important bacterial isolates by Kirby Bauer Method.

2. To determine the MIC levels of different antibiotics for clinically important bacterial isolates.

3. To study symptoms of common diseases with photographs: Polio, Tetanus, Cholera, Chicken pox, Anthrax, Ringworm.

4. To screen water samples from different sources for presence of enteric pathogens.

Suggested Reading:

1. Ananthanarayan, R. and Paniker, C.K.J. (2017). *Textbook of Microbiology*. 10th edition. Universities Press, India.

2. Carroll, K.C., Morse, S.A., Mietzner, T.A. and Miller, S. (2016). *Jawetz, Melnick and Adelberg's Medical Microbiology*. 27th edition. McGraw Hill Education.

3. Nagoba, B.S and Pichare, A. (2016). *Medical Microbiology and Parasitology*. 3rd edition. Elsevier India.

4. Park, K. (2017). Park's Textbook of Preventive and Social Medicine. 24th edition. Banarsidas Bhanot Publishers, India.

5. Pelczar, M.J., Chan, E.C.S. and Krieg, N.R. (1993). *Microbiology.* 5th edition. McGraw Hill, USA.

6. Tortora, G.J., Funke, B.R., and Case, C.L. (2016). *Microbiology: An Introduction*. 12th edition. Pearson Education, USA.

7. Willey, J. M., Sandman, K. and Wood, D. (2019). *Prescott's Microbiology.* 11th edition. McGraw Hill Higher Education, USA.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks
1	Student will be introduced to the microbial diseases of various organ systems, their causative agents, symptoms as well as transmission patterns. Will have gained a brief insight into newly emerging microbial diseases, their spread and control.	Class room lectures, EMs of causative agents, photographs of symptoms of diseases	Quizzes, MCQs and match the following type questions with causative agents, diseases and symptoms.
2	Students will learn about the mode of action of different anti- microbial agents, concepts of anti-microbial resistance and updates on current therapeutics	Detailed discussion on mode of action of anti- microbial agents and drug resistance. Pictorial presentations on antibiotic structure. Case studies	Match the following type questions, assignments on resistance mechanisms
3	Students will get familiarized with the methods of disease prevention, types of vaccines being used in the current scenario as well as immunization schedule.	Classroom lectures and interactive sessions on transmission of diseases as well as disease specific control and prevention methods. Invited lectures on status of contemporary diseases as well methods used in their prevention and control	Short answer type questions and objective tests on theoretical aspects of disease prevention and control

***Assessment tasks listed here are indicative, and may vary**

MICROB-SE6: MICROBIOLOGICAL ANALYSIS OF AIR AND WATER

Marks: 50 **Duration: 30 hours (2 credits)**

Course Objectives:

The major objective of this paper is to develop clear understanding of various aspects of microbiological analysis of air and water, in relation to the diversity of air- and water-borne microorganisms, their role in human health and environment, and methods to detect and control microorganisms, thus enabling students to better understand courses taught later such as environmental microbiology.

Course Learning Outcomes:

Upon successful completion of the course, the student:

CO1: Will be acquainted with the diversity of aero-microflora and its role in human health and environment promoting the understanding of the significance of aero-microflora in food, pharmaceuticals and health sectors.

CO2: Will have gained an in-depth knowledge of methods of air sampling and its microbial analysis along with identification. Will understand the air contamination control measures.

CO3: Will have gathered understanding of the water borne pathogens and the diseases they cause. They will be conversant with the methods to detect potability of water samples. Will have gained insight into the measures to control water contamination.

Contents:

Unit 1: Aeromicrobiology: Bioaerosols, air-borne microorganisms (bacteria, viruses, fungi) and their impact on human health and environment. Significance in food and pharmaceutical industries and operation theatres. Allergens. **4**

Unit 2: **Air sample analysis and control measures**: Bioaerosol sampling, air samplers, methods of analysis, CFU, culture media for bacteria and fungi, Identification characteristics; Control measures: Fate of bioaerosols, inactivation mechanisms – UV light, HEPA filters, desiccation, Incineration. **11**

Unit 3: Water Microbiology: Water borne pathogens, water borne diseases. Microbiological analysis of water: sample collection, treatment and safety of drinking (potable) water. Methods to detect potability of water samples: standard qualitative procedure - presumptive test (MPN test), confirmed and completed tests for faecal coliforms; membrane filter technique; tests for detection of presence of microbes. Control measures: Precipitation, chemical disinfection, filtration, high temperature, UV light. **15**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Isolation and microscopic examination of airborne fungi from different sites
2. Detection of coliforms to determine water potability using membrane filter method
3. Determine the potability of the water sample by presumptive, confirmed and completed test.
4. Study of organisms isolated from air and water in the following selective and differential media: SS agar, EMB agar, MacConkey agar.
5. Effectiveness of UV/heap filter in reducing microbial load.
6. Analysis of efficacy of different hand sanitizers in reducing microbial load.

Suggested Reading:

1. Atlas, R.M. and Bartha, R. (2000). *Microbial Ecology: Fundamentals and Applications*. 4th edition. Benjamin Cummings, USA.
2. Barton, L. and McLean, R. (2019). *Environmental Microbiology and Microbial Ecology*. 1st edition. John Wiley and Sons, UK.
3. Bergey, D.H. (2019). *Waste Water Microbiology*. 2nd edition. Medtech, India.
4. Da Silva, N., Taniwaki, M.H., Junqueira, V.C., Silveira, N., Nascimento, M.S. and Gomes, R.A.R. (2018). *Microbiological Examination Methods of Food and Water: A Laboratory Manual*. 2nd edition. CRC Press, USA.
5. Hurst, C.J., Crawford, R.L., Garland, J.L. and Lipson, D.A. (2007). *Manual of Environmental Microbiology*. 3rd edition. ASM press.

6. Pepper, I.L., Gerba, C.P. and Gentry, T.J (editors). (2014). *Environmental Microbiology.* 3rd edition. Academic Press, USA.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks
1	Student get acquainted with the diversity of aero-microflora and its role in human health and environment. This allows students to understand the significance of aero-microflora in food, pharmaceuticals and health sectors.	Class room lecture on aero-microflora and its impact on human health and environment Detailed talk on significance of the aero-microflora in food, pharma and operation theatres, including allergens	Short answer questions and fill in the blanks on aero-microbiology
2	Students gain an in-depth knowledge of methods of air sampling and its microbial analysis along with identification. Will understand the air contamination control measures.	Detailed discussion on air sampling methods and detection and identification of bacteria and fungi. Pictorial and video presentations of control measures including bioaerosols, inactivation mechanisms- UV light, HEPA filters, dessication and incineration	Match the following type quiz on air sample collection and analysis. Pictorial quiz for identification of control measures.
3	Gather an understanding of the water borne pathogens and the diseases they cause. They will be conversant with the methods to detect potability of water samples. Gain an insight into the measures to control water contamination.	Interactive lectures on treatment and safety of drinking water. Familiarizing students with methods to detect potability of water Detailed account on control measures	Problem solving situation-based test on potability of water and control measures Pop quiz based on these topics

***Assessment tasks listed here are indicative, and may vary**

MICROB-SE7: FUNDAMENTALS OF BIOINFORMATICS

Marks: 50 **Duration: 30 hours (2 credits)**

Course Objectives:

The major objective of this course is to develop a clear understanding of the various concepts in bioinformatics which encompasses molecular biology, genetics, genomics, transcriptomics, proteomics, and their applications in research and development. This will enable students to take up interdisciplinary subjects later.

Course Learning Outcomes:

Upon successful completion of the course, the student:

CO1: Will be acquainted with bioinformatics and its relation with molecular biology, genetics and genomics, various modes of data transfer and simultaneously learning the advantages of encrypted data transfer, gained an in-depth knowledge of primary, secondary and composite databases, organization of diverse types of biological databases. Students will also be familiar with the file formats of sequence file formats. This allows students to apply the acquired knowledge in retrieving and analyzing biological information on the web.

CO2: Will have learnt the concept and significance of sequence alignment, comparative assessment of global and local sequence alignment, softwares used for pairwise and multiple sequence comparisons and their applications, phylogeny, types of phylogenetic trees. Student will have gathered understanding of diversity of viral, prokaryotic, eukaryotic genomes and their organization, sequencing strategies and also the knowledge of current techniques in genomics and transcriptomics namely NGS Sequencing, Microarray, along with current concepts in gene organization, challenges in gene prediction, primer designing.

CO3: Will understand the details of domains, motifs and folds, homology modelling for protein structure prediction, proteomics, computer aided drug designing and discovery

Contents:

Unit 1: Introduction to biological databases and sequence file formats: Aims and Scope of Bioinformatics. Mode of data transfer (FTP, SFTP, SCP), advantage of encrypted data transfer. Biological databases – nucleotide sequence, genome, protein sequence and structure, gene expression, metabolic pathways, general human genetics, cancer genes**.** File formats - FASTA, Genbank. Data submission & retrieval from NCBI, EMBL, PDB **10**

Unit 2: Sequence alignments, phylogeny and genomics analysis: Basic concepts of sequence similarity, sequence alignment, Local and Global Sequence alignment, BLAST and its types, pairwise and multiple sequence alignment. Representation of phylogeny, types of phylogenetic trees- rooted and unrooted trees, molecular clocks. Diversity of genomes: viral, prokaryotic (*E. coli*) and eukaryotic (human) genomes. Techniques used in genomics and transcriptomics: Primer designing, Gene Prediction methods, Microarray, NGS. **12**

Unit 3: Protein structure predictions: Structural classes: motifs, folds and domains. Homology modelling (swiss model) and evaluation by Ramachandran plot. Proteomics-use of MASCOT in protein identification. Computer aided drug discovery. **8**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Introduction to bioinformatics databases: NCBI, PDB
2. Sequence retrieval using BLAST.
3. Sequence alignment & phylogenetic analysis using clustal omega & phylip.
4. Picking out a given gene from genomes using Genscan or other softwares (promoter region identification, repeat in genome, ORF prediction). Gene finding tools (Glimmer, GENSCAN), Primer designing, Genscan/Genetool.
5. Protein structure prediction: primary structure analysis, secondary structure prediction using psi-pred, homology modeling using Swissmodel. Molecular visualization using Jmol/Pymol, Protein structure model evaluation (PROCHECK).

6. Prediction of different features of a functional gene.

7. Virtual screening of drugs using autodoc-vina.

Suggested reading:

1. Baker, L. (editor). (2018). *Bioinformatics: Tools and Techniques*. 1st edition. Callisto Reference.

2. Ghosh, Z. and Mallick, V. (2015). *Bioinformatics- Principles and Applications*. 1st edition. Oxford University Press, India.

3. Kaushik, A.C., Kumar, A., Bharadwaj, S., Chaudhary, R. (2018). *Bioinformatics Techniques for Drug Discovery: Applications for Complex Diseases*. 1st edition. Springer International. 2018.

4. Lesk, M.A. (2014). *Introduction to Bioinformatics*. 4th edition. Oxford Publication, UK.

5. Malkoff, C. (editor) (2017). *Bioinformatics, Proteomics and Genomics.* Callisto Reference.

6. Mukhopadhyay, C.S., Choudhary, R.K. and Iquebal, M.A. (2017). *Basic Applied Bioinformatics.* 1st edition. Wiley-Blackwell, USA.

7. Rastogi, S.C., Mendiratta, N. and Rastogi, P. (2007). *Bioinformatics: methods and applications, genomics, proteomics and drug discovery*. 4th edition. Prentice Hall India Publication.

8. Selzer, P.M., Marhöfer, R.J. and Koch, O. (2018). *Applied Bioinformatics: An Introduction.* 2nd edition. Springer, USA.

9. Sinha, P.K. and Sinha, P. (2017). *Foundations of Computing*. 6th edition. BPB Publications, India.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks
1	Will be acquainted with bioinformatics and its relation with molecular biology, genetics and genomics, various modes of data transfer and simultaneously learning the advantages of encrypted data transfer, gained an in-depth knowledge of primary, secondary and composite databases, organization of diverse types of biological databases. Students will also be familiar with the file formats of sequence file formats. This	Class room lecture on introduction and scope of Bioinformatics, Detailed talk on need for organization and annotation of biological data. ICT/live session on features of different types of biological databases. Detailed discussion on parts of sequence file formats. Hands on session/video on tools/softwares for uploading and downloading data from NCBI, EMBL, PDB	MCQ on primary, secondary and composite databases, Group task on identify the database with the help of a pictorial quiz. Give one word type of oral quiz on tools and softwares for data submissions and retrieval

	allows students to apply the acquired knowledge in retrieving and analyzing biological information on the web.		
2	Will have learnt the concept and significance of sequence alignment, comparative assessment of global and local sequence alignment, softwares used for pairwise and multiple sequence comparisons and their applications, phylogeny, types of phylogenetic trees, Student will have gathered understanding of diversity of viral, prokaryotic, eukaryotic genomes and their organization, sequencing strategies and also the knowledge of current techniques in genomics and transcriptomics namely NGS Sequencing, Microarray, along with current concepts in gene organization, challenges in gene prediction, primer designing.	Theory class on local and global sequence alignment, pairwise and multiple sequence alignment. Familiarizing students with similarity and homology. Practical example based teaching sequence retrieval using BLAST Interactive lecture on softwares Multiple sequence alignment. Diagrammatic representation of a phylogenetic tree. Practical example-based teaching on viral, bacterial and eukaryotic genomes. Interactive discussion on genome organization and the recent developments in genome sequencing and assembly. Practical example based primer designing and gene prediction	Exercise on Sequence retrieval using BLAST. Mathematical problem on construction a phylogenetic tree using the given set of sequences. Pop quiz on Identification of rooted and unrooted tree. MCQ on features of bacterial, viral and eukaryotic genomes. Identify the technique type of pictorial quiz on Microarray , NGS. Exercise on primer design to isolate a mRNA
3	Will understand the details of domains, motifs and folds, homology modelling for protein structure prediction, proteomics, computer aided drug designing and discovery	Class lecture on domains, folds and motifs. Practical example based teaching on prediction of protein structure. Practical exercise on evaluation of a model, 3D structure viewers (RasMOL, PyMOL). Hands on comparative modelling using SWISS MODEL. Video lecture on Molecular Docking	Pictorial Quiz on identification of secondary and super secondary structures. Exercise on protein structure prediction from a primary sequence

***Assessment tasks listed here are indicative, and may vary.**

MICROB-SE8: BIOSTATISTICS

Marks: 50 **Duration: 30 hours (2 credits)**

Course Objectives:

The primary objective of this course is to understand the basic concepts of statistics and how statistics helps in analysing biological data by using simple examples. To prepare students to handle biological data and to draw appropriate conclusions from the analyses.

Course Learning Outcomes:

Upon successful completion of the course, the student will have developed a clear understanding of:

CO1: Measures of central tendency and measures of dispersion. Coefficient of variation, skewness and kurtosis, coefficient of correlation.

CO2: Learning different probability discrete and continuous distributions and their implementation at realistic models.

CO3: Basic concepts of hypothesis testing, including framing of null and alternative hypothesis. Hypothesis testing based on a single sample and two samples using both classical and p value approach. Chi square, t and F distributions and their applications.

Contents:

Unit 1: Collection, classification and tabulation of data: bar diagrams and histogram, frequency curve and frequency polygon, Ogives. Mean, median, mode, standard deviation. Probability theory: random experiments, sample space, probability theory, conditional probability. Introduction to random variable (discrete and continuous), probability density function (discrete and continuous) and distribution function. **10**

Unit 2: Relation between two variables, scatter diagram, curve fitting, principles of least squares. Karl Pearson's coefficient of correlation, rank correlation, tied ranks. Standard distributions: Exponential distribution, binomial distribution, Poisson distribution and normal distribution. **10**

Unit 3: Sampling parameters, difference between sample and population, sampling errors, difference between parametric and non-parametric statistics, sampling distributions, standard error. Testing of hypothesis. Level of significance and degree of freedom. Interpretation and significance of p-value. Large sample test based on normal distribution, small sample test based on t-test and F test. Confidence interval, distribution-free test - Chi-square test and its applications. **10**

Practicals:

Marks: 50 **Duration: 60 hours (2 credits)**

1. Handling of data using measures of central tendency.
2. Handling of data using measures of dispersion.
3. Finding Karl Pearson correlation coefficient and interpretation of result.
4. Spearman rank correlation with and without ties.
5. Fitting of binomial distributions for n and p = q = ½ given.
6. Fitting of Poisson distributions for given value of lambda.
7. Application problems based on binomial distribution.
8. Application problems based on Poisson distribution.
9. Problems based on area property of normal distribution.
10. To find the ordinate for a given area for normal distribution.
11. Application based problems using normal distribution
12. Problems based on Large Sample Tests and interpretation of result
    a. Estimators of population mean.
    b. Confidence interval for the parameters of a normal distribution (one sample and two sample problems).
    c. Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems.
13. Application of Chi-Square Distribution and interpretation of result on given data set
    a. Chi-square test of proportions.
    b. Chi-square tests of association.
    c. Chi-square test of goodness-of-fit
14. Application of small sample tests and interpretation of result on given data set

Suggested Reading:

1. Bancroft, H. (1962). *Introduction to Biostatistics*. P.B. Hoebar, USA.

2. Daniel, W.W., and Cross, C.L. (2013). *Biostatistics: A Foundation for Analysis in the Health Sciences.* Wiley and Sons, USA.

3. Goon, A.M., Gupta, M. K. and Dasgupta, B. (2002).*Fundamentals of Statistics* Volumes I and II. 8th edition. The World Press, India.

4. Khan, I.A and Khanum, A. (2004). *Fundamentals of Biostatistics*. 2nd edition. Ukaaz, India.

5. Miller, I. and Miller, M. (2012). *John E. Freund's Mathematical Statistics with Applications.* 8th edition. Pearson Education, India.

6. Mood, A.M., Graybill, F.A. and Boes, D. C. (2007). *Introduction to the Theory of Statistics*. 3rd edition. Tata McGraw-Hill Publishing Company, India.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks
1	Measures of central tendency and measures of dispersion. Coefficient of variation, skewness and kurtosis, coefficient of correlation.	Classroom lectures and Practical work using SPSS/Excel	Participation in class discussion and completion of assignments, short quiz.
2	Learning different probability discrete and continuous distributions and their implementation at realistic models.	Classroom lectures and Practical work using SPSS/Excel.	Participation in class discussion and completion of assignments, MCQ.
3	Basic concepts of hypothesis testing, including framing of null and alternative hypothesis. Hypothesis testing based on a single sample and two samples using both classical and p value approach. Chi square, t and F distributions and their applications.	Classroom lectures and Practical work using SPSS/Excel.	(i) Participation in class discussion. (ii) Identification of appropriate tests based on sample size, interpretation of results and conclusion.

***Assessment tasks listed here are indicative, and may vary.**