UNIVERSITY OF DELHI
MASTER OF SCIENCE (MICROBIOLOGY)
Syllabus of Sem 1 and Sem 2
based on
NEP-PGCF-2024

As approved in the meeting of 'Committee of Courses' held on 24th Feb 2025, in the meeting of 'Faculty of Interdisciplinary and Applied Sciences' held on 17th March 2025, and meeting of 'Standing Committee' held on 02nd May 2025

PROGRAMME BROCHURE

XXXXX Revised Syllabus as approved by Academic Council on XXXX, 2025 and Executive Council on YYYY, 2025

I. About the Department

Historical Background of Department

The Department of Microbiology was established in 1984, initially functioning in the University's main campus at the Patel Chest Institute where classes for the M.Sc. Microbiology program were held. The M.Sc. program was initiated with the enrollment of five students each year. The current intake for this program is fifteen students each year.

The Department moved to the South Campus in 1986 and became affiliated with the Faculty of Interdisciplinary and Applied Sciences upon its establishment in 1988. The students who graduate from our Master's program take up positions in academia/industry or pursue higher studies. The Microbiology Department started the Ph.D. program as well in 1988. Since then, more than one hundred students have carried out their doctoral research work in the Department, and several of them now hold leadership positions in academia and industry.

Department Highlights

The Department is now well established, currently with seven faculty members. Extramural grants from DBT, DST, ICMR, CSIR, UGC, ICAR and DRDO, as well as intramural grants from the University of Delhi, have strengthened the Department's research. The Department has also been funded under the DST-FIST, UGC-SAP and DU-DST PURSE programs. Every faculty member has a well-equipped laboratory with the necessary instruments to carry out research. The departmental Central Instrumentation Facility houses several pieces of high-end equipment. More than six hundred research papers have been authored by faculty members of the Department in peer-reviewed journals of international repute. The achievements of the Department have been recognized in the form of several awards conferred on the Department's faculty and students.

About the Program

The M.Sc. Microbiology program offered by Delhi University is of two years' duration and is divided into four semesters. The various courses of the program are designed to include classroom teaching and lectures, laboratory work, project work, viva, seminars, and assignments.

Six categories of courses are being offered in this program: Department Specific Core (DSC) Courses, Department Specific Elective (DSE) Courses, Generic Elective (GE) courses (student may opt for any of the Generic Elective courses offered by any other Department of the Faculty of Interdisciplinary and Applied Sciences), Skill Enhancement Courses (SEC), Research methods/ tools/ writing courses, and Dissertation/ Problem-based Research work. The Core Courses and Discipline Specific Elective Courses are four-credit courses. The Generic Electives are also four-credit courses. The student is required to accumulate twenty-two credits each semester: a total of eighty-eight credits over four semesters to fulfill the requirements for a Master of Science degree in Microbiology (two-year program), and forty-four credits over two semesters to fulfill the requirements for a Master of Science degree in Microbiology (one-year program) .

About Post-Graduate Attributes

The curriculum is designed to train the students in basic and advanced areas of Microbiology, keeping in mind the latest advances in the field. Particular emphasis is laid on the practical aspects of the field. Students are taught how to plan experiments, perform them carefully, analyze the data accurately, and present qualitative and quantitative results. To enable them to develop speaking and presentation skills they are encouraged to deliver seminars on a wide range of topics covering the different areas of Microbiology. This also leads them to read about different themes and enhances their assimilation abilities. A major component of their course in Structure 2 and Structure 3 is a research project they work on in their final year. The student is guided in choosing a research problem, executing experiments related to it, collecting data and analyzing it, and presenting the results in the form of an oral presentation as well as a thesis. The student presents their research orally at the end of the final semester of the program, coupled with a viva-voce exam. This not only equips the student for a career in research/ industry, but also fosters self-confidence and self-reliance in the student as they learn to work and think independently. At the end of the program the student will be well-versed in essential microbiology as well as be familiar with the most recent advances in microbiology, and will have gained hands-on experience in microbiology, including fermentation technology and molecular biology techniques. The student will be able to design a short research problem, plan and execute experiments to investigate the problem, as well as analyze and present the results obtained both qualitatively and quantitatively. The student will be able to take up a suitable position in academia or industry, and be equipped to pursue a career in research if so desired.

Program Objectives (POs):

At the time of completion of the program the student will have developed extensive knowledge in various areas of Microbiology. Through the stimulus of scholarly progression and intellectual development the program aims to equip students with excellence in education and skills, thus enabling them to pursue a career of their choice. By cultivating talents and promoting all-round personality development through multi-dimensional education, a spirit of self-confidence and self-reliance will be infused in the student. The student will be instilled with values of professional ethics and be made ready to contribute to society as responsible individuals.

Program Specific Outcomes (PSOs):

At the end of the two-year program, the student will understand and be able to explain different branches of Microbiology such as Bacteriology and Virology. The student will be able to explain various applications of Microbiology such as Environmental Microbiology, Industrial Microbiology, Food Microbiology, and Microbial Pathogenicity. They will be able to design and execute experiments related to Basic Microbiology, Immunology, Molecular Biology, Recombinant DNA Technology, and Microbial Genetics, and will be able to execute a short research project incorporating techniques of Basic and Advanced Microbiology under supervision. The student will be equipped to take up a suitable position in academia or industry and pursue a career in research if desired.

About Program Structure

The M.Sc. Microbiology program is a two-year program divided into four semesters, or a one-year program divided into two semesters. A student has to accumulate twenty-two credits in each semester. Under the two-year M.Sc. program a student is required to complete eighty-eight credits for completion and award of M.Sc. degree, while under the one-year M.Sc. program a student is required to complete forty-four credits for completion and award of M.Sc. degree. The program structure is based on the Post Graduate Curricular Framework (PGCF) under New Education Policy (NEP)-2020.

Under PGCF, in the first year of the two-year program, the student is required to study mandatory Discipline Specific Core courses (three DSC in each semester) and a total of four / Discipline Specific Elective courses (two DSE in each Semester). In lieu of one DSE in each Semester, the student may choose to study a Generic Elective course offered by any other Department of FIAS. In addition, the student will also be required to study one mandatory Skill enhancement course (SEC) in each semester of the first year.

In the second year of the two-year program, the student will have an option to choose any one of the three structures: Structure 1 (PG with only coursework), Structure 2 (PG with coursework and research), or Structure 3 (PG with coursework and more emphasis/weightage on research). The details regarding these structures have been summarized in tabular form.

SEMESTER-WISE PROGRAM STRUCTURE of M.Sc. MICROBIOLOGY COURSE (NEP-PGCF)

First year (common in Program Structure 1, 2 and 3)

Semester-1

	Credits in each course			
	Theory	Practical	Tutorial	Credits
Discipline Specific Core (DSC) courses				
DSC-01: Bacteriology	3	1	0	4
DSC-02: Molecular Virology	3	1	0	4
DSC-03: Microbial Physiology and Metabolism	3	1	0	4
Discipline Specific Elective (DSE) courses*				
DSE-01: Immunology	3	1	0	4
DSE-02: Cell Biology	3	1	0	4
Generic Elective (GE) courses*				
GE-01: Essentials of Microbiology	3	0	1	4
Skill enhancement course (SEC)/ workshop/ Specialized laboratory/ Hands-on Learning				
SEC-01: Basic Microbiological Techniques	0	2	0	2
Research Methods/ Tools/ Writing	-	-	-	-
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research				
-	-	-	-	-
Total credits				22

***** *(a student can opt for either two DSE courses, or one DSE with one GE)*

Semester-2

	Credits in each course			
Course	Theory	Practical	Tutorial	Credits
Discipline Specific Core (DSC) courses				
DSC-04: Environmental Microbiology	3	1	0	4
DSC-05: Industrial Microbiology	3	1	0	4
DSC-06: Microbial Pathogenicity	3	1	0	4
Discipline Specific Elective (DSE) courses*				
DSE-03: Molecular Biology	3	1	0	4
DSE-04: Plant Pathogen Interactions	3	1	0	4
Generic Elective (GE) courses*				
GE-02: Microbial Biotechnology	3	0	1	4
Skill enhancement course (SEC)/ workshop/ Specialized laboratory/ Hands-on Learning				
SEC-02: Environmental, Industrial & Molecular Microbiology Techniques	0	2	0	2
Research Methods/ Tools/ Writing	-	-	-	-
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research				
-	-	-	-	-
Total credits				22

***** *(a student can opt for either two DSE courses, or one DSE with one GE)*

DISCIPLINE SPECIFIC CORE COURSE – DSC-01: BACTERIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-01: BACTERIOLOGY	**4**	**3**	**0**	**1**	**B.Sc. in any branch of Life Science**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is to introduce the students to the fundamentals of bacteriology.
- The students will gain knowledge about the structural and functional details of bacteria cells as well as archaea.
- The course will familiarize the students with bacterial cell division, genome organization and survival.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students will be able to describe the structural components of bacterial cells in detail, including the cell wall difference in gram-negative and gram-positive bacteria
- Students will be able to recall bacterial cell division and endospore formation
- Students will be able to evaluate the key features of some model archaeal organisms and differentiate them from eubacteria
- Students will be able to describe the salient features of the genome organization of several selected bacteria including extremophiles
- Students will be able to analyze quorum sensing and its significance in competence and pathogenesis

SYLLABUS OF DSC-01

UNIT – I (15 hours)

Bacterial and Archaeal cell structure, Archaeal diversity and model organisms: Overview of bacterial cell organization: nucleoid, intracytoplasmic membranes and cell inclusions. Overview of Gram-negative and Gram-positive bacterial cell wall, outer membrane lipopolysaccharide (LPS). Detailed account of cell wall synthesis and its inhibitors. External cell

surface structures: capsule, glycocalyx, slime layer and S-layer. Biogenesis and function of various cell structure appendages: flagella- structure, assembly and mechanism of movement; pili and fimbriae. Phylogenetic diversity and key features of different phyla. General characteristics of archaeal cell structure. A detailed account of model archaeal organisms: Methanococcus, Halobacterium, Pyrococcus and Sulfolobus

UNIT – II (12 hours)

Bacterial cell division, mode of reproduction, bacterial genome: Binary fission and other forms of reproduction in bacteria. Bacterial cell cycle. Bacterial Z ring : Assembly, maintenance and disassembly, chromosome segregation. Endospore structure and stages involved in endospore development in *Bacillus subtilis*. Timeline of genome sequencing, Genome organization of *E.coli* and salient features of genomes of *Deinococcus radiodurans*, *Azotobacter vinelandii*, *Buchnera sp*., *Agrobacterium tumefaciens* and *Epulopiscium sp*.

UNIT-III (10 hours)

Bacterial secretion system: Introduction. Sec secretion pathway, SecB secretion pathway, SRP pathway, Tat pathway. Protein secretion in Gram-negative bacteria: Sec dependent system (Type II, V, VIII, IX) Sec independent system (Type I, III, IV, VI). Protein secretion in Gram-positive bacteria: Type VII, Sec A2, Sortases and Type VII secretion systems.

UNIT-IV (8 hours)

Quorum sensing: Discovery, role as illustrated by bioluminescence (*Vibrio fischeri*, *Vibrio harveyi*), virulence (*Pseudomonas aeruginosa*, *Staphylococcus aureus*), competence and sporulation (*Bacillus subtilis*). Quorum quenching: impact and mechanism.

Practical component (30 hours)

1. Isolation of bacteria pure culture from soil.
2. Characterization of the bacteria by colony morphology, staining characteristics and biochemical characteristics.
3. Extraction of genomic DNA from the isolated bacteria
4. PCR amplification of the 16S rRNA gene using universal primers, analyzing the given 16srRNA sequences by BLAST PCR amplification of the 16S rRNA gene using universal primers, analyzing the given 16srRNA sequences by BLAST

Essential/recommended readings

Theory:

1. Fundamentals of Bacterial Physiology and Metabolism by Rani Gupta and Namita Gupta. Springer 2021.
2. Prescott's Microbiology by, J. Willey, K. Sandman, D. Wood. 12th edition. McGraw Hill Education. 2023.
3. Brock Biology of Microorganisms by M. Madigan, K. Bender, D. Buckley, W. Sattley, D. Stahl. 15th Edition. Pearson Education. 2018.

Practicals:

1. Microbiology, A laboratory manual by James G. Cappuccino and Chad T. Welsh. 12th Edition. Pearson Education. 2019.
2. Laboratory Exercises in Microbiology by Nathan Rigel and Javier Izquierdo. 12th edition. Mc Graw Hill Education. 2022.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE DSC– 02: MOLECULAR VIROLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-02: MOLECULAR VIROLOGY	**4**	**3**	**0**	**1**	**B.Sc. in any branch of Life Science**	**None**

Learning Objectives

The Learning Objectives of this course are as follows:

- The student will be able to develop understanding of molecular virology by examining common processes and principles in viruses to illustrate viral complexity and understand viral reproduction
- They will gain understanding of the molecular biology of viral reproduction and the interplay between viruses and their host organisms
- They will understand the strategies by which viruses spread within a host, and are maintained within populations.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to describe the classification of viruses, tools for studying virus structure, process of virus attachment and entry, virus assembly and release
- Student will be able to recall steps in the replication of the genome of RNA viruses, retroviruses, and DNA viruses
- Student will be able to discuss steps in virus infection, transmission, patterns of infection, virus virulence, and host defense against virus infection.
- Student will be able to describe the methods of making virus vaccines and anti-viral drugs, drivers of virus evolution, and emerging viruses
- Student will be able to recall unusual infectious agents, virus mediated cellular transformation and oncogenesis, evasion strategies used by viruses, and learn to apply their knowledge to investigate virus outbreak

SYLLABUS OF DSC- 02

UNIT – I (13 hours)

Virus Structure, Assembly, and Release: Common strategy of viruses, classification of viruses, the virus infection cycle, methods of studying virus infection, modified Koch's Postulates for

viruses. Virus genome types: double-stranded DNA (dsDNA), gapped DNA genomes, single-stranded (ssDNA) genomes, double-stranded RNA (dsRNA), single-stranded RNA (ssRNA), (+) strand RNA, single-stranded (+) sense RNA with DNA intermediate, single-stranded RNA (-) sense, ambisense RNA genomes. Concept of metastability in the context of virus structures, different tools for studying viral structural biology. Helical symmetry in viruses, Icosahedral symmetry in viruses, Triangulation number, Quasi-equivalence. Virus attachment and entry, Initiation of infection, Affinity and Avidity between virus and its receptor, cellular receptor for viruses. Virus entry into the nucleus, virus disassembly, concentrating viral components for virus assembly, and how components get to the right place in the cell. How do viruses make sub-assemblies, sequential and concerted assembly? Viral genome packaging signals, packaging of segmented genome, acquisition of an envelope by viruses, and budding strategies.

UNIT – II (8 hours)

RNA directed RNA synthesis, Reverse Transcription and Integration, Translation, and genome replication of DNA viruses: Identification of RNA polymerase, how RNA synthesis occurs in viruses, Reverse transcriptase, retrovirus genome organization, steps of DNA synthesis in retroviruses. Regulation of translation in the virus infected cells. Basic rules of genome replication in DNA viruses, viral origins of DNA replication, virus coded polymerases. Generic steps in transcription, initiation, splicing, alternate splicing, promoter structure, steps in the regulation of transcription, enhancers, virus-coded transcriptional regulators, transcriptional cascade, and export of transcript from the nucleus.

UNIT – III (16 hours)

Virus Infections basics, virus-host interactions, Vaccines and anti-viral drugs, virus evolution and emerging viruses: Fundamental questions of viral pathogenesis, Virion defenses to hostile environment, viral spread, viremia, determinants of tissue tropism. Virus shedding, transmission of infection, host defense, innate immune response, virus virulence, identifying virulence genes. Toxic viral proteins, cellular virulence genes, immunopathology, systemic inflammatory response syndrome. Immune complexes, virus-induced auto-immunity, general pattern of infection. Inapparent acute infections, defense against the acute infection. Pathogenesis of Influenza, Polio, Measles, and Rotavirus. Persistent infections, and chronic and latent Infections. Concept of herd immunity, requirement of an effective anti-viral vaccine, different ways of making vaccine. Inactivated vaccines, subunit vaccines, live attenuated vaccines, how influenza vaccine and Polio vaccine were made, and polio eradication. Anti-viral drugs, search for anti-viral drugs, the path for drug discovery, mechanism-based screens, cell-based screen, and antiviral screening. Resistance to antiviral drugs. Main drivers of virus evolution, the quasi-species concept, error threshold, genetic bottlenecks, Muller ratchet, genetic shift and drift. Theories on the origin of the virus, evolution of new viruses, emerging viruses, factors that drive viral emergence, and evolving host-virus relationship.

UNIT – IV (8 hours)

Unusual Infectious Agents, viral-mediated transformation, evasion strategies, virus outbreaks: Viroids, origin of viroids, Satellites, Prions, Transmissible spongiform encephalopathy (TSE) caused by prions, Prion hypothesis, Prion species barrier. Virus-induced

cancer by RNA viruses, Avian leucosis retroviruses, Proviral DNA sequences, Proto-oncogenes, DNA tumor Viruses, the link between DNA virus biology and transformation. Strategies for evasion, Translational regulation, Innate defense targets, Viral modulators of interferon, Autophagy, Apoptosis, Apoptotic pathway and viruses, Immune modulation, and Immune modulation strategies. Case study of health risks associated with a virus epidemic, the origin of outbreak, the spread, the intervention strategies, public health response.

Practical component (30 hours)

1. Handling, upkeep and calibration of micropipette for measuring small volumes.
2. Sterilization techniques and their application in the microbiology lab.
3. Working with a biosafety cabinet in a BSL2 lab
4. Culturing of eukaryotic cells of epithelial and lymphoid origins.
5. Counting and passaging of eukaryotic cells of epithelial and lymphoid origins**.**
6. Principles and techniques of freezing and thawing eukaryotic cells for long-term storage**.**

Essential/recommended readings

Theory:

1. Principles of Virology: Molecular Biology, Pathogenesis and Control of Animal Viruses by S.J. Flint, L.W. Enquist, V.R. Racaniello, A.M. Skalka. 5th edition. ASM Press. 2020.
2. Introduction to Modern Virology by N. Dimmock, A. Easton, K. Leppard. 7th edition. Blackwell Publishing. 2016.
3. Basic Virology by Edward K. Wanger, M. Hewiett, D. Bloom, D. Camerini. 3rd edition. Blackwell Publishing. 2007.
4. Principles of Molecular Virology by A.J. Cann. 6th edition. Elsevier Academic Press. 2015.

Practicals:

1. Microbiology: A laboratory manual by JG Cappucino, C.T. Welsh. 11th edition. Pearson. 2017.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – DSC-03: MICROBIAL PHYSIOLOGY AND METABOLISM

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-03: MICROBIAL PHYSIOLOGY AND METABOLISM	**4**	**3**	**0**	**1**	**B.Sc. in any branch of Life Science**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The objective of this paper is to develop a clear understanding of various aspects of microbial physiology.
- To understand diverse metabolic pathways in bacteria concerning its survival and propagation.
- To enable students to understand better courses taught later, such as Microbial Pathogenicity and biotechnology-based courses.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students will be able to interpret the data acquired from methods of measuring microbial growth and calculating growth kinetic parameters with an understanding of steady-state and continuous growth.
- Students will be able to define in-depth knowledge of primary, secondary, and group translocation transport systems existing in bacteria.
- Students will be able to describe the central metabolic pathways for carbon metabolism in bacteria and their regulation in diverse physiological conditions. This will allow students to apply the acquired knowledge for engineering the metabolic pathways for developing industrially useful strains.
- Students will be able to understand the inorganic and organic nitrogen assimilation, regulation and role of glutathione in cellular redox regulation.
- Students will be able to understand the details of lipid and nucleotide metabolism in *E. coli* and its regulation along with the biochemical basis of lipid accumulation in yeasts.
- Students will be able to describe bacteria's intracellular signaling in response to various nutritional and physiological stresses.

SYLLABUS OF DSC-03

UNIT – I (14 hours)

Growth and cell division: Measurement of growth, physiology, cell division, growth yields, growth kinetics, steady-state growth and continuous growth. **Solute Transport:** Introduction, simple and facilitated diffusion, kinetics, primary and secondary transport. Membrane transport proteins: porins and aquaporins, mechanosensitive channels, ABC transporter, group translocation PEP-PTS system. Catabolite repression, inducer exclusion and expulsion.

UNIT – II (08 hours)

Central Metabolic Pathways and Regulation: Glycolysis and its regulation, Gluconeogenesis, Pentose-Phosphate Pathway, Entner-Doudoroff Pathway, Citric Acid Cycle, alternate TCA, Glyoxylate Pathway and its regulation. Examples of pathway engineering of carbon metabolic pathways to develop valuable industrial strains.

UNIT – III (08 hours)

Nitrogen metabolism: Inorganic nitrogen assimilation- nitrate and ammonia assimilation, glutamate synthetase and its regulation. Outline of amino acid biosynthesis: using precursors from glycolytic pathway, from Citric Acid Cycle. Glutathione: distribution in bacteria, biosynthesis and role in redox regulation.

UNIT – IV (15 hours)

Metabolism of lipids and nucleotides: Biosynthesis and degradation of lipids and its regulation in *E. coli*, lipid accumulation in yeast. Purine and pyrimidine biosynthesis, deoxyribonucleotide synthesis, regulation of purine and pyrimidine biosynthesis, inhibitors of nucleotide biosynthesis. **Physiological Adaptation and Intracellular Signalling:** Introduction to two-component system. Response to physiological stress: aerobic-anaerobic shifts- Arc and Fnr system, osmotic homeostasis. Response to nutritional stress: phosphate supply- Pho regulon, and stringent response.

Practical Component (30 hours)

1. To determine the specific growth rate and doubling time of *E. coli* strain in different media.
2. To study the diauxic growth curve of *E. coli* strain in media containing glucose and lactose and perform β-galactosidase assay.
3. To study glucose uptake by *E. coli*.
4. To draw the titration curve of the amino acid (glycine) and determine its pI.
5. To draw the titration curve of acid and base.
6. To prepare a 1M Phosphate buffer solution for pH 7 using the Henderson-Hasselbach equation.
7. To prepare the standard curve of Glucose by using the DNSA method.
8. To separate amino acids/sugars using Thin Layer Chromatography (TLC).
9. To study spectral scanning to understand the UV absorption of protein due to aromatic amino acids.

Essential/recommended readings

Theory:

1. Biochemistry by Berg, J.M., Tymoczko, J.L., Gatto, G.J., and Stryer, L. 9th edition. W.H. Freeman and Company, UK. 2019.
2. Microbial Biochemistry by Cohen, G.N. 2nd edition. Springer, Germany. 2014.
3. Lippincott's Illustrated Reviews: Biochemistry by Ferrier, D.R. (editor). 6th edition. Lippincott Williams and Wilkins, USA. 2013.
4. Microbial Physiology by Moat, A.G., Foster, J.W. and Spector, M.P. 3rd edition. John Wiley & Sons, USA. 2002.
5. Lehninger Principles of Biochemistry by Nelson, D.L. and Cox, M.M. 7th edition. W.H. Freeman and Company, UK. 2017.
6. Understanding Enzymes by Palmer, T. and Horwood, E. 3rd edition. Wiley, UK. 1991.
7. Biochemical Calculations by Segel, I.H. 2nd edition. Wiley and Sons, UK. 2004.
8. The Physiology and Biochemistry of Prokaryotes by White, D., Drummond, J. and Fuqua, C. 4th edition. Oxford University Press, UK. 2011.
9. Biochemistry by Zubay, G.L. 4th edition. Brown Company, USA. 1999.
10. The Cell: A Molecular Approach by G.M. Cooper. 8th edition. Oxford University Press, UK. 2018.

Practicals:

1. A Cell Biology Manual by J. Francis. Kendall. Hunt Publishing Co, USA. 2022.
2. Practical Laboratory Manual- Cell Biology by A. Gupta, B.K. Sati. Lambert Academic Publishing, USA. 2019.
3. Cell Biology Practical Manual by R. Gupta, S. Makhija and R. Toteja. Prestige Publishers, India. 2018.
4. Laboratory Manual of Cell Biology by R. Majumdar, R. Sisodia. Prestige Publishers, India. 2018.
5. Essential Cell Biology Vol **1**: Cell Structure- A Practical Approach by J. Davey and M. Lord. Oxford University Press, UK. 2003.
6. Essential Cell Biology Vol **2**: Cell Function- A Practical Approach by J. Davey and M. Lord. Oxford University Press, UK. 2003.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – DSC-04: ENVIRONMENTAL MICROBIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-04: ENVIRONMENTAL MICROBIOLOGY	**4**	**3**	**0**	**1**	**B.Sc. in any branch of Life Science**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The primary objective of this course is to introduce the basic concepts of environmental microbiology and the role of microorganisms in ecosystems.
- The students will learn about microbial diversity (in soil, water, and air).
- They will become familiar with the role of microorganisms in biogeochemical cycles and their importance in maintaining ecological stability.
- The students will explore microbial biodegradation and bioremediation processes and their use in pollution control.
- They will discover extremophiles, how they adapt, and their industrial applications.
- The students will gain knowledge on wastewater treatment and microbial-based sustainable environmental management.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students will be able to describe the diversity of soil, water, and air microorganisms.
- Students will be able to explain the role of microorganisms in biogeochemical cycling, including carbon, nitrogen, sulfur, and phosphorus cycles.
- Students will be able to evaluate the role of microbial biodegradation and bioremediation in environmental sustainability.
- Students will be able to examine the properties and adaptations of extremophiles and their biotechnological uses.
- Students will be able to describe wastewater treatment principles in various treatment types and the significance of microorganisms involved in different treatment processes.
- Students will be able to evaluate the effects of human behavior on microbial ecosystems and highlight microbial approaches to environmental conservation.

Syllabus of DSC-04

UNIT-I (14 hours)

Developments in Environmental Microbiology and Microbial Diversity: Development of microbial ecology and the emergence of environmental microbiology, significant applications of microbes in solving environmental pollution problems. Role of microorganisms in achieving Sustainable Development Goals (SDGs), including clean water, climate action, sustainable agriculture, and pollution control. Understanding microbial diversity in the environment by culture-dependent and culture-independent approaches, Analysis by FAME, measuring metabolic capabilities using BIOLOG, G+C analysis, slot-blot hybridization of community DNA, and fluorescent in situ hybridization of intact cells, metagenomic analysis of solid and aquatic sediments. Introduction to advanced omics technologies (metatranscriptomics, metabolomics) for microbial community analysis. Principles and applications of SAGs in studying unculturable microorganisms.

UNIT-II (15 hours)

Extremophiles and Environmental Microbial Applications: Occurrence, diversity, adaptations and potential applications of oligotrophs, thermophiles, psychrophiles, organic solvent and radiation tolerants, metallophiles, acidophiles, alkaliphiles and halophiles. Biotechnological applications of the same. Exploration of extremophiles in space research and astrobiology. Soil and water microbiology: Importance of soil microorganisms, microbial antagonism, biofilms, and their biotechnological applications. Lignocellulolytic microorganisms, enzymes, and their biotechnological applications in: (i) biopulping, (ii) biobleaching, (iii) textiles, (iv) biofuels, (v) animal feed production.

UNIT-III (8 hours)

Liquid and solid waste management: Treatment of sewage (primary, secondary, and tertiary treatments), treatment of industrial effluents (distillery, textile, pulp, and paper), methods to detect various pollutants (metals, sediments, toxins, and organic matters). Solid waste types, composting, landfill development, incineration methods, composting and sustainable agriculture, biogas production, plastic degrading microorganisms as a tool for bioremediation, and challenges in waste management.

UNIT-IV (8 hours)

Bioremediation and Emerging Pollutants: Petroleum hydrocarbons and pesticides, use of biosensors for their detection. Microbial enhanced oil recovery, bioleaching of copper, gold, and uranium, electronic waste management. Microbial approaches for PFAS (forever chemicals) degradation and other emerging pollutants.

Practical Component (30 hours):

1. Microbiological Quality of Water (MPN Method)
2. Detection of *E. coli* in Water
3. Detection of *Salmonella* in Water
4. Soil Sample Basic Properties (pH, water holding capacity, moisture content, and organic matter content)
5. Microbial Activity in Soil by CO_2 Evolution
6. Effect of Moisture and Organic Matter on Microbial Activity in Soil

7. Dehydrogenase Activity by Soil Microorganisms
8. FDA Hydrolysis to Determine Microbial Activity in Soil
9. Nitrate Reduction Activity by Soil Microorganisms

Suggested Readings:

Theory:

1. Microbial Ecology by R.M. Atlas, R. Bartha. 3rd edition. Benjamin Cummings Publishing Co, USA. 1993.
2. Environmental Microbiology by A.H. Varnam, M.G. Evans. Manson Publishing Ltd. 2000.
3. Environmental Microbiology edited by R. Mitchell, J-D Gu. 2nd edition. Wiley-Blackwell. 2009.
4. Environmental Microbiology by R. Maier, I. Pepper, C. Gerba. 2nd edition. Academic Press. 2009.
5. Environmental Microbiology: Principles and Applications by P.K. Jemba, Science Publishing Inc. 2004.
6. Lignocellulose Biotechnology: Future Prospects by R.C. Kuhad, A. Singh. I.K. International. 2007.
7. Environmental Microbiology of Aquatic & Waste Systems by N. Okafor. 1st edition, Springer, New York. 2011.
8. Microbial Bioremediation: Biochemical and Molecular Technologies by Shilpi Gupta. Springer. 2021.

Practical:

1. Manual of Environmental Microbiology edited by C.J. Hurst, R.L. Crawford, J.L. Garland, D.A. Lipson, A. L. Mills, L.D. Stetzenbach. 3rd edition. Blackwell Publishing. 2007.
2. Environmental Microbiology: A Laboratory Manual by C.J. Hurst. 2nd edition. American Society for Microbiology, 2016.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE: DSC-05
INDUSTRIAL MICROBIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-05: INDUSTRIAL MICROBIOLOGY	**4**	**3**	**0**	**1**	**B.Sc. in any branch of Life Science**	**None**

Learning Objectives

The Learning Objectives of this course are as follows:

- This course aims to give students an overview of Industrial microbiology by studying the different processes involved in microbial product development.
- The goal of this course is to familiarize students with the various bottlenecks in technology development, from bench scale to product commercialization.
- They will gain proficiency in modifying microbial strains through metabolic engineering.
- Students will gain knowledge about the cost-effective production of biopharmaceuticals and recombinant therapeutics through bio-manufacturing.
- They will explore various types of equipment and their designs used in large-scale biomass processing and product recovery.
- They will acquire practical experience in various bulk recovery processes for microbial products.
- Students will acquire essential knowledge about different chromatography techniques and tools utilized in product refinement.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students will be able to describe various kinetic parameters of microbial growth.
- Students will understand microbial strain development and the design of media requirements for optimal growth.
- Students will comprehend the sterilization process during large-scale operations.
- Students will be able to distinguish between laboratory-scale and industrial-scale bioreactor design and operation.

- Students will be able to discuss the equipment and processes involved in microbial product recovery.
- Students will efficiently utilize various microorganisms to produce commercial enzymes and microbial products economically

Syllabus of DSC-05

UNIT – I (8 hours)

Introduction to industrial microbiology and Microbial growth kinetics: Introduction to Industrial microbiology, microbial products, and fermentation processes, sources of industrially important microorganisms, oxidation-reduction principle in fermentation, stoichiometric balance analysis of carbon and nitrogen in different biochemical reactions, biomanufacturing and biofoundry, BioE3 (Biotechnology for Economy, Environment and Employment) policy, Monod kinetics of microbial growth, growth and non-growth associated product formation, specific growth and product formation kinetics, mathematical modeling of microbial processes, open and closed systems, Batch cultivation, fed-batch cultivation, types of fed-batch cultures, feeding strategies for large scale biomass production in fed-batch (exponential, DOstat, pHstat), Continuous Stirred Tank Reactor (CSTR) operation, bioprocess optimization strategies

UNIT – II (11 hours)

Media optimization, designing of industrial strains and Sterilization operations: Media for microbial and animal cultures, designing of cost-effective media for industrial operations. Mathematical strategies for media optimization Role of microorganisms in industrial production processes, microbial cultures and preservation techniques, inoculum development, metabolic engineering, and flux analysis in microbial strain improvement, high throughput screening methods, the role of recombinant DNA technology in strain modification, **S**terilization techniques for different types of growth media, kinetics and mathematical modeling of sterilization processes, Arrhenius equation and role of Del factor in large-scale industrial sterilization processes, the effect of sterilization on media quality, biomass, and product yield coefficients, types of equipment and operation in batch, and continuous sterilization, filter and steam sterilization at industrial scale

UNIT – III (8 hours)

Designing different fermenters and instrumentation control parameters: Designing of laboratory and industrial scale fermenters, Cleaning in Place (CIP) and Sterilization in Place (SIP) operations, Basic components of a fermenter, fermenter construction materials, Glass and stainless steel fermenters, types of impellers, types of baffle and spargers, foam controller, types of fermenter; stirred tank, bubble column*, Airlift, hollow fibers, p*acked beds, fluidized beds, perfusion cultures, photo-bioreactors and animal cell culture bioreactor, Measurement of various control parameters in bioreactor like pH, dissolved oxygen, temperature, antifoam, PID control, *respiratory quotient,* oxygen mass transfer coefficient (KLa), effect of dissolved Oxygen on microbial processes, effect of foam and anti-foam on oxygen transfer,

UNIT – IV (18 hours)

Development and **Downstream processing of microbial products:** Development of heterologous expression platforms like bacteria, yeast, and mammalian cells, process optimization of recombinant

biopharmaceuticals; industrial enzymes and food additives, therapeutic proteins, biosimilars, chimeric and humanized antibodies, antibody fragments, applications of enzyme immobilization and cell surface display technology, Development of nano-biocatalyst, Current Good Manufacturing Practice (CGMP) Batch Filtration, Stokes Law of batch filtration, batch and continuous centrifugation operations, Physical and chemical methods of microbial product recovery, Liquid Liquid Centrifugal Separator, chromatography techniques in product recovery (Affinity, Ion exchange, size exclusion, reverse phase, and hydrophobic interaction chromatography), cross-flow/tangential flow filtration, ultra-filtration, and reverse osmosis, drying (lyophilization and spray drying), Principle of Fast Protein Liquid chromatography (FPLC) and High-Performance Liquid chromatography (HPLC). Process economics of fermentation process, cost breakdown at various stages in the process development, industrial effluent treatment.

Practical Component (30 hours):

1. Preparation of competent yeast cells
2. Transformation of Yeast cells with recombinant plasmids for intracellular and extracellular of Green fluorescent protein (GFP) and red fluorescent protein (RFP)
3. *E. coli* expression studies using GFP and RFP as model protein
4. Isolation and Refolding of inclusion bodies produced in bacterial expression system
5. Recovery of microbial products using various physical and chemical methods.
6. Principle of cross-flow/tangential flow filtration strategy and recovery of recombinant Lipase from *Pichia* expression system
7. Designing strategies for microbial products purification using affinity Chromatography
8. Designing strategies for microbial products purification using Ion exchange chromatography.
9. Desalting of proteins using size exclusion chromatography
10. Purification of recombinant proteins using Fast Protein Liquid chromatography (FPLC)
11. Analysis of purified proteins using High-Performance Liquid chromatography (HPLC)

Suggested Readings:

1. Principles of Fermentation Technology by Peter Stanbury, Allan Whitaker, Stephen Hall Butterworth-Heinemann. 3rd edition. 2016.
2. Bioprocess Engineering: Basic Concepts by Michael L. Shuler and Fikret Kargi. 2nd Edition. Pearson Education India. 2015.
3. Modern Industrial Microbiology & Biotechnology by N. Okafer. CRC Press, USA. 2007.
4. Fermentation Microbiology and Biotechnology by El Mansi & Bryce. CRC Press. 2012.
5. Microbial Biotechnology: Fundamentals of Applied Microbiology by Alexander N. Glazer and Hiroshi Nikaido. 2nd edition. Cambridge University Press. 2007.
6. Pharmaceutical Biotechnology: Concepts and Applications by Gary Walsh. John Wiley & Sons Ltd. 2016.
7. Pharmaceutical Biotechnology: Fundamentals and Applications by Daan J. A. Crommelin, Robert D. Sindelar, and Bernd Meibohm. 4th Edition. Springer. 2013.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE: DSC–06: MICROBIAL PATHOGENICITY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-06 MICROBIAL PATHOGENICITY	**4**	**3**	**0**	**1**	**B.Sc. in any branch of Life Science**	**NONE**

Learning Objectives:

- The objective of this course is to help the students understand various attributes that make the microbes pathogenic or disease-causing, the emergence of newer pathogens that are relevant to India and the various tools for their local or global spread.
- The students would also learn the mechanisms of resistance of bacteria to antibiotics and the role of newer vaccines in controlling infectious diseases.
- The course would also enable students to describe the molecular diagnostic methods and automated equipment that may be used to diagnose diseases caused by microorganisms.

Learning Outcomes:

Upon successful completion of the course:

- The student will be able to understand classical and molecular determinants of disease-causing microbes
- The student will be able to describe the characteristics of newer disease-causing bacteria and viruses
- The student will be able to study and critique the various molecular tools available to work on the molecular epidemiology of disease-causing microorganisms.
- The student will be able to study and evaluate mechanisms underlying the resistance of bacteria to antibiotics, the spread of resistance and the use of newer vaccines to control infectious diseases
- The student will be able to gather information as to how infectious diseases may be diagnosed using newer diagnostic tools and what automated equipment is available for use in diagnostic microbiology laboratories.

SYLLABUS OF DSC-06

UNIT – I (13 hours)

Classical view and Molecular microbial pathogenicity: Define pathogenicity and virulence; Quantitative measures of pathogenicity: minimal lethal dose (MLD), LD50, ID50, TCID50. Virulence determinants: colonization, toxins, enzymes and invasiveness. Facultative/ obligate intracellular pathogens. Molecular Koch's postulates, multiplicity of virulence determinants,

coordinated regulation of virulence genes, and environmental regulation of virulence determinants by two-component signal transudation systems, antigenic variation; clonal and panmictic nature of microbial pathogens, type three secretion system (TTSS, T3SS), Role of biofilms and quorum sensing in microbial pathogenicity.

UNIT – II (20 hours)

Emerging pathogens and Molecular Epidemiology: Illustrate emerging and re-emerging pathogens using *V. cholerae* 0139, X-MDR *M. tuberculosis, Helicobacter pylori,* Enterohaemorrhagic *E. coli* (EHEC), *Cryptosporidium parvum*, Bird/swine flu, AIDS and dengue hemorrhagic fever, opportunistic fungal pathogens. Mechanisms of emergence of new pathogens: horizontal gene transfer (HGT) and pathogenicity islands (PAI). Objectives of microbial epidemiology. Biochemical and Immunological tools - biotyping, serotyping, phage typing, multilocus enzyme electrophoresis (MLEE); Molecular typing: RAPD, rep (REP, ERIC, BOX)-PCR, IS based typing PFGE, AFLP, MLST, VNTR and whole genome sequence, use of geographical information system (GIS) for microbial epidemiology.

UNIT – III (4 hours)

Environmental change and infectious diseases: Global warming-led increase in vector-borne and water-borne infectious diseases; Impact of increasing urbanization, international travel and trade on infectious diseases.

UNIT – IV (8 hours)

Rapid diagnostic principles

Nucleic acid probes in diagnostic microbiology, nucleic acid amplification methods, real-time PCR, lateral flow assays, diagnostic sequencing, mutation detection, automated instruments for detection/ diagnosis of infectious agents (BACTAC and Vitek-2, GeneXpert).

Practical component (30 hours):

1. To study resident microflora of skin.
2. To study resident microflora of the oral cavity.
3. To study cultural characteristics of pathogenic bacteria on the following selective/differential media: TCBS agar; Hektoen Enteric agar; XLD agar; Endo agar; Salmonella-Shigella agar; Deoxycholate citrate agar.
4. To study the pathogenicity of *Staphylococcus aureus* by coagulase test.
5. To perform the rapid (P/A format) coliform test.
6. To study antimicrobial susceptibility testing using an octa disc.
7. To determine minimal inhibitory concentration (MIC) of an antibiotic using an E-test.
8. To determine the minimal inhibitory concentration (MIC) of an antimicrobial compound by micro-broth dilution method.
9. To perform minimal bactericidal concentration (MBC) of an antimicrobial compound.
10. To perform sterility testing of a sample.

Essential/recommended readings

1. Jawetz, Melnick, &Adelberg's Medical Microbiology by Carroll KC, Hobdon JA, Miller S, Morse SA, Mietzner TA. 27th edition. Lange Publication, 2016.
2. Beginner’s guide to comparative genome analysis using next generation sequence

data by Edward DJ and Holt KE in Microbial Informatics and Experimentation, 3:2, https://doi.org/10.1186/2042-5783-3-2, 2013.
3. Bacterial Pathogenesis: A molecular approach by Wilson BA, Salyers AA, Whitt DD, Winkler ME. 3rd edition. American Society for Microbiology Press. 2011.
4. Bacterial Pathogenesis: Molecular and Cellular Mechanisms by Locht C, Simonet M. Caister Academic Press. 2012.
5. Molecular Microbiology: Diagnostic Principles and Practice by Persing DH, Tenover FC, Hayden R, Leven M, Miller MB, Nolte FS, Tang YW, Belkum AAV. 3rd edition. American Society for Microbiology Press. 2016.
6. Infectious Disease Epidemiology: Theory and Practice by Nelson KE, Williams CM. 4th edition. Jones and Bartlett. 2019.

Practicals:

1. Microbiology: A laboratory manual by JG Cappucino, C.T. Welsh. 11th edition. Pearson. 2017.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE: DSE-01
IMMUNOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-01: IMMUNOLOGY	**4**	**3**	**0**	**1**	**B.Sc. in any branch of Life Science**	**NONE**

Learning Objectives:

- The objective of this course is to understand the various components of the host immune system, their structure and organization, and their functions to serve as the defence system of the body.
- It would also help the students understand the operational mechanisms which underlie the host defense system, allergy and organ transplantation.

Learning Outcomes:

Upon successful completion of the course:

- The student will be able to understand the fundamental bases of the immune system and immune response
- The student will be able to gather information about the structure and organization of various components of the immune system
- The student will be able to comprehend the genetic organization of the genes meant for the expression of immune cell receptors and the basis of the generation of their diversity
- The student will be able to understand the operation and the mechanisms which underlie the immune response
- The student will be able to apply the knowledge gained to understand phenomena like host defense, hypersensitivity (allergy), organ transplantation and certain immunological diseases

SYLLABUS OF DSE-01

UNIT-I (12 hours)

Overview of Immune system: History of immunology. An immune system of our microbial universe. Three fundamental concepts in immunology: Specificity, discrimination of self from non-self and memory. Innate immunity and inflammation: Innate vs. adaptive immunity. . Resident sentinel cells and their role in innate immunity. Contrast antiviral and antibacterial immune response. Role of Type-I IFN. Cells of innate immunity. Pus formation. Microbial recognition and responses in the innate immune system: PAMPs and PRRs (function of different TLRs and other receptors). Signals for Innate Immunity. Introducing complement.

Agglutinins and complement proteins. Complement pathways. Diseases Linkage (Hepatitis as an example).

UNIT-II (16 hours)

Immune cell receptors and Genetic Organization: Detailed structure and development of B cell (Ig) and T cell (TcR) receptors; Structure of CD4, CD8, MHC-I, MHC-II molecules, cellular adhesion molecules (ICAM, VCAM, selectins, integrins); Pattern Recognition Receptors (PRRs) including Toll-like receptors (TLR), RIG like Receptors (RLR) and Nucleotide-binding Oligomerization Domain Like Receptors (NLRs) ; Markers of suppressor / regulatory cells - CD4+ CD25+ Foxp3+Treg , iNKT. Lymphocyte development and diversity: Organization of the genes for B and T cell receptors. Genetic organization of MHC-I and MHC-II complex (both HLA and H-2). Molecular mechanisms responsible for generating diversity of antibodies and T cell receptors. Peptide loading and expression of MHC-I and MHC-II molecules (Lysosomal and Proteasomal pathways); Hybridoma technology and monoclonal antibodies, antibody-engineering including bispecific antibodies.

UNIT- III (**12 hours)**

Immune response and signaling: Humoral and cell-mediated immune response; Innate immune response and pattern recognition; Recent advances in innate immune response especially NK-DC interactions; Important cytokines and their role in immune mechanisms: TNF, IFN-γ, IL-1, IL-2, IL-4, 1L-6, 1L-12, IL-17, TGFb; Cell signaling through MAP kinases and NF-kB. T cell activation by antigens (Role of dendritic cells and antigen presentation. Activation of DCs. Co-stimulation and Two-Signal requirement). T-cell dependent B-cell responses (Clonal selection and expansion, formation of germinal centers, affinity maturation and isotype switching). Helper T cells (TH-1, TH2 and TH17 cells) and functions. Effector functions of Cytotoxic T cells and therapeutic checkpoints.

UNIT- IV (**5 hours)**

Immunological disorders and hypersensitivity: Deficiencies/defects of T-cells, B-cells, and phagocytic cells; Comparative study of Type I-V hypersensitivities with examples.

Practical component (30 hours):

1. To study morphological and staining characteristics of lymphocytes, neutrophils, monocytes, eosinophils, and basophils.
2. To perform immune-electrophoresis.
3. To perform radial immune-diffusion assay.
4. To perform rocket immune-electrophoresis.
5. To study quantitative precipitation assay.
6. To perform latex agglutination test.
7. To perform dot-ELISA.
8. To perform sandwich ELISA (antigen capture or antibody capture).

Essential/recommended readings

1. Kuby Immunology by J.A. Owen, J. Punt, S.A. Stranford. 7th edition. WH Freeman. 2013.
2. Cellular and Molecular Immunology by A.K. Abbas, A.H. Lichtman, S. Pillai. 9th edition. Saunders Elsevier. 2018.

3. Janeway's Immunobiology by K. Murphy, W. Casey. 9th edition. Garland Science Publishing. 2017.
4. Review of Medical Microbiology and Immunology by W.Levinson. 15thedition.Lange Publication. 2018.
5. Fundamental Immunology by W.E. Paul. 7th edition. Lippincott Williams and Wilkins. 2013.
6. Roitt's Essential Immunology by P.J. Delves, S.J. Martin, D.R. Burton, I.M. Roitt. 13th edition. Blackwell Publishing. 2017.

Practicals:

1. Microbiology: A laboratory manual by JG Cappucino, C.T. Welsh. 11th edition. Pearson. 2017.

DISCIPLINE SPECIFIC ELECTIVE COURSE: DSE-02
CELL BIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-02: CELL BIOLOGY	4	3	0	1	B.Sc. in any branch of Life Science	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is to introduce the students to fundamental and advanced concepts in cellular organization, signaling, and function
- The students will gain knowledge and in-depth understanding of cellular structures, functions, and interactions at the molecular level
- The course will familiarize the students with stem cells and cancer cell biology

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to describe the cellular compartments and organelles present in eukaryotic cells in detail; and will be able to differentiate between prokaryotic and eukaryotic cells
- Student will be able to evaluate different types of cell signaling and signal transduction pathways
- Student will be able to describe the different phases of the cell cycle, and understand cell cycle checkpoints and regulatory molecules.
- Student will be able to understand more about stem cells and differentiation including cancer cells.

SYLLABUS OF DSE-02

UNIT – I (12 hours)

Cell Structure & Organization: Subcellular compartments: Nucleus, mitochondria, endoplasmic reticulum, Golgi apparatus. Prokaryotic vs. Eukaryotic cells. Plasma membrane: Structure and function, Membrane dynamics and lipid rafts. Cytoskeleton structure and functions (actin, microtubules,microfilaments, intermediate filaments). Organelle biogenesis and trafficking (ER, Golgi, lysosomes, peroxisomes). Endocytosis, exocytosis, and vesicular

transport

UNIT – II (9 hours)

Cell Signaling & Communication: Types of signaling: Paracrine, autocrine, endocrine, synaptic. Signal transduction pathways: GPCRs, RTKs, JAK-STAT, MAPK. Second messengers: cAMP, Ca^{2+}. Regulation of cellular responses to external signals

UNIT – III (12 hours)

Cell Cycle and Regulations and Cancer: Phases of the cell cycle (G1, S, G2, M). Checkpoints and regulatory molecules (Cyclins, CDKs, tumor suppressors). Mechanisms of apoptosis and necrosis. Oncogenes and tumor suppressors in cancer. Hallmarks of cancer and tumor microenvironment. Oncogenes and tumor suppressor genes. Metastasis and angiogenesis. Targeted therapies and drug resistance mechanisms

UNIT – IV (12 hours)

Stem Cells ,Differentiation and Development of Multicellular organisms: Pluripotency and stem cell niches. Cellular reprogramming and induced pluripotent stem cells (iPSCs). Types of stem cells: Embryonic, adult, induced pluripotent (iPSCs). Mechanisms of differentiation and dedifferentiation. Stem cell applications in regenerative medicine. Overview of development. Mechanism of pattern formation: Hox protein, Trithorax and Polycomb Group protein. Morphogenesis and growth. Neural development.

Practical component (30 hours)

1. Culturing human cancer cell lines, seeding and splitting of cell lines
2. Cryopreservation of human cell lines in Liquid Nitrogen.
3. Performance of nuclear staining of Hela cell lines by DAPI and Hoechst stain.
4. Cytoskeleton staining of F-actin, Lysosome staining and Mitochondria staining

Essential/recommended readings

Theory:

1. Essential Cell Biology by Alberts, B., Hopkin, K., Johnson, A.D., Morgan, D. and Raff, M. 5th edition. WWNorton & Co, USA. 2019.
2. Molecular Cell Biology by H. Lodish, A. Berk, C. Kaiser, M. Krieger, A. Bretscher, H.Ploegh, A. Amon and K.C. Martin. 9th edition. W.H. Freeman, UK. 2021.
3. Cell and Molecular Biology by G. Karp, J. Iwasa, W. Marshall. 9th edition. Wiley, USA. 2019.

Practicals:

1. Cell Biology: A laboratory handbook by Julio E. Celis. 3rd Edition. Academic Press. 2006.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE: DSE-03
MOLECULAR BIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-03: MOLECULAR BIOLOGY	**4**	**3**	**0**	**1**	**B.Sc. in any branch of Life Science**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The purpose of this course is to introduce the student to the advanced concepts in molecular biology.
- Students will gain an understanding of molecular mechanisms of DNA replication, DNA repair, transcription, translation, and gene regulation in prokaryotic and eukaryotic organisms.
- The student will study the techniques and experiments used to understand these mechanisms.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students will be able to describe the structure of DNA and RNA, and the organization of the eukaryotic genome.
- Students will be able to compare and contrast the mechanisms of bacterial and eukaryotic DNA replication, DNA repair, and transcription.
- Students will be able to explain concepts in DNA mutation mechanism, DNA repair mechanisms, and recombination as a molecular biology tool.
- Students will be able to explain various levels of gene regulation in both prokaryotic and eukaryotic organisms.
- Students will be able to describe post-transcriptional processes, RNA editing and RNA transport.
- Students will be able to understand the translation mechanism in prokaryotes and eukaryotes, regulation, and post-translational processing.
- Students will be able to describe post-translational processes.

SYLLABUS OF DSE-03

UNIT – I (8 hours)

The nature of genetic material: Background about DNA discovery, the structure of DNA and RNA; selection of DNA over RNA, melting of DNA, complexity of the DNA and Cot curve analysis, superhelicity. Organization of genomes: organization of microbial genomes, organization of eukaryotic genomes, chromatin arrangement, nucleosome formation, nucleosome sliding.

UNIT – II (10 hours)

DNA replication: Arrangement of replicons in a genome, various modes of replication, continuous, discontinuous synthesis, various replication enzymes, replication fork, priming, leading and lagging strand, initiation, elongation, termination. Specific features of prokaryotes and eukaryotes replication, action of topoisomerases, Telomerase: telomere maintenance. Fidelity, Processivity and Catalytic Efficiency of DNA Polymerases. Relationship between DNA replication and cell cycle, DNA copy number maintenance. **Repair of DNA:** Mutation and DNA repair, mechanisms of mutation, DNA mismatch repair, Base excision repair/Nucleotide excision repair, double Strand Break repair and recombination.

Unit – III (15 hours)

Transcription mechanism and regulations: Transcription machinery of prokaryotes: various transcription enzymes, cofactors, sigma factors. Mechanism of transcription: initiation, elongation, and termination. Transcription machinery of eukaryotes: various forms of RNA polymerase and cofactors, promoters. Mechanism of transcription: initiation, elongation and termination. Regulation of transcription: enhancers, silencers, activators, the effect of chromatin structure. **Post-transcriptional processes:** RNA processing: capping and polyadenylation, splicing mechanism: group-I, group-II, and pre-mRNA splicing. Alternate splicing, rRNA and tRNA processing, RNA transport, and RNA Editing. Post-transcriptional gene regulation.

UNIT – IV (12 hours)

Translation: The genetic code and degeneracy of genetic code. Essential components of translation in prokaryotes: ribosome structure, tRNA structure, Aminoscyl tRNA synthetase. Process of translation: initiation, elongation and termination. Essential component of translation in eukaryotes, Process of translation: initiation complex, elongation and termination. In vitro translation systems, polysomes, polycistronic/ monocistronic synthesis. Regulation of translation, RNA instability, inhibitors of translation. **Post-translational processes**: Protein modification, folding, chaperones, transportation. The Signal Hypothesis. Protein degradation.

Practical component (30 hours):

1. Transcriptional analysis of mRNA using Northern Blotting.
2. Analysis of mRNA using reverse transcription-polymerase chain reaction (RT-PCR).
3. Analysis of expression of heterologous proteins in *E. coli* host cell using SDS-PAGE followed by coomassie staining.
4. Impact of temperature, concentration of inducing agent, and induction time on the protein expression.
5. Analysis of expression of proteins using western blotting.

Essential/recommended readings

Theory:

1. Molecular Cell Biology by H. Lodish, A. Berk, C. Kaiser, M. Krieger, A. Bretscher, H.Ploegh, A. Amon and K.C. Martin. 9th edition. W.H. Freeman, UK. 2021.
2. Essential Cell Biology by Alberts, B., Hopkin, K., Johnson, A.D., Morgan, D. and Raff, M. 5th edition. W.W. Norton & Co, USA. 2019.
3. Karp's Cell and Molecular Biology by G. Karp, J. Iwasa and W. Marshall. 9th edition. Wiley, USA. 2019.
4. The Cell: A Molecular Approach by G.M. Cooper. 8th edition. Oxford University Press, UK. 2018.
5. Cell and Molecular Biology by E.D.P. De Robertis and E.M.F. De Robertis, Jr. 8th edition. Lippincott, Williams and Wilkins, USA. 2006.
6. Biochemistry by Berg, J.M., Tymoczko, J.L., Gatto, G.J., and Stryer, L. 9th edition. W.H. Freeman and Company, UK. 2019.
7. Lewin's Genes XII by Krebs, J., Goldstein, E. and Kilpatrick, S. 12th edition. Jones and Bartlett Learning, USA. 2017.
8. Molecular Biology of the Gene by Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. 7th edition. Cold Spring Harbour Laboratory Press, USA. 2014.
9. Molecular Biology by Weaver, R.F. 4th edition. McGraw Hill, USA. 2007.

Practicals:

1. Molecular Cloning: A laboratory manual by Joseph Sambrook, David Russell, 4th edition. Cold Spring Harbor Laboratory Press. 2012.
2. Current Protocols in Molecular Biology by F. M. Ausubel, R. Brent, R.E. Kingston, D. D. Moore, J. A. Smith, K. Struhl (editors). John Wiley and Sons, USA. 2007.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE : DSE-04
PLANT PATHOGEN INTERACTIONS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-04: PLANT PATHOGEN INTERACTION	**4**	**3**	**0**	**1**	**B.Sc. in any branch of Life Sciences**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- This course aims to give students an overview of how pathogens interact with various plants and affect plant physiology, including photosynthesis, respiration, transpiration, and translocation.
- They will learn about strategies for studying physiology, photosynthesis, respiration, transpiration, and translocation in plants
- Students will gain insight into molecular interactions and the roles of various enzymes and toxins will assist in developing biocontrol strategies and creating transgenic plants.
- Students will learn about viral diseases, their management and the diseases impacting key cereals, vegetables, and crops.
- They will be introduced to the genetics of host-pathogen interactions, including plant resistance genes and mechanisms.
- They will learn about innovative strategies in molecular diagnostic methods and accurate forecasting of plant diseases.

Learning Outcomes:

The Learning Outcomes of this course are as follows:

- The student will be able to describe various causes of plant diseases and the effects of microbial infections on plant physiology, photosynthesis, respiration, transpiration, and translocation.
- The student will learn about various enzymes and toxins involved in plant diseases and the role of phytoalexins.
- The student will comprehend the information regarding crown gall, the symptoms of viral diseases and their control, and the diseases affecting some important cereals, vegetables, and crops.

- The student will gain knowledge of various traditional and plant disease control methods, including physical, chemical, and biological approaches.
- The student gains insight into the genetics of host-pathogen interactions, including resistance genes and mechanisms in plants.
- The student will differentiate between several modern molecular diagnostics for plant disease and the development of transgenic plants, along with their applications and constraint
- The student will acquire insight into various important disease control and forecasting milestones relevant to Indian farming.

SYLLABUS OF DSE-04

UNIT-I (7 hours)

Concepts and physiology of plant diseases: Causes of disease, pathogenesis, pathogenesis in relation to environment, effect of microbial infections on plant physiology, photosynthesis, respiration, transpiration, translocation

UNIT-II (18 hours)

Biochemical and Genetic basis of plant diseases and their control strategies: Enzymes and toxins in plant diseases, phytoalexins. Genetics of host-pathogen interactions, resistance genes, resistance mechanisms in plants, Principles of plant disease control, physical and chemical methods of disease control, biocontrol, biocontrol agents - concepts and practices, fungal agents, *Trichoderma* as biocontrol agent, biocontrol agents – uses and practical constraints.

UNIT -III (10 hours)

Some important plant diseases and their etiological studies: Crown gall, symptoms of viral diseases and their control, diseases of some important cereals, vegetables and crops.

UNIT- IV (10 hours)

Molecular diagnostic and Disease forecasting approach: Molecular diagnosis, transgenic approach for plant protection, futuristic vision of molecular diagnosis, applications and constraints. History and important milestones in disease control, disease forecasting and its relevance in Indian farming.

Practical component (30 hours)

1. Isolation of pathogens from soil.
2. Isolation of pathogens from plant tissue,
3. Biochemical and physical identification of plant pathogens
4. Chemical control of soil-borne pathogens using Acylanilide and Alkyl phosphonates.
5. Preparation of plant pathogen genomic DNA
6. Antibody-based testing of plant pathogens (ELISA and Western blot) and PCR amplification and 16S sequencing.
7. Quantification of pathogens population in infected plant samples using qPCR

Suggested Readings:

1. Plant Pathology by G. N. Agrios. 5th edition. Academic Press. 2005
2. Plant Pathology by R.S. Mehrotra, and A. Aggarwal, 3rd edition. Tata McGraw Hill. 2017
3. Bacterial plant pathology: cell and molecular aspects by D. C. Sigee. Cambridge University Press.1993.
4. Molecular plant pathology by M. Dickinson. BIOS Scientific Publishers, London. 2003.
5. The essentials of Viruses, Vectors, and Plant diseases by A.N. Basu & B.K. Giri. Wiley Eastern Limited.1993.
6. Biocontrol of Plant Diseases (Vol. I) by K.G. Mukerji and K. L. Garg. CRC Press Inc.,USA.1988.
7. Molecular Biology of Filamentous Fungi by U. Stahl and P. Tudzyski. VCH VerlagsgesellschaftmbH. 1992.
8. Molecular Cloning: A laboratory manual by Joseph Sambrook, David Russell, 4th edition. Cold Spring Harbor Laboratory Press. 2012.

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GENERIC ELECTIVE COURSE: GE-01
ESSENTIALS OF MICROBIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
GE-01: ESSENTIALS OF MICROBIOLOGY	**4**	**3**	**1**	**0**	**-**	**None**

Learning Objectives:

- The objective of this course is to make the students understand various basic aspects of microbiology.
- The students will learn about different microbial diseases and will be exposed to role of microbes in the food industry.
- The course would enable students to understand the applied aspects of microbiology.

Learning Outcomes:

Upon successful completion of the course:

- The student will be able to understand different types of microbes and contrast it with eukaryotic cell
- The student will be able to describe the epidemiology, methods of diagnosis and treatment of bacterial and viral infections
- The student will be able to study and critique the various sources of fungal infections and protozoan diseases
- The student will be able to get glimpses of microbial spoilage, food safety concerns, and regulations
- The student will be able to gather information about the microbial growth and control of bacterial growth for bioprocesses
- The student will be able to understand the importance of microbes in the environment and how the microbes adapt to extreme conditions.
- The student will be practice and relate the theory portions in the tutorial sessions.
- The student will be exposed to real world problems in the tutorial sessions

SYLLABUS OF GE-01

UNIT – I (6 hours)

Introduction to Microbial Life: Origins of Microbiology, Use of microscopy in Microbiology, Contributions of Louis Pasteur and Robert to early microbiology, discovery of microbial diversity and introduction to groups of microbes. Microbial cell structure using bacterial as a model system. Role of microbes in gut.

UNIT – II (18 hours)

Microbes and human diseases: Introduction to virology, common strategy of viruses, virus infection cycle, virus infection basics, viral spread, pathogenesis of viral-diseases- influenza, Polio. Emerging viruses. Epidemiology and disease microbiology, diagnostics, treatment of important bacterial diseases: tuberculosis, colitis, urinary tract infections, meningitis, pneumonia and dental caries and medical device associated bacterial infections. Fungi and Protozoans human diseases: Deadly mushrooms, Mode of transmission of fungal pathogens (airborne, arthropod and direct contact). Food and water as a source of fungal infections. Opportunistic fungal pathogens. Understanding the etiology, epidemiology, diagnostics and treatments of important protozoan diseases such as Malaria, Leishmaniasis, Trypanosomiasis and amoebiasis.

Unit – III (14 hours)

Food Microbiology, Microbial Growth kinetics and bioprocess development: Microbial spoilage of food. Environmental factors. Food-borne disease out breaks. Diagnostics of food-borne pathogens. Regulations in food safety. Microbiology of beer, cheese etc. Microbial growth kinetics, Stoichiometric calculations of growth parameters, Measurement of biomass and product yields coefficients, Cellular maintenance requirements, Monod batch kinetics, Fed-batch fermentation, Continuous Stirred Tank Reactors (CSTRs), Operational strategies for high cell density fermentation

Unit – IV (7 hours)

Environmental Microbiology: Overview of environmental microbiology. Study of microbial diversity in the environment by culture-dependent and independent approaches. Diversity, adaptations, and biotechnological applications of extremophiles. Exploration of extremophiles in space research and astrobiology. Soil and water microbiology, plant-microbe interactions, drinking water microbiology. Microbial applications in bioremediation and waste treatment.

Tutorial Component (15 hours)

The tutorial will include:

1. Group discussions: Clinical case studies and research articles covering beneficial as well as harmful pathogens of relevance.
2. Group and Individual assignments: Relevant to harmful and beneficial microbes.
3. Flip classroom training and assessment: Presentation preparation, Q & A covering the theory taught in the main lectures.

Essential/recommended readings

1. Brock Biology of Microorganisms by Madigan, Bender, Buckley, Sattley and Stahl. 15th Edition. Pearson Global Edition. 2018.
2. Microbiology by Pelczar, M.J., Chan, E.C.S. and Krieg, N.R. 5th edition. McGraw Hill, USA. 1993.
3. General Microbiology by Stanier, R.Y., Ingrahm, J.I., Wheelis, M.L. and Painter, P.R. 5th edition. McMillan Press, UK. 1987.
4. Microbiology: An Introduction by Tortora, G.J., Funke, B.R., Case, D., Weber, D. and Bair, W. 13th edition. Pearson Education, USA. 2019.

5. Introduction to fungi by Webster, J. and Weber, R. 3rd edition. Cambridge University Press, UK. 2007.
6. Prescott's Microbiology by Willey, J. M., Sandman, K. and Wood, D. 11th edition. McGraw Hill Higher Education, USA. 2019.
7. Microbiology: A Laboratory Manual by Cappuccino, J. and Welsh, C.T. 11th edition. Pearson Education, USA. 2016.
8. Principles of Fermentation Technology by Peter Stanbury, Allan Whitaker, Stephen Hall Butterworth-Heinemann. 3rd edition. 2016.
9. Bioprocess Engineering: Basic Concepts by Michael L. Shuler and Fikret Kargi. 2nd Edition. Pearson Education India. 2015.
10. Modern Industrial Microbiology & Biotechnology by N. Okafer. CRC Press, USA. 2007.

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GENERIC ELECTIVE COURSE: GE-02
MICROBIAL BIOTECHNOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
GE-02: MICROBIAL BIOTECHNOLOGY	**4**	**3**	**1**	**0**	**-**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- This course aims to give students an overview of the various applications of microbes in developing products for agriculture, industry, and clinical use.
- Students will become familiar with cellular growth and the kinetics of product formation.
- Students will gain knowledge of recombinant expression platforms for product development.
- Students will develop an understanding of the construction and types of laboratory and industrial-scale bioreactors.
- They will explore different fermented foods and beverages and their health benefits.
- They will learn about various strategies for optimizing bioprocesses to establish multiple industrial production methods.
- Students will learn about the various regulatory approval requirements for drug development.

Learning Outcomes:

Upon successful completion of the course, the student:

- The student will understand various microbial products relevant to industry and their production processes, as well as the role of biotechnology in environmental management.
- The student will grasp the strain development process and the selection of high-yield producers.
- The student will become skilled in designing recombinant heterologous expression systems, including *E. coli,* yeast, and mammalian cells.
- The students will understand the reactor scale sterilization process and the available strategies.
- The student will be well-informed about designing large-scale industrial processes and different cultivation strategies.

- The student will understand recombinant biomolecules, therapeutic proteins, biopesticides, biofertilizers, and probiotics.
- The student will scrutinize the different types of regulatory approvals required for drug development, as well as the differences between biologics, biosimilars, and biobetters.

SYLLABUS OF GE-02

UNIT-I (5 hours)

Introduction to microbial biotechnology: Historical developments of microbial biotechnology, Biotechnology, and its applications in microbial processes. BioE3 (Biotechnology for Economy, Environment, and Employment) Policy Role of microbial biotechnology in environment management. What is bio-manufacturing and bio-foundry

UNIT-II (14 hours)

Microbial growth Kinetics and Designing large-scale industrial processes: kinetics microbial growth and product formation, measurement of growth and product formation kinetics, diauxic growth, Aerobic and anaerobic fermentation, Application of bioprocess engineering in microbial product development, batch fermentation, fed-batch fermentation, type of bioreactors, designs and control parameters in a fermenter, high cell density cultivation strategies, continuous cultivation processes, limiting parameters in large-scale process development, oxygen mass transfer coefficient.

UNIT-III (16 hours)

Improvement of Microbial strains, Sterilization operations and Recombinant gene expression platforms: Strains development, selection of hyper producers, microbial products, Mutagenesis approaches for the selection of induced mutants, Strategies for metabolic and flux engineering in the development of industrial products; Different types of sterilization strategies, sterilization of large-scale bioreactors, calculation of heating, holding, and cooling time. Continuous and batch sterilization operations. Microbial death kinetics. Effects of sterilization on media quality, Development of recombinant heterologous expression systems e.g. *E. coli*, yeast, and mammalian. Plant cells as bio-factories. Control parameters in the stability of these expression platforms at the industrial scale. Soluble and insoluble expression of recombinant products. Advantages and disadvantages of inclusion bodies. Refolding strategies for inclusion bodies. Role of signal sequences in extracellular product secretions.

UNIT-IV (10 hours)

Development of microbial products, Regulatory approvals and clinical trials:: Fermented milk products, fermented vegetables, probiotics, malt beverages, wines, distilled liquors, recombinant biomolecules, therapeutic proteins, therapeutic enzymes, industrially important enzymes, and green fuel production, bioethanol and biodiesel, Development of bio-pesticides and bio-fertilizers. Good laboratory practice (GLP), Current Good Manufacturing Practice (CGMP), different phases of clinical trials, intellectual property rights, difference between biologics, biosimilar, and bio-better, development of biosimilars and generic biomolecules, analysis of process economics

Tutorial Component (15 hours)

1. Discussion about development of Biosimilar and generic drugs
2. Students will study 10 latest approved biological by FDI
3. Designing of upstream and downstream equipment's using cost effective strategies.
4. Study about process control and role of AI shall be discussed through student's presentation.
5. Designing artificial metabolic flux network for strain improvements.
6. Problem solving using different feed-back control mechanism for optimal process parameters

Suggested Readings:

1. Principles of Fermentation Technology by P. Stanbury, A. Whitaker, S. Hall. 3rd edition. Butterworth-Heinemann. 2016.
2. Modern Industrial Microbiology & Biotechnology by N. Okafor. 1st edition. CRC Press, USA. 2007.
3. Microbial Biotechnology: Fundamentals of Applied Microbiology by A.N. Glazer and H. Nikaido. 2nd edition. Cambridge University Press. 2007.
4. Pharmaceutical Biotechnology: Concepts and Applications by G. Walsh. John Wiley & Sons Ltd. 2007.
5. Pharmaceutical Biotechnology: Fundamentals and Applications by J.A.D. Crommelin, R. D. Sindelar, and B. Meibohm. 4thEdition. Springer. 2013.

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SKILL ENHANCEMENT COURSE: SEC-01
BASIC MICROBIOLOGICAL TECHNIQUES

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
SEC-01: BASIC MICROBIOLOGICAL TECHNIQUES	**2**	**0**	**0**	**2**	**B.Sc. in any branch of Life Science**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The objective of this paper is to develop a clear understanding of various microbiological techniques and their application.
- This course will train the students to analyze bacterial motility and pigment production.
- Students will be able to gain knowledge of fluorescence microscopy techniques for live cell imaging.
- The course will develop the skill to use a spectrophotometer and estimate the concentration of protein and DNA.
- The students will be trained to analyze the bacterial biofilm growth on different substrates.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Students will be able to illustrate whether a given bacteria is motile and producing the pigments.
- Student will be able to demonstrate the use of florescence microscopy for studying sub-cellular localization of proteins and/or viruses.
- Students will be able to estimate the concentration of protein(s) and DNA.
- Students will be able produce bacterial biofilm on different substrates.

SYLLABUS OF SEC- 01

UNIT – I (30 hours)

Bacterial Motility assay and pigment production assays: Plate based assays to assess different types of motilities in bacteria. Quantifying pigment production in bacteria (pyocyanin and pyoverdine production in *Pseudomonas aeruginosa*). **Viral pathogenesis:** Studying virus infection progression in virus-infected cells using GFP labeled virus and fluorescent

microscopy. Live/ fixed cell imaging using GFP labeled protein for sub-cellular localization.

UNIT – II (30 hours)

Estimation of protein and DNA: To prepare a standard curve of BSA and determine the concentration of unknown protein samples using the Bradford method. Determination of DNA concentration using a spectrophotometer. **Planktonic vs. Sessile mode of growth in bacteria:** Growing biofilms of bacteria on different substrates and effect of different growth conditions on biofilms.

Essential/recommended readings

1. Microbiology, A laboratory manual by James G. Cappuccino and Chad T. Welsh, Pearson Education, 2021
2. A Cell Biology Manual BY J. Francis. Kendall. Hunt Publishing Co, USA. 2022.
3. Practical Laboratory Manual- Cell Biology by A. Gupta, B.K. Sati. Lambert Academic Publishing, USA. 2019.
4. Cell Biology Practical Manual by R. Gupta, S. Makhija and R. Toteja. Prestige Publishers, India. 2018.
5. Laboratory Manual of Cell Biology by R. Majumdar, R. Sisodia. Prestige Publishers, India. 2018.
6. Essential Cell Biology Vol **1**: Cell Structure- A Practical Approach by J. Davey and M. Lord. Oxford University Press, UK. 2003.
7. Essential Cell Biology Vol **2**: Cell Function- A Practical Approach by J. Davey and M. Lord. Oxford University Press, UK. 2003.
8. Microbiology: A laboratory manual by JG Cappucino, CT Welsh. 11th Edition. Pearson. 2017.

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SKILL ENHANCEMENT COURSE: SEC-02
ENVIRONMENTAL, INDUSTRIAL & MOLECULAR MICROBIOLOGY TECHNIQUES

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
SEC-02: ENVIRONMENTAL, INDUSTRIAL & MOLECULAR MICROBIOLOGY TECHNIQUES	**2**	**0**	**0**	**2**	**B.Sc. in any branch of Life Science**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The objective of this course is to introduce students to essential microbiological techniques related to water, soil, dairy microbiology, enzyme activity, and molecular biology.
- The students will gain hands-on experience assessing microbial water quality and soil health using standard microbiological methods.
- They will develop proficiency in enzyme screening and activity assays for industrially relevant microbial enzymes.
- Students will study the growth behavior of microorganisms, calculating specific growth rates, biomass yields, and product yields.
- The student will be introduced to the application of molecular techniques in Microbiology.

Learning Outcomes

The Learning outcomes of this course are as follows:

- Students will be able to assess the microbiological quality of water using MPN and selective media for pathogen detection.
- Students will be able to analyze soil's physical and microbial properties and evaluate microbial activity using biochemical assays.
- Students will be able to perform and interpret enzyme screening and activity assays for amylase, lipase, xylanase, and cellulase.
- Students will be able to determine the efficiency of milk pasteurization through MBRT and alkaline phosphatase tests.
- Students will be able to evaluate microbial metabolic activity in environmental samples using FDA hydrolysis and nitrate reduction assays.
- Students will be able to describe the methods used for growth measurement.

- Students will be able to execute the Polymerase Chain Reaction to optimize the PCR yield.

SYLLABUS OF SEC-02

UNIT-I (30 hours)

Dairy Microbiology and Quality Control: To perform MBRT with a given milk sample. To perform an alkaline phosphatase test to check the milk sample pasteurization efficiency. To determine microbial activity in soil by estimating FDA hydrolysis. **Isolation and Screening of Enzymes:** To isolate and screen amylase, lipase, xylanase, and cellulase-producing microorganisms using the enrichment culture technique. To determine amylase and xylanase activity using the DNSA assay.

Unit- II (30 hours)

Microbial Cultivation and Optimization for Bioprocessing: Preparation of growth media; microbial inoculation for primary and secondary cultures; optimization of growth conditions (physical and chemical parameters); production of microbial enzymes; measurement of enzymatic activity. **Molecular Techniques in Microbiology: Polymerase Chain Reaction (PCR):** Amplification of gene(s) using Polymerase Chain Reaction (PCR). PCR components, PCR steps, and optimization of annealing temperature. Visualization of amplified DNA using agarose gel electrophoresis. Working of agarose gel electrophoresis: preparation of agarose gel, DNA sample preparation and loading, observation, and interpretation. Gradient Polymerase Chain Reaction amplification of gene(s).

Suggested Readings:

1. Environmental Microbiology of Aquatic & Waste Systems by N. Okafor. 1stedition, Springer, New York. 2011.
2. Environmental Microbiology: A Laboratory Manual by C.J. Hurst. 2nd Edition. American Society for Microbiology, 2016.
3. Molecular Cloning: A laboratory manual by Joseph Sambrook, David Russell, 4th Edition. Cold Spring Harbor Laboratory Press. 2012.
4. Current Protocols in Molecular Biology by F. M. Ausubel, R. Brent, R.E. Kingston, D. D. Moore, J. A. Smith, K. Struhl (editors). John Wiley and Sons, USA. 2007
5. Molecular Microbiology: Diagnostic Principles and Practice by Persing DH, Tenover FC, Hayden R, Leven M, Miller MB, Nolte FS, Tang YW, Belkum AAV. 3rd Edition. American Society for Microbiology Press. 2016.
6. Infectious Disease Epidemiology: Theory and Practice by Nelson KE, Williams CM. 4th Edition. Jones and Bartlett. 2019.
7. Microbiology: A laboratory manual by JG Cappucino, CT Welsh. 11th Edition. Pearson. 2017.
8. Bioprocess Engineering: Basic Concepts by Michael L. Shuler and Fikret Kargi. 2nd Edition. Pearson Education India. 2002.
9. Modern Industrial Microbiology & Biotechnology by Nduka Okafor and Benedict C. Okeke. 2nd Edition. CRC Press, USA. 2017.
10. Microbial Biotechnology: Fundamentals of Applied Microbiology by Alexander N. Glazer and Hiroshi Nikaido. 2nd Edition. Cambridge University Press. 2007.

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