UNIVERSITY OF DELHI

MASTER OF SCIENCE (MICROBIOLOGY)

based on

NEP-PGCF-2024

2nd Year MSc. Microbiology Syllabus

As approved in the meeting of 'Committee of Courses' held on 24th Feb 2025 & 12-02-2026, in the meeting of 'Faculty of Interdisciplinary and Applied Sciences' held on 23-02-2026, and meeting of 'Standing Committee' held on 13-03-2026

PROGRAMME BROCHURE

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 Based Courses (SBC), 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 based course (SBC) 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.

Course Credit Scheme

Program Structure-1: (PG with only coursework)

Sem	***Core courses***		***Elective courses***		***Skill Based courses***		***Res Method courses***		***Dissertation/ Project***		***Total Credits***
	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	2	8	3	12	1	2	-	-	-	-	22
IV	2	8	3	12	1	2	-	-	-	-	22
Total Credits	**40**		**40**		**8**		**-**		**-**		**88**

Program Structure-2: (PG with coursework and research)

Sem	***Core courses***		***Elective courses***		***Skill based courses***		***Res Method courses***		***Project work***		***Total Credits***
	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	2	8	2	8	-	-	-	-	1	6	22
IV	2	8	2	8	-	-	-	-	1	6	22
Total Credits	**40**		**32**		**4**		**-**		**12**		**88**

Program Structure-3: (PG with coursework and more emphasis on research)

Sem	***Core courses***		***Elective courses***		***Skill based courses***		***Res Method courses***		***Dissertation/ Project***		***Total Credits***
	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	1	4	1	4	-	-	2	4	1	10	22
IV	-	-	1	4	-	-	1	2	1	16	22
Total Credits	**28**		**24**		**4**		**6**		**26**		**88**

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 based course (SBC)/ workshop/ Specialized laboratory/ Hands-on Learning				
SBC-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 based course (SBC)/ workshop/ Specialized laboratory/ Hands-on Learning				
SBC-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)*

Second Year: Program Structure -1 (PG with only coursework)

Semester-3

	Credits in each course			
Course	Theory	Practical	Tutorial	Credits
Discipline Specific Core (DSC) courses				
DSC-07: Food Microbiology	3	1	0	4
DSC-08: Fundamentals of Mycology and Phycology	3	1	0	4
Discipline Specific Elective (DSE) courses*				
DSE-05: Microbial Genetics	3	1	0	4
DSE-10: Advances in Antimicrobial Resistance Management	3	0	1	4
DSE-11: Extremophile Microbiology	3	0	1	4
Generic Elective (GE) courses*				
GE-03: Emerging Trends in Microbial Biotechnology	3	0	1	4
Skill basedcourse (SBC)/ workshop/ Specialized laboratory/ Hands-on Learning				
SBC-03: Mycology & Biochemical 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 three DSE courses, or two DSE with one GE)*

Semester-4

Course	Theory	Practical	Tutorial	Credits
Discipline Specific Core (DSC) courses				
DSC-09: Medical Microbiology	3	1	0	4
DSC-10: Biosafety, Biosecurity and Biosurveillance	3	1	0	4
Discipline Specific Elective (DSE) courses*				
DSE-09: Bacterial Biofilms and Chronic Infection	3	1	0	4
DSE-12: Microbial Ecology	3	0	1	4
DSE-13: Facets of Protozoan Biology	3	0	1	4
Generic Elective (GE) courses*				
GE-04: Downstream Processing of Microbial Products	3	0	1	4
Skill-based course (SBC) / workshop/ Specialized laboratory/ Hands-on Learning				
SBC-04: Antimicrobial & Microscopy 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 three DSE courses, or two DSE with one GE)*

Second Year: Program Structure -2 (PG with Coursework and Research)

Semester-3

	Credits in each course			
Course	Theory	Practical	Tutorial	Credits
Discipline Specific Core (DSC) courses				
DSC-07: Food Microbiology	3	1	0	4
DSC-08: Fundamentals of Mycology and Phycology	3	1	0	4
Discipline Specific Elective (DSE) courses*				
DSE-05: Microbial Genetics	3	1	0	4
DSE-06: Biochemical Methods[#]	3	1	0	4
DSE-10: Advances in Antimicrobial Resistance Management	3	0	1	4
DSE-11: Extremophile Microbiology	3	0	1	4
Generic Elective (GE) courses*				
GE-03: Emerging Trends in Microbial Biotechnology	3	0	1	4
Skill-based course (SBC)/ workshop/ Specialized laboratory/ Hands-on Learning				
-	-	-	-	-
Research Methods/ Tools/ Writing				
-	-	-	-	-
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research				
RES-01: Project Work- I	-	6	-	6
Total credits				22

***** *(a student can opt for either two DSE courses, or one DSE and one GE) # Research Track Paper*

Semester-4

	Credits in each course			
Course	Theory	Practical	Tutorial	Credits
Discipline Specific Core (DSC) courses				
DSC-09: Medical Microbiology	3	1	0	4
DSC-10: Biosafety, Biosecurity and Biosurveillance	3	1	0	4
Discipline Specific Elective (DSE) courses*				
DSE-07: Enzymology and Biocatalysis	3	1	0	4
DSE-08: Introduction to Genomics[#]	3	1	0	4
DSE-12: Microbial Ecology	3	0	1	4
DSE-13: Facets of Protozoan Biology	3	0	1	4
Generic Elective (GE) courses*				
GE-04: Downstream Processing of Microbial Products	3	0	1	4
Skill-based course (SBC)/ workshop/ Specialized laboratory/ Hands-on Learning				
-	-	-	-	-

Research Methods/ Tools/ Writing				
-	-	-	-	-
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research				
RES-02: Project Work- II	-	6	-	6
Total credits				22

***** *(a student can opt for either two DSE courses, or one DSE and one GE) # Research Track Paper*

Second Year: Program Structure -3 (PG with Coursework and more emphasis on Research)

Semester-3

	Credits in each course			
Course	Theory	Practical	Tutorial	Credits
Discipline specific Core (DSC) courses				
DSC-11: Principles of Genetic engineering[#]	3	1	0	4
Discipline specific Elective (DSE) courses				
DSE-05: Microbial Genetics	3	1	0	4
DSE-06: Biochemical Methods[#]	3	1	0	4
DSE-10: Advances in Antimicrobial Resistance Management	3	0	1	4
DSE-11: Extremophile Microbiology	3	0	1	4
Generic Elective (GE) courses				
-	-	-	-	-
Skill-based course (SBC)/ workshop/ Specialized laboratory/ Hands-on Learning				
-	-	-	-	-
Research Methods/ Tools/ Writing				
RM-01: Advanced Research Methodology	2	0	0	2
RM-02: Tools for Research	2	0	0	2
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research				
RES-03: Dissertation- I	-	10	-	10
Total credits				22

***** *(a student can opt for one DSC and one DSE courses, and 2 RM courses) # Research Track Paper*

Semester-4

	Credits in each course			
Course	Theory	Practical	Tutorial	Credits
Discipline Specific Core (DSC) courses				
-	-	-	-	-
Discipline Specific Elective (DSE) courses				
DSE-07: Enzymology and Biocatalysis	3	1	0	4
DSE-08: Introduction to Genomics[#]	3	1	0	4
DSE-09: Bacterial Biofilms and Chronic Infection	3	1	0	4
DSE-12: Microbial Ecology	3	0	1	4
DSE-13: Facets Of Protozoan Biology	3	0	1	4
Generic Elective (GE) courses				
-	-	-	-	-

Skill-based course (SBC)/ workshop/ Specialized laboratory/ Hands-on Learning				
-	-	-	-	-
Research Methods/ Tools/ Writing				
RM-03: Techniques of Research Writing	2	0	0	2
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research				
RES-04: Dissertation- II	-	16	-	16
Total credits				22

***** *(a student can opt for one DSE courses, and 1 RM courses) # Research Track Paper*

Discipline Specific Core (DSC) courses
DSC-01: Bacteriology
DSC-02: Molecular Virology
DSC-03: Microbial Physiology and Metabolism
DSC-04: Environmental Microbiology
DSC-05: Industrial Microbiology
DSC-06: Microbial Pathogenicity
DSC-07: Food Microbiology
DSC-08: Fundamentals of Mycology and Phycology
DSC-09: Medical Microbiology
DSC-10: Biosafety, Biosecurity and Biosurveillance
DSC-11: Principles of Genetic Engineering #

Discipline Specific Elective (DSE) courses*
DSE-01: Immunology
DSE-02: Cell Biology
DSE-03: Molecular Biology
DSE-04: Plant Pathogen Interactions
DSE-05: Microbial Genetics
DSE-06: Biochemical Methods#
DSE-07: Enzymology and Biocatalysis
DSE-08: Introduction to Genomics#
DSE-09: Bacterial Biofilms and Chronic Infection
DSE-10: Advances in Antimicrobial Resistance Management
DSE-11: Extremophile Microbiology
DSE-12: Microbial Ecology
DSE-13: Facets of Protozoan Biology

Generic Elective (GE) courses*
GE-01: Essentials of Microbiology
GE-02: Microbial Biotechnology
GE-03: Emerging Trends in Microbial Biotechnology
GE-04: Downstream Processing of Microbial Products

Skill based course (SBC)/ workshop/ Specialized laboratory/ Hands-on Learning
SBC-01: Basic Microbiological Techniques
SBC-02: Environmental, Industrial & Molecular Microbiology Techniques
SBC-03: Mycology & Biochemical Techniques
SBC-04: Antimicrobial & Microscopy Techniques

Research Methods/ Tools/ Writing

RM-01: Advanced Research Methodology
RM-02: Tools for Research
RM-03: Techniques of Research Writing

Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research
RES-01: Project Work- I
RES-02: Project Work- II
RES-03: Dissertation- I
RES-04: Dissertation- II

DISCIPLINE SPECIFIC CORE COURSE : DSC-07
FOOD 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-07: FOOD MICROBIOLOGY	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 taxonomical classification, phenotypic characteristics, and biochemical identification of molds, yeasts, yeast-like fungi, and food-related bacteria.
- They will learn about strategies for producing both fermented and non-fermented dairy products.
- They will be introduced to methods for creating plant-based fermented products, fish and meat items.
- The student will be conversant with various malt beverages, wines, distilled spirits, and kinds of vinegar.
- They will learn how microbes contribute to food spoilage and preservation.
- They will be acquainted with various preservation techniques used in the food processing industry
- Students will develop an understanding of various foodborne illnesses.

Learning Outcomes:

The Learning Outcomes of this course are as follows:

- The student will be able to describe various starter cultures and fermented milk products while understanding the production and use of probiotics, prebiotics, and nutraceuticals.
- The student will learn about fermentation protocols for producing microbial biomass, including edible yeasts, mushrooms, and single-cell proteins.
- The student will comprehend the information regarding microbes that cause food intoxication and foodborne infections.
- The student will gain knowledge of various traditional food preservation techniques.

- The student will differentiate between several modern preservation techniques in the food processing industry.
- The student will acquire insight into conventional methods for food quality analysis.
- The student will grasp the microbial standards essential for food safety and quality assurance programs that enhance food safety.

SYLLABUS OF DSC-07:

UNIT- I (12 hours)

Microbiology of food products: Taxonomical classification of microbes associated with food products, their phenotypic and biochemical identification. Food-associated molds, yeasts, yeast-like fungi, and bacteria. Microbiome of food material, Microbial habitat of specific food materials, adaptations and changes in the microbiome of vegetables, fruits, milk, fermented and non-fermented milk products, fresh meats, poultry and non-dairy fermented foods.

Essential reading:

1. Food Microbiology by W.C. Frazier, D.C. Westhoff , K.N. Vanitha. 5th edition. McGraw Hill Education. 2013. (Chapter 1&2).
2. Modern Food Microbiology by J.M. Jay, M.J. Loessner, D.A. Golden. 7th edition. Springer. 2006. (Chapter 2&3).
3. Food Microbiology by M. R. Adams, M. O. Moss, P. McClure. 4th edition. Royal Society of Chemistry. 2015. (Chapter 2&3).

UNIT- II (8 hours)

Microbial spoilage of milk, vegetables, cereals and meat products: Study of microorganisms responsible for spoilage and microbial succession during spoilage, Brief insights into chemical and physical spoilage of foods. Spoilage of milk and milk products. Types and causes of spoilage of cereals and cereals products, Spoilage of vegetables and fruits. **S**poilage of meat and meat products, spoilage of fish and other seafoods, spoilage of eggs and other poultry products

Essential reading:

1. Food Microbiology by W.C. Frazier, D.C. Westhoff , K.N. Vanitha. 5th edition. McGraw Hill Education. 2013. (Chapter 11, 13, 14, 15, 16, 24, 25 & 26).
2. Food Microbiology by M. R. Adams, M. O. Moss, P. McClure. 4th edition. Royal Society of Chemistry. 2015. (Chapter 5).

UNIT- III (17 hours)

Food preservation and Food-borne diseases: General principles of food preservation, various classical, physical, chemical, and biological methods of preservation. New developments in food preservation techniques. Analysis of practical implementation of such techniques. Blockchain technology (BCT) in food safety and quality control, IoE and AI in food processing industry; Food-borne bacterial, viral, and fungal infections. Study of infections due to food-borne parasites. In-depth study of various types and causes of food intoxication. Summary of prevention of microbial food infections. Identification and first aid for specific types of food infections.

Essential reading:

1. Food Microbiology by W.C. Frazier, D.C. Westhoff , K.N. Vanitha. 5th edition. McGraw Hill Education. 2013. (Chapter 5, 6, 7, 8, 9 &10).

2. Food Microbiology by M. R. Adams, M. O. Moss, P. McClure. 4th edition. Royal Society of Chemistry. 2015. (Chapter 3, 4, 5 7&8).

UNIT- IV (8 hours)

Fermentation processes, Food beverages and enzymes: Concept of the human microbiome, probiotics and prebiotics. Insight into health benefits of fermented milk products. Understanding the benefits of traditional and non-traditional fermented foods. Production of fermented milk and milk products, plant-based products, fish products, meat products and nutraceuticals. Manufacture of starter cultures from lab to pilot scale. Batch submerged and solid-state fermentation of foods. Introduction to bioactive compounds and a brief study of such compounds from fermented foods including malt beverages, wines, distilled liquors and vinegar.

Essential reading:

1. Food Microbiology by W.C. Frazier, D.C. Westhoff , K.N. Vanitha. 5th edition. McGraw Hill Education. 2013. (Chapter 21, 22&23).
2. Food Microbiology by M. R. Adams, M. O. Moss, P. McClure. 4th edition. Royal Society of Chemistry. 2015. (Chapter 9).

Practical component (30h)

1. To study the microbial flora of a fruits, milk, milk products and vegetables.
2. Biochemical and molecular Characterization of the bacteria isolated from the kitchen food product.
3. Preparation of *Lactobacillus* inoculum,
4. Preparation of fermented Food Products
5. Testing of milk and water quality using different biochemical methods
6. Preparation of cheese, yogurt and dahi,
7. Pickling of vegetables using microorganisms
8. Production of wine from grape juice.

Essential reading:

1. Food Microbiology by M. R. Adams, M. O. Moss, P. McClure. 4th edition. Royal Society of Chemistry. 2015. (Chapter 10).
2. Practical Food Microbiology Diane Roberts, Melody Greenwood 3rd Edition Blackwell Publishing Ltd. 2003.

Suggested Readings:

3. Food Microbiology by W.C. Frazier, D.C. Westhoff , K.N. Vanitha. 5th edition. McGraw Hill Education. 2013.
4. Modern Food Microbiology by J.M. Jay, M.J. Loessner, D.A. Golden. 7th edition. Springer. 2006.
5. Fundamental Food Microbiology by B. Rayand A. Bhunia. 5th edition. CRC press. 2013.
6. Food Microbiology by M. R. Adams, M. O. Moss, P. McClure. 4th edition. Royal Society of Chemistry. 2015.
7. Food Microbiology: Fundamentals and Frontiers by M. P. Doyle, L. R. Beuchat. 3rd edition. ASM press. 2007.
8. Food Microbiology: An Introduction by T. Montville, K. Matthews, K.Kniel. 4th edition. ASM press. 2017.

9. Practical Food Microbiology Diane Roberts, Melody Greenwood 3rd Edition Blackwell Publishing Ltd. 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-08
FUNDAMENTALS OF MYCOLOGY AND PHYCOLOGY

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-08: FUNDAMENTALS OF MYCOLOGY AND PHYCOLOGY	**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 major objective of this course is to introduce the students to the essentials of mycology and phycology.
- The students will be able to comprehend fungal and algal life cycles, physiology, and metabolism
- The course will familiarize the students with fungal 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 a fungal and algal cell in detail; and study the major fungal and algal groups.
- Students will be able to recall the features of fungal spore, spore dispersal and dormancy.
- Students will be able to define the role of fungus in the ecosystem and in-nutrient cycling.
- Students will be able to develop an industrial application of fungus. Understand the role of fungus in the biotechnology industry.
- Students will be able to apply algae for biotechnology.

SYLLABUS OF DSC-08

UNIT-I (14 hours)

Introduction to Mycology: History and scope of mycology. Characteristic features of Fungi. Overview of fungal diversity. Major fungal groups: Chytridiomycota, Zygomycota, Glomeromycota, Ascomycota, Basidiomycota. Life cycle of one representative genus of each major fungal groups. Structural and functional biology of fungi (hyphae, spores, fruiting bodies). Fungal cell structure: cell wall, membrane, and organelles. Reproduction (sexual and

asexual), and life cycles. Sporulation and spore dispersal, dormancy. Yeast as a model organism. Fungal genome organization and gene expression. Mating types and sexual compatibility. Horizontal gene transfer in fungi. Use of molecular tools for fungal identification (PCR, sequencing).

Essential reading:

1. The Fungi by Michael J. Carlile, Sarah C. Watkinson. 2nd edition. Elsevier. 2000. (Chapter 1, 2, 4)
2. Fungal Biology by Jim Deacon. 4th edition. Wiley. 2005. (Chapter 2, 3, 10,)
3. Fungi: Biology and application by Kevin Kavanagh. Wiley Blackwell. 2017. (Chapter 1)

UNIT-II (12 hours)

Fungal Ecology and Biotechnology: Role of fungi in ecosystems (decomposers, mutualists, pathogens). Symbiotic relationships (mycorrhizae, lichens). Fungal biogeography and their role in nutrient cycling. Environmental impact of fungi (bioremediation, soil health), Industrial applications: enzyme production, organic acids, antibiotics, and biopesticides. Fungi in food production: fermentation, edible mushrooms.

Essential reading:

1. The Fungi by Michael J. Carlile, Sarah C. Watkinson. 2nd edition. Elsevier. 2000. (Chapter 6, 7)
2. Fungal Biology by Jim Deacon. 4th edition. Wiley. 2005. (Chapter 11, 12, 13)
3. Fungi: Biology and application by Kevin Kavanagh. Wiley Blackwell. 2017. (Chapter 4, 5)

UNIT-III (10 hours)

Introduction to Phycology: General characteristics of algae. Classification of algae (Chlorophyta, Rhodophyta, Phaeophyta, Bacillariophyta, Cyanobacteria, Dinophyta, Charophyta, Chrysophyta). Life cycles of different algal groups. Algal cell structure and function. Photosynthesis in algae: Light absorption and pigment diversity.

Essential reading:

1. Algae: An introduction to phycology by C. van dan Hoek, David Mann, and H.M. Jahns. Cambridge University Press. 1996. (Chapter 1, 2)
2. Phycology by Robert Edward Lee. 5th edition. Cambridge University Press. 2018. (Chapter 1, 2)

UNIT-IV (9 hours)

Applied Phycology: Algae in biotechnology: Biofuels, biofertilizers, pharmaceuticals. Algal toxins and harmful algal blooms (HABs). Edible algae and nutraceutical applications. Algae in aquatic ecosystems (planktonic and benthic communities). Role of algae in global carbon cycling and climate change impact.

Essential reading:

1. Phycology by Robert Edward Lee. 5th edition. Cambridge University Press. 2018. (Chapter 23)

Practical component (30 hours)

1. Macroscopic identification of algae and fungi (immature and mature colony of fungi).
2. Microscopic characterization
3. Fungal and algal staining and permanent mount of fungi.
4. Identification of yeast by negative staining.
5. Molecular characterization of algae and Fungi by sequencing of ITS region.
6. Evaluating the susceptibility of the fungal isolate to a range of anti-fungal agents

7. Screening of soil for production of secondary metabolites

Essential/recommended readings

Theory:

1. The Fungi by Michael J. Carlile, Sarah C. Watkinson. 2nd edition. Elsevier. 2000.
2. Fungal Biology by Jim Deacon. 4th edition. Wiley. 2005.
3. Fungi: Biology and application by Kevin Kavanagh. Wiley Blackwell. 2017.
4. Algae: An introduction to phycology by C. van dan Hoek, David Mann, and H.M. Jahns. Cambridge University Press. 1996.
5. Phycology by Robert Edward Lee. 5th edition. Cambridge University Press. 2018.

Practicals:

1. Microbiology: A laboratory manual by Cappuccino and Welsh. 12th edition. Pearson Education. 2019.

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-09: MEDICAL 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-09: MEDICAL 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:

- To introduce the students to the clinical aspects of medical microbiology
- To expose students to the latest research-based advances in the management (diagnostics and treatment strategies) of infectious diseases.

Learning Outcomes:

The Learning Outcomes of this course are as follows:

- The student will be able to understand the different microbes associated with humans and their clinical significance.
- The student will be able to contrast the concepts of the pathology of important bacterial and viral diseases and gain knowledge on managing these diseases.
- The student will comprehend the fungi and parasites causing human diseases and will have the understanding of the management of fungal and parasitic infections.
- The student will gain in-depth knowledge on the principle of diagnosis of infectious diseases and understand the basics of developing diagnostic kits.
- The student will be able to recall the concepts of resistance acquisition in microbes against available therapeutics.
- The student will be able to appraise the new strategies against antibiotic-resistant pathogens and will be exposed to recent approaches.

SYLLABUS OF DSC-09

UNIT - I: (15 hours)

Metagenomics and Epidemiology of infectious diseases: Microbiota of skin, throat, gastrointestinal tract, urogenital tract. Significance of microbiome, symbiosis, dysbiosis, metagenomics in microbiome analysis. Impact of drugs on gut microbiota. Microbial communities coexisting with humans. Factors affecting the microbiota and impact on health. Classification and diversity of infectious agents, various factors affecting infections (epidemiological, social, economic and political conditions of countries). Important bacterial acute and chronic infections and their management: Mycobacteriosis and anaerobic

infections, Meningitis, upper and lower respiratory infections, colitis, urinary tract infections, diabetic foot ulcers, dental caries and ear infections. Viral pathogens and management: SARS Cov-2 and COVID-19, Polio, Herpes, Hepatitis, Rabies, Dengue, AIDS, Influenza (swine flu and bird flu), Ebola, Chikungunya, Japanese Encephalitis, Rotavirus, Zika virus.

Essential Reading:

1. Brock Biology of Microorganisms by Madigan, M.T. and Martinko, J.M. 15th edition. Prentice Hall International Inc., USA. 2017. (Chapter 24, 25, 29)
2. Prescott's Microbiology by Willey, J. M., Sandman, K. and Wood, D. 11th edition. McGraw Hill Higher Education, USA. 2019. (Chapter 30, 33)
3. Metagenomics: Perspectives, Methods and Applications. Edited by M. Nagarajan. 2nd edition. Academic Press. 2024. (Chapters 10, 11, 18, 21)

UNIT - II: (8 hours)

Mycosis and parasitology in Infectious diseases: Identify the etiology and management (diagnosis and treatment) of common mycosis infections such as Athlete's foot, candidiasis and aspergillosis. Basic understanding and management of parasitosis with special emphasis on parasites important to the Indian sub-continent (Malaria, Kala-azar, helminths).

Essential Reading:

1. Brock Biology of Microorganisms by Madigan, M.T. and Martinko, J.M. 15th edition. Prentice Hall International Inc., USA. 2017. (Chapter 33)
2. Prescott's Microbiology by Willey, J. M., Sandman, K. and Wood, D. 11th edition. McGraw Hill Higher Education, USA. 2019. (Chapter 23)
3. Textbook of Microbiology by Ananthanarayan, R. and Paniker. C.K.J. Universities Press, India. 2017. (Chapter 62, 63 and 64)

UNIT - III: (8 hours)

Principle of Diagnosis of Infectious Diseases: Manifestations of infections, Collection, transport and culturing of clinical specimens. Microbiological examinations (Direct examination techniques, culture-dependent and independent methods, serological diagnosis and biochemical assays). Principle and mechanism of different diagnostic tests: ELISA (rapid diagnostic kits) and agglutination-based tests (Widal test: qualitative & quantitative and VDRL test for Syphilis). Immunoassays, Molecular diagnostic approaches, microscopy in diagnostics of infectious diseases. Advanced techniques in diagnosing pathogens such as flow cytometer.

Essential Reading:

1. Brock Biology of Microorganisms by Madigan, M.T. and Martinko, J.M. 15th edition. Prentice Hall International Inc., USA. 2017. (Chapter 28)
2. Prescott's Microbiology by Willey, J. M., Sandman, K. and Wood, D. 11th edition. McGraw Hill Higher Education, USA. 2019. (Chapter 32)
3. Textbook of Microbiology by Ananthanarayan, R. and Paniker. C.K.J. Universities Press, India. 2017. (Chapter 67, 82)

UNIT - IV: (14 hours)

Antimicrobial resistance and emerging strategies against MDR pathogens: Concept of "One health". Social medicine. Recent concepts – multidrug efflux pumps, extended-spectrum b-lactamases (ESBL), X-MDR *M. tuberculosis*, methicillin-resistant *S. aureus* (MRSA), role of integrons. Recombinant vaccines, subunit vaccines, DNA vaccines, Vaccinia-BCG- and HIV vector-based vaccines. CRISPR-Cas9 Gene Editing as therapeutics, Gene silencing, nanoparticles, probiotic bacteria, antibacterial vaccines, phage therapy, phytochemicals and

combination therapies.

Essential Reading:

1. Prescott's Microbiology by Willey, J. M., Sandman, K. and Wood, D. 11th edition. McGraw Hill Higher Education, USA. 2019. (Chapter 31)
2. Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases by John E. Bennett, Raphael Dolin and Martin J. Blaser. 8th Edition Saunders 2015. Chapter 17-34). (Chapter 18 and 19)

Practicals (30 hours):

1. Culture-based diagnosis of infectious agents.
2. Detection of antigen or antibody by sandwich ELISA.
3. Detecting Treponemes by VDRL assay.
4. Perform antibacterial sensitivity by Kirby-Bauer method.
5. Determination of minimum inhibitory concentration by broth dilution method as per CLSI.
6. Isolation and purification of phages from different sources against clinically relevant bacteria.
7. Assessment of anti-biofilm potential of purified phages.

Essential/Recommended Reading:

1. Textbook of Microbiology by Ananthanarayan, R. and Paniker. C.K.J. Universities Press, India. 2017.
2. Jawetz, Melnick and Adelberg's Medical Microbiology by Carroll, K.C., Morse, S.A., Mietzner, T.A. and Miller, S. 27th edition. McGraw Hill Education. 2016.
3. Brock Biology of Microorganisms by Madigan, M.T. and Martinko, J.M. 15th edition. Prentice Hall International Inc., USA. 2017.
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. Prescott's Microbiology by Willey, J. M., Sandman, K. and Wood, D. 11th edition. McGraw Hill Higher Education, USA. 2019.
6. Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases by John E. Bennett, Raphael Dolin and Martin J. Blaser. 8th Edition Saunders 2015.

Practicals:

1. Microbiology: A laboratory manual by Cappuccino and Welsh. 12th edition. Pearson Education. 2019.

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-10
BIOSAFETY, BIOSECURITY, & BIOSURVEILLANCE

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-10: BIOSAFETY, BIOSECURIT, & BIOSURVEILLANCE	4	3	0	1	B.Sc. in any branch of Life Science	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- Student will be introduced to concepts of biosafety and biosecurity in Microbiology labs, and biosurveillance
- Student will gain understanding of biosafety levels, biosafety programs, and biosurveillance strategies
- Students will learn about risk assessments in Biological Laboratories

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to recall levels of biosafety laboratories and their facilities
- Student will be able to assess risks associated with a microbiological laboratory and identify practices required to mitigate those
- Student will be able to categorize laboratory biosafety levels with facilities and practices associated with them
- Student will be able to create a laboratory biosecurity program
- Student will be able to describe the proper use and handling of biosafety cabinets
- Student will be able to categorize animal laboratory biosafety levels with facilities and practices associated with them
- Student will be able to describe biosurveillance strategies

SYLLABUS OF DSC-10

UNIT – I (13 hours)

Introduction to Biosafety and Biosecurity, Biological Risk Assessment: Definitions, the occurrence of Laboratory-associated Infections, Evolution of Biosafety Guidelines, Risk criteria

for establishing ascending levels of containment, Record keeping and biosafety documentation, labeling biohazard material. The risk management process, Risk communication, Facilitating a culture of safety through Risk assessment, Safety equipment (Primary Barriers), Personal Protective Equipment, Facility Design and Construction (Secondary Barriers), Facility practices and procedures, Animal Facilities, Clinical Laboratories

Essential reading:

1. Biosafety in Microbiological and Biomedical Laboratories by US Department of Health and Human Services, NIH. , 6th Edition. June 2020. Section-I, II, and III, Appendix A (Part-2)
2. Laboratory Biosafety Manual by WHO. 4th Edition. 2020. Section-2

UNIT – II (8 hours)

Laboratory Biosafety Levels, and Biosafety cabinets: For Biosafety Level 1 to Biosafety Level 4 - Standard Microbiological Practices, Special Practices, Safety Equipment (Primary Barriers and Personal Protective Equipment, Laboratory Facilities (Secondary Barriers). Introduction to Biological Safety Cabinets, High-Efficiency Particulate Air (HEPA) Filters and the development of biological containment devices, Types of biosafety cabinets, their use, operation and handling of materials inside the Biosafety cabinets. Other Laboratory Hazards and Risk Assessment. Maintenance and decontamination of Biosafety cabinets.

Essential reading:

1. Biosafety in Microbiological and Biomedical Laboratories by US Department of Health and Human Services, NIH. , 6th Edition. June 2020. Section-IV, Appendix A (Part-3, 5, 7)

UNIT – III (8 hours)

Principles of Laboratory Biosecurity: Biosafety and laboratory biosecurity, Performing Risk Assessments in Biological Laboratories, Biohazard Risk Assessment- Pathogen, Procedures, and Personnel, Developing a laboratory biosecurity program, risk assessment and management process, elements of a laboratory biosecurity program, emergency and spill response, Administrative and work practices, personnel medical surveillance, disinfection and sterilization, shipping regulated biological materials

Essential reading:

1. Biosafety in Microbiological and Biomedical Laboratories by US Department of Health and Human Services, NIH. , 6th Edition. June 2020. Section-VI
2. Laboratory Biosafety Manual by WHO. 4th Edition. 2020. Section-8

UNIT – IV (16 hours)

Animal Biosafety, Biosurveillance Strategies: For Animal Biosafety Level 1 to Biosafety Level 4- Standard Microbiological Practices, Special Practices, Safety Equipment (Primary Barriers and Personal Protective Equipment, Animal Facilities (Secondary Barriers). Biosurveillance strategies, biothreat detection, waste-water surveillance, industrial waste safety, syndromic surveillance systems, alternative surveillance systems, laboratory surveillance, environmental surveillance, remote detection systems, limitations and challenges.

Essential reading:

1. Biosafety in Microbiological and Biomedical Laboratories by US Department of Health and Human Services, NIH. , 6th Edition. June 2020. Section-V

Practical component (30 hours)

1. Facilities and working in biosafety level 1 and 2 laboratories.
2. Use of laminar flow, biosafety precautions. Operation and handling of materials inside the Biosafety cabinets.
3. Case studies on laboratory-acquired infections.
4. Decontamination of equipment before and after use. Quality assessment of sterilization and decontamination procedure.
5. Fundamentals, importance, types of personal protective equipment, Waste management of the biorisk materials and biomedical waste management regulations.
6. Packaging, shipping and transportation of materials inside and outside the biosafety laboratory, Work Safety with Sharp Instruments

Recommended readings

Theory:

1. Biological Safety: Principles and Practices by Dawn P. Wooley (Editor), Karen B. Byers (Editor). 5th Edition. ASM Press. 2017.

Practicals:

1. Laboratory Biosafety Manual by WHO. 4th Edition. 2020.

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-11
PRINCIPLES OF GENETIC ENGINEERING

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-11: PRINCIPLES OF GENETIC ENGINEERING	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 course is to introduce the students to the essentials of recombinant DNA technology.
- The students will become familiar with the techniques currently used to manipulate/ analyze DNA, RNA and proteins.
- They will learn about the methods used to clone genes, and make and screen libraries.
- They will be educated about the various applications of PCR.
- They will be introduced to the methods currently used to carry out genome sequencing, as well as global analyses of transcription and protein expression.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to discuss cloning vectors, and basic methods of DNA, RNA and protein analysis.
- Student will be able to describe the various applications of PCR, and know how to make and screen genomic and cDNA libraries.
- Student will be able to outline the methods by which DNA is sequenced and discuss how genomes of organisms are sequenced.
- Student will be able to apply the many uses of reporter genes, and methods to study the transcriptome.
- Student will be able to analyze protein-DNA and protein-protein interactions, protein engineering, and proteomic methods.

SYLLABUS OF DSC-11

UNIT – I (8 hours)

Basics of DNA analysis, cloning, and construction of DNA libraries: Nucleic acid analysis by electrophoresis methods: agarose gel electrophoresis, polyacrylamide gel electrophoresis

(native and Urea-PAGE), pulsed-field gel electrophoresis. Nucleic acid analysis by blotting techniques: Southern and Northern blotting, labelling probes. RFLP analysis and its application in disease diagnosis. DNA fingerprinting and its applications in forensics. Simple cloning and cloning using linkers and adaptors. Uses of different cloning into various kinds of vectors: plasmids, phage lambda and M13, phagemids, cosmids, BACs and YACs. Selection and screening of clones. Vectors used in the construction of cDNA versus genomic DNA libraries. Steps in the construction of cDNA versus genomic DNA libraries. Screening libraries by colony hybridization and colony PCR. Screening expression libraries. Enriching for clones in cDNA libraries by subtractive hybridization.

Essential reading:

1. Molecular Biology by D.P. Clarke, N. Pazdernik, M.R. McGehee. 3rd edition. Academic Cell. 2018. (Chapters 5, 7)

UNIT – II (10 hours)

Polymerase chain reaction, genome sequencing, and genome manipulations: Concept of PCR. Thermophilic polymerases. Primer design. Cloning PCR products. Inverse PCR. RAPD fingerprinting. Ligation Chain Reaction. Overlap PCR. Site-directed mutagenesis: Traditional versus PCR-based methods. Reverse-transcription PCR. 5' RACE and 3' RACE. Real-Time PCR. Use of SYBR green, Taqman and Scorpion probes. Multiplex PCR. Sanger's DNA sequencing: manual versus cycle sequencing. Concept of primer walking. Shotgun sequencing. Next-generation sequencing methods and their applications. Creating genomic knockouts and conditional knockouts. Genome editing using CRISPR-Cas technology. Animal cloning methods.

Essential reading:

1. Molecular Biology by D.P. Clarke, N. Pazdernik, M.R. McGehee. 3rd edition. Academic Cell. 2018. (Chapters 6, 8, 9, 20)

UNIT-III (15 hours)

Transcriptomics and analysis of protein-DNA and protein-protein interactions: Types and applications of reporter genes. Use of reporter genes in transcriptional analysis. DNA microarrays and their applications in genomics as well as transcriptomics. RNA-seq analysis. Analysis of protein-DNA interactions: Gel retardation assays, DNA footprinting by DNAseI and DMS, yeast one-hybrid assays, ChIPs and ChIP-seq. Analysis of protein-protein interactions: yeast two-hybrid and three hybrid assays, co-immunoprecipitations and pulldown assays, FRET and BiFC, phage display.

Essential reading:

1. Molecular Biology by D.P. Clarke, N. Pazdernik, M.R. McGehee. 3rd edition. Academic Cell. 2018. (Chapter 21)

UNIT – IV (12 hours)

Protein expression systems and proteomics: Protein analysis by electrophoresis methods: native and SDS-PAGE, 2D gel electrophoresis, DIGE. Protein analysis by blotting techniques: Western blotting and Southwestern blotting. Bacterial expression systems**:** *E.coli* systems driven by lac, T7 and Tet-regulatable promoters. Yeast expression systems: *S.cerevisiae* and *P.pastoris* systems. Baculovirus overexpression system. Mammalian cell overexpression systems. Proteome analysis by 2D gel electrophoresis coupled to mass spectrometric analysis. Principles of MALDI-TOF and LC-MS platforms. PMF versus MS/MS. Protein arrays and their

applications.

Essential reading:

1. Molecular Biology by D.P. Clarke, N. Pazdernik, M.R. McGehee. 3rd edition. Academic Cell. 2018. (Chapter 15)

Practical component: (30 hours)

1. Analysis of plasmid DNA: Isolation of plasmid by alkaline lysis method and analysis of the different forms of plasmid DNA by agarose gel electrophoresis. Determination of plasmid size by restriction digestion followed by agarose gel electrophoresis.
2. Insertional activation: Alpha complementation and its use in gene cloning- simple cloning experiment.
3. Analysis of gene expression by real time PCR. Comparative analysis of mRNA using SYBR green and $2^{-\Delta\Delta Ct}$ method.

Recommended readings:

Theory:

1. Gene Cloning and DNA Analysis: An Introduction by T.A. Brown. 8th edition. Wiley- Blackwell Publishers. 2020.
2. Molecular Biology of the Gene by J. Watson, T. Baker, S. Bell, A. Gann, M. Levine, R. Losick. 7th edition. Pearson. 2014.
3. Molecular Cloning: A laboratory manual by J. Sambrook, D. Russell. 4th edition. Cold Spring Harbor laboratory Press. 2012.

Practicals:

1. Molecular Cloning: A laboratory manual by J. Sambrook, D. Russell. 4th edition. Cold Spring Harbor laboratory Press. 2012

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-05
MICROBIAL GENETICS

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-05: MICROBIAL GENETICS	**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 major objective of this course is to introduce the students to the essentials of microbial genetics.
- The students will gain knowledge about the mechanisms of genetic transfer in bacteria.
- They will become familiar with phage genetics and gene regulation.
- They will be educated about the effects and uses of bacterial transposition.
- They will be introduced to the general mechanism of gene regulation in bacteria and the concept of negatively and positively regulated operons.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to discuss the importance of mutation analysis, analyze mutations by complementation and recombination tests, and design a strategy to create gene replacement in bacteria.
- Student will be able to outline how plasmid copy number is regulated, and construct a genetic map of the bacterial genome using a conjugation-based method.
- Student will be able to compare and contrast generalized versus specialized transduction, and construct genetic linkage maps using two-factor and three-factor crosses.
- Student will be able to describe the events in the lytic and lysogenic phases of the lambda phage life cycle and the regulatory factors and events involved.
- Student will be able to review inducible and repressible systems and describe the regulation of the lac, trp, gal, ara and tol operons.

SYLLABUS OF DSE-05

UNIT-I (5 hours)

Genetic analysis of bacteria: Mutations and mutagenesis. Inheritance in bacteria: Directed Change versus Random Mutation hypotheses. Types of mutations. Types of mutagens. Reversion versus suppression. Complementation Tests and their applications. Cloning genes

by complementation. Recombination Tests and their applications. Cloning genes by marker rescue. Making bacterial and yeast gene knockouts.

Essential reading:

1. Snyder and Champness Molecular Genetics of Bacteria by T. Henkin and J. Peters. 5th edition. ASM Press, USA. 2020. Chapter 3.

UNIT-II: (10 hours)

Phage genetics and host defenses against phage infection: Icosahedral and filamentous phage life cycles. Virulent versus temperate phages. T4 and T7 phage biology: gene regulation. Use of T4 phage genetics in deciphering the genetic code. Lambda phage biology: Organization of lambda phage genome. Lytic versus lysogeny in lambda phage. Regulation of gene expression in the lytic cycle. Regulation of gene expression in the lysogenic cycle. Role of *cII* and *cI* in the establishment and maintenance of lysogeny. Events leading to lambda lysogen induction. Lambda immunity region and immunity to superinfection. Role of *cI* and *Cro* in regulating the lytic/ lysogenic switch. Role of restriction-modification systems and CRISPR-Cas systems in host defense against phage.

Essential reading:

1. Snyder and Champness Molecular Genetics of Bacteria by T. Henkin and J. Peters. 5th edition. ASM Press, USA. 2020. Chapter 7.

2. Molecular Genetics of Bacteria by L. Snyder, J.E. Peters, T.M. Henkin, and W. Champness. 4th edition. ASM Press, USA. 2013. Chapter 7, 8.

UNIT- III (15 hours)

Mechanisms of genetic transfer in bacteria and bacterial transposition: Genetic transfer by conjugation: Plasmid compatibility and copy number control mechanisms. Fertility in bacteria. Self-transmissible versus mobilizable plasmids. Molecular mechanism of horizontal gene transfer by conjugation. Regulation of conjugation. Hfr strains and F' plasmids. Using interrupted mating to map bacterial genomes. Ti plasmid transfer system and its role in making plant transgenics. Genetic transfer by transformation: Natural competence. DNA uptake systems in Gram-negative and Gram-positive bacteria. Regulation of competence in *B.subtilis*. Genetic transfer by transduction: Generalized and specialized transduction. Co-transduction-based mapping. Bacterial transposition: Types of transposons. Mechanisms of transposition. Effects of bacterial transposition. Conjugative transposons. Transposon mutagenesis. Cloning out genes by transposon mutagenesis. Mu transposon: life cycle of Mu phage. Mu*d* transposons and their use in cloning out genes. Yeast Ty-1 retroposon. Site-specific recombinases: lambda phage integrase system, P1 phage *loxP*-Cre system, *Salmonella* phase variation system.

Essential reading:

1. Snyder and Champness Molecular Genetics of Bacteria by T. Henkin and J. Peters. 5th edition. ASM Press, USA. 2020. Chapters 4, 5, 6, 8.

UNIT-IV (15 hours)

Gene regulation in bacteria: Negative and positive gene regulation. Repressors, activators and inducers. Attenuation. Gene regulation in the *lac, trp, gal, ara* and *tol* operons. Global

regulation: regulons and stimulons. Stress responses in bacteria: Iron regulation in *E. coli*. Regulation of virulence genes in bacteria: diphtheria.

Essential reading:

1. Molecular Genetics of Bacteria by L. Snyder and W. Champness. 3rd edition. ASM Press, USA. 2007. Chapter 12.

Practical component: (30 hours)

1. Analysis of genetic transfer by bacterial transformation: Preparation of competent cells and transformation of *E. coli* with plasmid DNA. Determination of transformation efficiency.

2. Analysis of genetic transfer by conjugation: Transfer of an antibiotic resistance marker from one bacterial strain to another by bacterial mating and selection of exconjugants.

3. Determination of phage titer in lysate: Bacterial infections with serial dilutions of phage lysate and determination of pfu/ml.

Recommended readings

Theory:

1. Microbial Genetics edited by M.K. Rai, S. Okon, B. Zimowska. CRC Press. 2024.
2. Genetics of Bacteria by Sheela Srivastava. Springer-Nature India. 2013.
3. Fundamental Bacterial Genetics by N. Trun, J. Trempy. 1st edition. Wiley-Blackwell Publishing. 2004.
4. Modern Microbial Genetics edited by U.N. Streips, R.E. Yasbin. 2nd edition. Wiley-Liss Publishers. 2002.
5. Microbial Genetics by S.R. Maloy, J.E. Cronan, Jr., D. Freifelder. 2nd edition. Jones and Bartlett Publishers. 1994.

Practicals:

1. Experiments in Bacterial Genetics: A laboratory Manual by A Cell Biology Manual. Edited by L. Bossi, A. Camilli, A. Grundling. Cold Spring Harbor Laboratory Press. 2024.

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

DISCIPLINE SPECIFIC ELECTIVE: DSE-06
BIOCHEMICAL METHODS

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-06: BIOCHEMICAL METHODS	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 course is to train students in basic principles and applications of essential laboratory equipment.
- To expose the students to various advanced laboratory techniques in the areas of biochemistry and molecular biology.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Students will be able to understand the basic principles of electrochemistry and buffer preparation.
- Students will be able to analyze the data from spectroscopy, instrumentation, and applications.
- Students will be able to design a multi-step purification protocol for a target protein through chromatography.
- Students will be able to understand the applications and instrumentation of various kinds of microscopy.
- Students will be able to explain and execute DNA and protein labelling experiments.

SYLLABUS OF DSE-06:

UNIT – I (13 hours)

Basic principles of electrochemistry: Electrolytes, Ionization of weak acids and bases. Measurement of the pH: the pH electrode, pH buffers, pH buffer capacity, selection of biochemical buffers, preparation of phosphate buffer, Ionization properties of amino acids: zwitterion ion, isoelectric point. **Principles and techniques of spectroscopy:** Principle of spectroscopy, Beer-Lambert's Law, concept of absorptions, transmission, scattering, phosphorescence, fluorescence, luminescence, diffraction spectra regions of electromagnetic spectrum. Principle, instrumentation and applications of UV - visible and IR spectroscopy. Hypo and Hyperchromicity, Fluorimetry: Flow cytometry.

Essential reading:

1. The Physical and Chemical Basis of Molecular Biology by Thomas E Creighton. Published by Helvetian

Press. 2010. (Chapter 1, 2, 3, 10).
2. Principles and Techniques of Biochemistry and Molecular Biology by Wilson, K. and Walker, J. 8th edition. Cambridge University Press, Cambridge. 2022 (Chapter 10 & 13).

UNIT – II (17 hours)

Separation Techniques -I: Chromatography: Basics principles and applications of various chromatography methods: Paper and thin layer chromatography, Column Chromatography: Gel-filtration, Ion-exchange, affinity, Reversed-phase, Hydrophobic interaction chromatography. High, Ultra and Fast Performance Liquid Chromatography (HPLC, UPLC, FPLC). Gas-Liquid Chromatography (GLC). **Separation Techniques -II: Centrifugation:** Basic principles of sedimentation, RCF/RPM, Sedimentation (s). Types of centrifuges: Bench-top centrifuge and High-Speed refrigerated centrifuge (Ultracentrifugation). Types of rotors: Preparative centrifugation, Differential centrifugation, Density-Gradient centrifugation. Analytical ultracentrifugation: molecular weight determination.

Essential reading:

1. The Physical and Chemical Basis of Molecular Biology by Thomas E Creighton. Published by Helvetian Press. 2010. (Chapter 16, 18 & 20).
2. Principles and Techniques of Biochemistry and Molecular Biology by Wilson, K. and Walker, J. 8th edition. Cambridge University Press, Cambridge. 2022 (Chapter 5 & 12).

UNIT- III (08 hours)

Microscopy: Basics of microscopy: image formation, magnification, resolution, Biological applications and instrumentation of various kinds of microscopy: Bright field, Phase-contrast, Fluorescence and Confocal Microscopy, Electron Microscope – Scanning and Transmission Electron Microscopy, Atomic Force Microscopy. Histopathology – definition, fixation, decalcification, tissue processing, cutting, staining, and analysis.

Essential reading:

1. The Physical and Chemical Basis of Molecular Biology by Thomas E Creighton. Published by Helvetian Press. 2010. (Chapter 8).
2. Principles and Techniques of Biochemistry and Molecular Biology by Wilson, K. and Walker, J. 8th edition. Cambridge University Press, Cambridge. 2022 (Chapter 11).

UNIT – IV (07 hours)

DNA and Protein labelling: DNA probes, Types of DNA probes and applications, Molecular beacons. Types of Probe Labelling (enzymatic/chemical). Protein Labelling Methods & Mechanisms: Chemical Labelling, Enzymatic Labelling, Genetic Labelling (Fusion Proteins), Isotopic Labelling. Optimization of Labelling Efficiency. Maintaining Protein Activity Post-Labelling.

Essential reading:

1. The Physical and Chemical Basis of Molecular Biology by Thomas E Creighton. Published by Helvetian Press. 2010. (Chapter 21).
2. Biophysical chemistry, Principles and Techniques by Upadhyay A, Upadhyay K and Nath N; Himalaya Publishing House, India. 2016. (Chapter 13).

Practical component (30 hours):

1. To draw the titration curve of the acid and base.
2. Preparation of different buffers (phosphate buffer) and pH calibration.
3. Instrumentation and analysis of data generated from the spectrophotometer. Estimation

of protein/DNA concentration using spectrophotometer.
4. Preparation and demonstration of column chromatography.
5. Preparation of density-gradient columns for centrifugation experiments.
6. Demonstration of high-speed refrigerated ultracentrifuge.
7. Analysis of GFP labeled protein using fluorescent microscopy for sub-cellular localization.
8. Visualization and analysis of bacteria/tissue samples under microscopy.

Essential/recommended readings

Theory:

1. Principles and Techniques of Biochemistry and Molecular Biology by Wilson, K. and Walker, J. 8th edition. Cambridge University Press, Cambridge. 2022
2. The Physical and Chemical Basis of Molecular Biology by Thomas E Creighton. Published by Helvetian Press. 2010.
3. Biophysical Chemistry by James, P. Allen. Wiley Blackwell, New Jersey. 2008.
4. Fundamentals of Light Microscopy and Electron Imaging by Murphy, D.B. and Davidson, M. W. Wiley-Blackwell, New Jersey. 2012.
5. Physical Biochemistry- Application to Biochemistry and Molecular Biology by Freifelder, D.M. W.H. Freeman, New York. 1983.
6. Analytical Biochemistry: 3rd edition. Holme DJ, Peck H. Prentice Hall.
7. Biophysical chemistry, Principles and Techniques by Upadhyay A, Upadhyay K and Nath N; Himalaya Publishing House, India. 2016.
8. Conjugation of enzymes to antibodies by Winston, S.E. Current Protocols in Molecular Biology. 2001.
9. Unraveling protein dynamics to understand the brain–the next molecular frontier by Brewer, Kyle D., Sophia M. Shi, and Tony Wyss-Coray. Molecular Neurodegeneration. 2022.

Practicals:

1. Molecular Cloning: A laboratory manual by Joseph Sambrook, David Russell, 4th edition. Cold Spring Harbor Laboratory Press. 2012.
2. Fundamentals of Light Microscopy and Electron Imaging by Murphy, D.B. and Davidson, M. W. Wiley-Blackwell, New Jersey. 2012.
3. 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-07
ENZYMOLOGY AND BIOCATALYSIS

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-07: ENZYMOLOGY AND BIOCATALYSIS	**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 major objective of this course is to introduce students to the fundamentals of enzymology, including enzyme structure, kinetics, and mechanisms.
- The students will gain insights into advanced enzyme technology, including enzyme engineering and large-scale production.
- They will become familiar with industrial and medical applications of enzymes, emphasizing extremozymes and whole-cell biocatalysis.
- The students will gain knowledge of enzyme commercialization, entrepreneurial opportunities, and sustainability-focused enzyme applications.
- The students will develop hands-on expertise in enzyme purification, kinetics, immobilization, and biotechnological techniques.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students will be able to explain enzyme structure, catalytic mechanisms, and factors affecting enzyme activity.
- Students will be able to analyze enzyme kinetics and apply graphical methods to study enzyme activity.
- Students will be able to explore the properties and applications of extremozymes and whole-cell biocatalysts.
- Students will be able to demonstrate enzyme production methods, immobilization techniques, and their applications.
- Students will be able to examine enzyme engineering strategies and evaluate challenges in scaling enzyme production.
- Students will be able to gain entrepreneurial insights through case studies on enzyme-based startups and explore commercialization strategies.

SYLLABUS OF DSE-07:

UNIT – I (16 hours)

Fundamentals of Enzymology and Enzyme Kinetics: Introduction to enzymology, historical background, and significance. Structure and classification of enzymes: holoenzyme, apoenzyme, cofactors, coenzyme, prosthetic groups, and metalloenzymes. Catalytic mechanisms: activation energy, transition state theory, and enzyme-substrate interaction models (lock-and-key and induced fit). Factors affecting enzyme activity: enzyme concentration, substrate concentration, temperature, pH, and inhibitors. Kinetics of enzyme activity. Significance of Km, catalytic efficiency, turnover number. Michaelis-Menten equation, determination of K_M and Vmax using Lineweaver-Burk and other plots. Inhibition and regulation: competitive, non-competitive, uncompetitive inhibition, and allosteric regulation.

Essential reading:

1. ENZYMES: A Practical Introduction to Structure, Mechanism, and Data Analysis by R.A. Copeland. 2nd edition. Wiley, USA. 2000. (Chapters 1 and 5)
2. Lehninger Principles of Biochemistry by D.L. Nelson & M.M. Cox. 6th edition. W.H. Freeman, USA. 2017. (Chapter 6)
3. Principles and Techniques of Biochemistry and Molecular Biology by K. Wilson and J. Walker. 7th edition. Cambridge University Press, UK. 2010. (Chapters 15)

UNIT – II (6 hours)

Study of Extremozymes – Exploring Unique Enzymatic Features: Extremozymes: unique properties, stability, and activity under extreme conditions (temperature, pH, and salinity). Adaptations of extremophiles: thermostable, halotolerant, and cold-active enzymes, along with their structural features. Applications of extremozymes: industrial uses in molecular biology, pharmaceutical synthesis, and green chemistry.

Essential reading:

1. Extremophiles: From Biology to Biotechnology (Editors: R. Durvasula & V. Subba Rao). CRC Press, USA. (Chapters 1, 7 and 11)

UNIT – III (15 hours)

Enzyme Engineering and Advances in Biocatalysis: Enzyme engineering techniques such as site-directed mutagenesis to enhance enzyme activity and stability. Methods to optimize enzyme-substrate interactions, improve catalytic efficiency, and increase stability under various conditions such as high temperature, extreme pH, and organic solvents. Designer enzymes: computational and rational design for tailored industrial and biomedical applications. Whole-cell biocatalysis concept, benefits, and applications in biotransformation and bioprocessing. Cell-free protein synthesis (CFPS), its advantages, challenges, and applications in protein production. Use of these biocatalysis strategies in pharmaceuticals, biofuels, and green chemistry.

Essential reading:

1. Lehninger Principles of Biochemistry by D.L. Nelson & M.M. Cox. 6th edition. W.H. Freeman, USA. 2017. (Chapter 6)
2. Cell-Free Protein Synthesis: Methods and Protocols edited by J. Swartz. Methods in Molecular Biology, Vol. 1118. Springer, USA. 2014. (Chapter 4 and 6)

UNIT – IV (8 hours)

Commercialization and Entrepreneurship in Enzyme Technology: Lab-to-market journey of enzyme technologies with case studies. Entrepreneurship in enzyme technology: intellectual

property, patents, and funding opportunities. Future directions: enzyme applications in the circular bioeconomy, green chemistry, and sustainability.

Essential Reading:

1. Biotechnology Entrepreneurship (Ed. Craig Shimasaki), Elsevier, 2014. (Chapters 14, 15)
2. The Business of Bioscience: What Goes into Making a Biotechnology Product by C.D. Shimasaki. 1st edition. Springer, USA. 2014. (Chapters 2, 6 and 13)

Practical Component (30 hours):

1. Determination of enzyme activity and specific activity of a purified enzyme sample.
2. Determination of kinetic parameters (Km, Vmax, and Kcat) using Michaelis-Menten and Lineweaver-Burk plots.
3. Study of pH optima, pH stability, temperature optima, and temperature stability of a given enzyme sample.
4. Calculation of inactivation constant (Kd) and t1/2 for enzyme reaction.
5. Comparative analysis of extremozymes and mesophilic enzymes to understand adaptive mechanisms.

Suggested Readings:

Theory:

1. Molecular Cell Biology by H. Lodish et al. 9th edition. W.H. Freeman. 2021.
2. Essential Cell Biology by B. Alberts et al. 5th edition. W.W. Norton & Co. 2019.
3. Karp's Cell and Molecular Biology by G. Karp et al. 9th edition. Wiley. 2019.
4. The Cell: A Molecular Approach by G.M. Cooper. 8th edition. Sinauer Associates. 2018.
5. Principles of Enzymology by N.C. Price. 4th edition. Oxford University Press. 2013.
6. Biocatalysts and Enzyme Technology by K. Buchholz, V. Kasche, U.T. Bornscheuer. 2nd edition. Wiley-VCH, Weinheim, Germany. 2012.
7. Guide to Protein Purification edited by M. P. Deutscher. 2nd edition. Academic Press, USA, 2009.
8. Enzymes: Biochemistry, Biotechnology, Clinical Chemistry by Trevor Palmer. 2nd edition. Horwood Publishing House, England, 2007.
9. Biocatalysis – Fundamentals and Applications by A.S. Bommarius, B.R. Riebel. Wiley-VCH, Weinheim, Germany. 2004.
10. Enzymology Labfax by P.C. Engel. BIOS Scientific Publishers, Academic Press, USA. 1996.
11. Enzyme Inhibitors by U. Brodbeck. Verlag Chemie, Weinheim, Germany. 1980.
12. Biochemical Calculations by Irwin Segel. 2nd edition. John Wiley and Sons, USA. 1976.

Practical component:

1. A Cell Biology Manual by J. Francis, Kendall/Hunt Publishing. 2022.
2. Practical Laboratory Manual- Cell Biology by A. Gupta, B.K. Sati, Lambert Academic Publishing. 2019.
3. Essential Cell Biology Vol. 1 & 2 by J. Davey and M. Lord. Oxford University Press. 2003.
4. Enzyme Kinetics and Mechanism by P. F. Cook, W.W. Cleland. Garland Science Publishing, 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-08
INTRODUCTION TO GENOMICS

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-08: INTRODUCTION TO GENOMICS	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 course is to introduce the students to the essential concepts and recent discoveries in genomics.
- The students will become familiar with the currently used techniques to sequence whole genomes.
- They will gain knowledge about the methods used to annotate genome sequences.
- They will be educated about the various applications of genomics in human health.
- They will be introduced to the applications of metagenomic analyses.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to discuss how complex genomes are sequenced *de novo*.
- Student will be able to describe the various high-throughput methods used to sequence genomes.
- Student will be able to list the various databases used to store genomics data.
- Student will be able to relate the uses of genomics in the prediction of human diseases.
- Student will be able to compare the different methods of genome editing.

SYLLABUS OF DSE-08

UNIT – I (12 hours)

First generation and next generation genome sequencing methods: DNA sequencing by chain termination: Sanger's manual versus automated methods. Concept of primer walking and chromosome walking. Principles of shotgun genome sequencing. Whole genome versus hierarchical shotgun sequencing approach. The Human Genome Sequencing Project. Next generation sequencing platforms: pyrosequencing-based, reversible terminator-based, single-molecule real-time sequencing-based, ion torrent sequencing, nanopore sequencing. Preparation of libraries for NGS. Importance and applications of NGS.

Essential reading:

1. Molecular Biology by D.P. Clarke, N. Pazdernik, M.R. McGehee. 3rd edition. Academic Cell. 2018. (Chapters 8, 9)

UNIT-II (8 hours)

Genome sequence annotation: Databases, databanks, and genome browsers. Computer program overview for genomics: Genome Linux, NCBI blast tools. Annotation at the nucleotide level. Nucleic acid sequence databases. Annotation at the protein level. Protein sequence databases. Databases of genetic diseases. Databases of structures. AlphaFold: breakthrough in protein structure prediction. Databases of proteomics and metabolic pathways. The Kyoto Encyclopedia of Genes and Genomes (KEGG).

Essential reading:

1. Introduction to Genomics by Arthur Lesk. 4th edition. Oxford University Press. 2025. (Chapter 3)

UNIT –III (12 hours)

Genomics in human health and disease: Identification of human biomarkers using genomics. Genome-wide association studies (GWAS) and their application in human health and personalized medicine. Comprehensive whole-genome sequencing projects: 1000 Genomes Project (The International Genome Sample Resource), 10,000 Genomes Project (Genome India Project), 100,000 Genomes Project (Genomics England initiative). Neonatal genome sequencing: benefits and risks. Application of genomics in the understanding, detection and treatment of cancer. Genome editing using CRISPR-Cas.

Essential reading:

1. Introduction to Genomics by Arthur Lesk. 4th edition. Oxford University Press. 2025. (Chapters 1, 10)

UNIT-IV (13 hours)

Metagenomics and its applications: Investigating complex microbial communities: gut microbiome and its role in human health and disease. Soil and water microbiomes as a measure of pollutants and climate change. Role of soil microbiome in crop health, and development of biofertilizers. Identification of microbial enzymes and pathways useful in industrial processes in soil microbiota genomes.

Essential reading:

1. Metagenomics: Perspectives, Methods and Applications. Edited by M. Nagarajan. 2nd edition. Academic Press. 2024. (Chapters 10, 11, 18, 21)

Practical component (30 hours)

1. Use of genome browsers: Trawling genome sequence databases for information with respect to the organization of the genome, genes, proteins and metabolic pathways.
2. Protein structure prediction and modeling: Use of Phyre 2 and AlphaFold to model protein structure from amino acid sequence.

Recommended readings

Theory:

1. Gene Cloning and DNA Analysis: An Introduction by T.A. Brown. 8th edition. Wiley-Blackwell Publishers. 2020.

2. Molecular Biology of the Gene by J. Watson, T. Baker, S. Bell, A. Gann, M. Levine, R. Losick. 7th edition. Pearson. 2014.
3. Introduction to Genomics by Arthur Lesk. 4th edition. Oxford University Press. 2025.

Tutorials:

1. Use of NCBI tools, use of Phyre 2 and AlphaFold: https://www.ncbi.nlm.nih.gov.in, https://www.sbg.bio.ic.ac.uk/~phyre2/ , https://alphafoldserver.com/welcome

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-09
BACTERIAL BIOFILMS AND CHRONIC INFECTIONS

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 09: BACTERIAL BIOFILMS AND CHRONIC INFECTIONS	**4**	**3**	**0**	**1**	**B.Sc. in any branch of Life Science**	**NA**

Learning Objectives:

- The objective of this course is to make the students understand the difference between biofilm and planktonic modes of life.
- The students will learn about the medical complications associated with biofilms.
- The course will enable students to understand the tools available to study biofilms.

Learning Outcomes:

Upon successful completion of the course:

- The student will be able to understand how biofilm bacteria are different from their planktonic counterparts.
- The student will be able to describe the characteristics of bacterial biofilms.
- The student will be able to study and critique the various biofilm-associated diseases impacting humans
- The student will be able to understand various *in vitro* and *in vivo* models to study biofilm which will help them design their research
- The student will be able to gather information on how chronic infections are diagnosed and what treatment options available.

SYLLABUS OF DSE-09

UNIT- I (12 hours)

Introduction to biofilms and chronic infections: Planktonic and biofilm-growing bacteria. Where do biofilms grow: environment, artificial materials, and live cells. Stages of biofilm formation and role of different biomolecules. Biofilm matrix polysaccharides and other components of biofilms. Key features of biofilms including quorum sensing. Chronic infections and host responses. Immune evasion responses. Treatment failures and persistence: role of persister cells. Biofilm in chronic infections: Introduction, Oral biofilms, Skin Microbiology, Commensal Biofilm- gut flora, Bacteria and Biofilms are ubiquitous, Cystic fibrosis, chronic wounds, Implants, Tissue filler, Otitis Media, Intravascular catheters.

Essential reading:

1. Bacterial Biofilms by Tony Romeo. Springer 2008 (Chapter 2, 3, 7, 8, 9, 12)

UNIT – II (13 hours)

***In vitro* and ex vivo models to study biofilms:** Characteristics, advantages and uses of different model systems. *In vitro* models (Open systems: micro-titer plate assays, biofilm ring test, Calgary biofilm device; closed systems: Kadouri system, flow cells, CDC bioreactor, drip flow reactor, micro-fermenters, modified Robbins Device, microfluidic biochips and continuous flow system. Microcosms: Zurich Oral biofilm model, Zurich burn biofilm model, Reconstitute human epithelia (RHE), microfluidic co-culture model); *Ex vivo* models: Root canal biofilms, cardiac valve ex vivo model, Candidiasis in vaginal mucosa.

Essential reading:

1. From *in vitro* to *in vivo* models of bacterial biofilm-related infections. Lebeaux D, Chauhan A, Rendueles O, Beloin C. *Pathogens*. May 13;2(2):288-356. (2013) doi: 10.3390/pathogens2020288.
2. Analytical Methodologies for Biofilm Research by Bhowmik, A., Malhotra, A., Jana, S., Chauhan, A. Nag, M., Lahiri, D. (eds). Springer Protocols Handbooks. Springer, New York, NY. (2021). https://doi.org/10.1007/978-1-0716-1378-8_1
3. Critical review on biofilm methods. Azeredo, J., Azevedo, N. F., Briandet, R., Cerca, N., Coenye, T., Costa, A. R., Sternberg, C. Critical Reviews in Mcirobiology, 43 (3), 313-351. (2107) https://doi.org/10.1080/1040841X.2016.1208146

UNIT-III (10 hours)

Animal models (*in vivo*) to study biofilms: Non-mammalian animal models: drosophila, Zebrafish, *C. elegans* as model systems; Mammalian models: a) tissue related models: burn wound infection biofilm model, native valve endocarditis infection model, b) urinary tract catheters, vascular catheter model, orthopedic implants, prosthetic joints and endotracheal tubes.

Essential reading:

1. Lebeaux D, Chauhan A, Rendueles O, Beloin C. (2013) From *in vitro* to *in vivo* models of bacterial biofilm-related infections. *Pathogens*. May 13;2(2):288-356. doi: 10.3390/pathogens2020288.
2. Analytical Methodologies for Biofilm Research by Bhowmik, A., Malhotra, A., Jana, S., Chauhan, A. (2021). Nag, M., Lahiri, D. (eds). Springer Protocols Handbooks. Springer, New York, NY. https://doi.org/10.1007/978-1-0716-1378-8_1

UNIT – IV (10 hours)

Diagnosis and treatment of chronic infections: Diagnosis of biofilm infections and challenges. Culture dependent, molecular methods (PCR etc.) and microscopy. Treatment of chronic infections. Pharmacokinetic of a drug in context with biofilm infections and comparison with planktonic bacteria. Minimum biofilm inhibitory concentration vs. minimum inhibitory concentration. Antimicrobial resistance/tolerance/persistence of biofilms. Role of persister cells in treatment options. Various innovative approaches from recent research.

Essential reading:

1. Lebeaux D, Chauhan A, Rendueles O, Beloin C. (2013) From *in vitro* to *in vivo* models of bacterial biofilm-related infections. *Pathogens*. May 13;2(2):288-356. doi: 10.3390/pathogens2020288.
2. Allison, K., Brynildsen, M. & Collins, J. (2011). Metabolite-enabled eradication of bacterial persisters by aminoglycosides. *Nature* **473**, 216–220. https://doi.org/10.1038/nature 10069

3. Baquero, F., Levin, B.R. Proximate and ultimate causes of the bactericidal action of antibiotics. (2021) *Nat Rev Microbiol* **19**, 123–132. https://doi.org/10.1038/s41579-020-00443-1

Practical component (30 hours):

1. Growth of bacterial biofilms in a microfuge tube.
2. Growth of biofilms in a micro-titre plate.
3. Evaluation of different staining methods for biofilms.
4. Effect of media and substrate on biofilm growth.
5. Visualization of biofilm under microscope.
6. Comparing antibacterial and antibiofilm activity of different compounds: MIC vs. MBIC.

Essential/recommended readings

1. Oral Biofilms in Health and Disease by Hyun Koo, Nicholas Jakubovics, Bastiaan P. Kron. Sringer. 2025.
2. Biofilm Matrix by Courtney Reichhardt. Springer 2024
3. Antibiofilm Strategies by Katharina Richter and Kasper Norskov Kragh. Springer 2022.
4. Control of Biofilm Infections by Single Manipulation. By Naomi Balaban. Springer. 2008
5. Bacterial Biofilms by Tony Romeo. Springer 2008.
6. Allison, K., Brynildsen, M. & Collins, J. (2011). Metabolite-enabled eradication of bacterial persisters by aminoglycosides. *Nature* **473**, 216–220. https://doi.org/10.1038/nature 10069
7. Baquero, F., Levin, B.R. Proximate and ultimate causes of the bactericidal action of antibiotics. (2021) *Nat Rev Microbiol* **19**, 123–132. https://doi.org/10.1038/s41579-020-00443-1
8. Lebeaux D, Chauhan A, Rendueles O, Beloin C. (2013) From *in vitro* to *in vivo* models of bacterial biofilm-related infections. *Pathogens*. May 13;2(2):288-356. doi: 10.3390/pathogens2020288.
9. Analytical Methodologies for Biofilm Research by Bhowmik, A., Malhotra, A., Jana, S., Chauhan, A. (2021). Nag, M., Lahiri, D. (eds). Springer Protocols Handbooks. Springer, New York, NY. https://doi.org/10.1007/978-1-0716-1378-8_1

Practical:

1. O'Toole GA. Microtiter dish biofilm formation assay. J Vis Exp. 2011 Jan 30;(47):2437. doi: 10.3791/2437. PMID: 21307833; PMCID: PMC3182663.

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-10
ADVANCES IN ANTIMICROBIAL RESISTANCE MANAGEMENT

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-10: Advances in Antimicrobial Resistance Management	**4**	**3**	**0**	**1**	**Class B.Sc. pass with Biology/ Biotechnology/ Biochemistry**	**NA**

Course Objectives

Upon successful completion of this course, students will be able to:

- Perform and interpret standardized laboratory techniques for antimicrobial susceptibility testing (AST), including MIC determination (Broth Microdilution) and phenotypic detection of key resistance determinants (e.g., ESBL, inducible resistance) using CLSI/EUCAST guidelines.
- Design and execute basic molecular biology protocols (DNA extraction, PCR) to detect and confirm the presence of specific antimicrobial resistance genes (ARGs) in clinical or environmental isolates.
- Analyze and interpret complex microbiological data sets, including MIC distributions, anti-biograms, and epidemiological data, using appropriate statistical and data visualization tools.
- Appraise and critique primary scientific literature concerning antimicrobial development and resistance mechanisms, identifying key hypotheses, methodological limitations, and future research directions.
- Demonstrate professional responsibility and ethical awareness regarding the appropriate use of antimicrobials and the handling of clinical and research data in the context of AMR.

Course Learning Outcomes:

Upon successful completion of the course:

- The student will be able to understand the global challenge of Antimicrobial Resistance (AMR) from molecular, clinical, and public health perspectives.
- The student will be able to analyze the mechanisms of action for major classes of antibiotics and the corresponding resistance mechanisms.
- The student will be able to evaluate current strategies and novel approaches for discovering and developing new antimicrobial agents.
- The student will be able to execute essential laboratory techniques for antimicrobial susceptibility testing, resistance mechanism identification, and antimicrobial screening.

SYLLABUS OF DSE-10

Unit 1 (12 hours)

The Biology of Antimicrobial Agents: History and Classification of antibiotics: Brief history of antibiotics (e.g., Penicillin, Streptomycin). Classification based on chemical structure, mechanism of action, and spectrum of activity. Mechanisms of Action: Detailed examination of how key classes of antibiotics kill or inhibit bacteria: Cell Wall Synthesis Inhibitors: beta-Lactams (Penicillins, Cephalosporins, Carbapenems, Monobactams), Glycopeptides (Vancomycin). Protein Synthesis Inhibitors: Aminoglycosides, Macrolides, Tetracyclines, Lincosamides. Nucleic Acid Synthesis Inhibitors: Fluoroquinolones, Rifamycins. Metabolic Pathway Inhibitors: Sulfonamides, Trimethoprim.

Essential Reading:

1. Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases by John E. Bennett, Raphael Dolin and Martin J. Blaser. 8th Edition Saunders 2015. (Chapter 17-34)

Unit 2 (12 hours)

Mechanisms and Spread of Antimicrobial Resistance: Molecular Mechanisms of Resistance: Enzymatic Degradation/Inactivation: beta-Lactamases (ESBLs, KPCs), Aminoglycoside-modifying enzymes. Target Modification: Altered PBPs (MRSA), Ribosomal modifications (Macrolide resistance), D-Ala-D-Lac substitution (Vancomycin resistance). Efflux Pumps: Structure and function of major efflux systems (e.g., RND family) and their role in multi-drug resistance (MDR). Reduced Permeability: Role of outer membrane porins (e.g., *Pseudomonas aeruginosa*). Genetic Basis of Resistance: Role of Plasmids and Transposons in horizontal gene transfer (Conjugation, Transformation, and Transduction). The concept of the Resistome. Clinical and Epidemiological Issues: Emergence of "Superbugs" (e.g., MRSA, VRE, CRE, MDR-TB).

Essential Reading:

1. Molecular mechanisms of antibiotic resistance by Blair, J., Webber, M., Baylay, A. *et al. Nat Rev Microbiol* **13**, 42–51 (2015)
2. Extending the Potency and Lifespan of Antibiotics: Inhibitors of Gram-Negative Bacterial Efflux Pumps. Jumde, R. P., da Costa, R. M. A., Ropponen, H.-K., & Piddock, L. J. V. *ACS Infectious Diseases*, *10*(5), 1438–1454. (2024)
3. Mechanisms of antimicrobial resistance in biofilms by Liu, H.Y., Prentice, E.L. & Webber, M.A. *npj Antimicrob Resist* **2**, 27 (2024)
4. Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases by John E. Bennett, Raphael Dolin and Martin J. Blaser. 8th Edition Saunders 2015. (Chapter 18 and 19)

Unit 3 (11 hours)

Antimicrobial Discovery, Development, and Innovation Management: Traditional Discovery Strategies: The "Golden Age" Legacy: The Waksman platform and systematic screening of Soil Actinomycetes. Bioprospecting: Exploration of extreme environments (marine, endophytic, and deep-sea microbes) for novel chemical scaffolds. Chemical Libraries: Principles of combinatorial chemistry and the synthesis of "diversity-oriented" libraries. Case Study: The discovery of Teixobactin as a paradigm shift in natural product screening. Modern Drug Design & Screening Technologies: Target-Based vs. Phenotypic Screening: * Target-based: Using genomics to identify "essential" bacterial proteins (e.g., FtsZ, LpxC). Phenotypic: Whole-cell screening and the advantage of capturing "prodrugs" and permeability. High-Throughput Screening (HTS): Automation, assay miniaturization (384/1536-well plates), and fluorescence-based readouts. Non-Traditional & Adjunct Therapies: Antibiotic Adjuvants: Reversing resistance through synergy (e.g., beta-lactamase inhibitors like Avibactam; Efflux Pump

Inhibitors). Biological Alternatives: Phage Therapy: Biology of lytic phages, "Phage cocktails," and regulatory hurdles. Antimicrobial Peptides (AMPs): Structure-activity relationships and membrane-targeting mechanisms. Anti-virulence Strategies: Targeting Quorum Sensing (QS) and toxin production to reduce pathogenicity without killing the microbe. Vaccines and Immunotherapies against resistant pathogens.

Essential Reading:

1. Bacteriophage therapy for multidrug-resistant infections: current technologies and therapeutic approaches. Kim, M. K., Suh, G. A., & D'Hérelle, G. *Journal of Clinical Investigation*, *135*(2), e187996. 2025.
2. ARG Context Profiler: extracting and scoring the genomic contexts of antibiotic resistance genes using assembly graphs. Moumi, N. A., Ahmed, S., Brown, C., Pruden, A., & Zhang, L. *Frontiers in Cellular and Infection Microbiology*, *15*, 1582613. 2025

Unit 4(10 hours)

Management of AMR: Global Health, Policy, and Diagnostics: Public Health, Policy, and "One Health" The One Health Triad: The interconnectedness of human medicine, veterinary usage (growth promoters), and environmental reservoirs (water/soil). Global Surveillance: Role of the WHO GLASS (Global Antimicrobial Resistance and Use Surveillance System). Antimicrobial Stewardship (AMS): Core elements of hospital-based AMS programs; "Right drug, right dose, right time." National Action Plans: Analyzing government policies for reducing antibiotic consumption. Advanced Diagnostics & Stewardship: Phenotypic Standards: Mastery of CLSI/EUCAST guidelines for Disk Diffusion and Broth Microdilution (MIC/MBC). Rapid Molecular Diagnostics: * Nucleic Acid Amplification: PCR, LAMP, and Multiplex assays for rapid "Gene-to-Result" (e.g., GeneXpert for MDR-TB). Whole Genome Sequencing (WGS): Real-time outbreak tracing and "In silico" resistome profiling. Point-of-Care (POC) & Biosensors: Development of rapid, bedside tests to differentiate viral vs. bacterial infections (e.g., Procalcitonin, CRP, or microfluidic chips). The Economics and Regulatory Landscape: The "Market Failure" of Antibiotics: Why the R&D pipeline is dry; the low Return on Investment (ROI) compared to chronic disease drugs. Incentivizing Innovation: * Push Mechanisms: Grants, tax credits, and public-private partnerships (e.g., CARB-X). Pull Mechanisms: Market Entry Rewards (MER) and the "Subscription Model" (The Netflix Model for antibiotics). Regulatory Pathways: FDA/EMA expedited approvals (LPAD pathway) for drugs targeting unmet medical needs.

Essential Reading:

- Jawetz, Melnick, & Adelberg's Medical Microbiology by Stefan Riedel, Jeffery A. Hobden, Steve Miller, Stephen A. Morse, Timothy A. Mietzner, Barbara Detrick, Thomas G. Mitchell, Judy A. Sakanari, Peter Hotez, Rojelio Mejia. 28th Edition. A & L Lange Series. McGraw Hill 2019 (Chapter 47)
- *Antibiotic Use and Stewardship in the United States, 2024 Update: Progress and Opportunities*. Centers for Disease Control and Prevention. CDC 2024
- Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases by John E. Bennett, Raphael Dolin and Martin J. Blaser. 8th Edition Saunders 2015. (Chapter 51)

Practical Component (30 hours)

1. Antimicrobial Susceptibility Testing (AST): Perform Disk Diffusion (Kirby-Bauer) assay and interpret results using CLSI standards. Determine the Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) via Broth Microdilution.
2. Identification of Resistance Phenotypes: Screen for beta-Lactamase activity (e.g., using nitrocefin). Perform the Combined Disk Test for Extended-Spectrum beta-Lactamase (ESBL) detection.
3. Basic Antimicrobial Screening: Primary screening of an unknown compound/natural product extract against a panel of test organisms using the Agar Well Diffusion method.
4. Molecular Detection of Resistance Genes: Genomic DNA extraction from a resistant organism. Perform Polymerase Chain Reaction (PCR) to detect a common resistance gene (e.g., a *bla* gene, *mecA*, or *vanA*).
5. Data Analysis and Reporting: Interpretation of MIC/MBC data and comparison with clinical breakpoints. Statistical analysis of screening data.

Essential/Recommended readings

These provide the foundational knowledge necessary for the entire course.

1. Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases by John E. Bennett, Raphael Dolin and Martin J. Blaser. 8th Edition Saunders 2015.
2. Medical Microbiology by Patrick R. Murray, Ken S. Rosenthal, and Michael A. Pfaller. 2nd Edition Elsevier 2025
3. Goodman & Gilman's: The Pharmacological Basis of Therapeutics by Laurence L. Brunton, Björn C. Knollmann. 14th Edition. McGraw Hill. 2022.
4. Jawetz, Melnick, & Adelberg's Medical Microbiology by Stefan Riedel, Jeffery A. Hobden, Steve Miller, Stephen A. Morse, Timothy A. Mietzner, Barbara Detrick, Thomas G. Mitchell, Judy A. Sakanari, Peter Hotez, Rojelio Mejia. 28th Edition. A & L Lange Series. McGraw Hill 2019
5. Extending the Potency and Lifespan of Antibiotics: Inhibitors of Gram-Negative Bacterial Efflux Pumps. Jumde, R. P., da Costa, R. M. A., Ropponen, H.-K., & Piddock, L. J. V. ACS Infectious Diseases, *10*(5), 1438–1454. 2024
6. Mechanisms of antimicrobial resistance in biofilms by Liu, H.Y., Prentice, E.L. & Webber, M.A. npj Antimicrob Resist **2**, 27 (2024)
7. ARG Context Profiler: extracting and scoring the genomic contexts of antibiotic resistance genes using assembly graphs. Moumi, N. A., Ahmed, S., Brown, C., Pruden, A., & Zhang, L. Frontiers in Cellular and Infection Microbiology, *15*, 1582613. 2025
8. Bacteriophage therapy for multidrug-resistant infections: current technologies and therapeutic approaches. Kim, M. K., Suh, G. A., & D'Hérelle, G. Journal of Clinical Investigation, *135*(2), e187996. 2025
9. Rapid Diagnostic Tests and Antimicrobial Stewardship Programs for the Management of Bloodstream Infection: What Is Their Relative Contribution to Improving Clinical Outcomes? A Systematic Review and Network Meta-analysis. Peri, A. M., Chatfield, M. D., et al. Clinical Infectious Diseases, *79*(2), 502–515. 2024
10. Antibiotic Use and Stewardship in the United States, 2024 Update: Progress and Opportunities. Centers for Disease Control and Prevention. CDC 2024

11. Molecular mechanisms of antibiotic resistance by Blair, J., Webber, M., Baylay, A. et al. Nat Rev Microbiol **13**, 42–51 (2015)

Practical:

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-11
EXTREMOPHILE 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		
DSE-11: Extremophile Microbiology	**4**	**3**	**1**	**0**	**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 students to microorganisms that thrive in extreme environments and to highlight the ecological significance of extreme ecosystems.
- The students will learn about the diversity, physiology, and molecular adaptations of extremophiles, including thermophiles, psychrophiles, halophiles, acidophiles, alkaliphiles, barophiles, and polyextremophiles.
- They will become familiar with methods used for bioprospecting extreme habitats, including culture-dependent and culture-independent approaches, metagenomics, and meta-omics tools.
- The students will explore the mechanisms of microbial stress response and biofilm formation under extreme physicochemical conditions.
- They will understand the potential of extremophiles and extreme-environment microbes in blue biotechnology, bioremediation, biodegradation, and resource discovery.
- The students will gain exposure to modern tools such as environmental DNA (eDNA), AI-based protein structure prediction, and planetary simulation studies relevant to extremophile research.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students will be able to describe major extreme habitats and explain the diversity and ecological roles of microorganisms living under extreme conditions.
- Students will be able to explain the molecular and physiological strategies that enable microbial survival under stress conditions such as high temperature, high salinity, extreme pH, pressure, radiation, and desiccation.
- Students will be able to evaluate bioprospecting strategies and interpret metagenomic and meta-omic data relevant to the discovery of novel biomolecules from extreme environments.
- Students will be able to examine microbial stress-response pathways and analyze biofilm

behavior in extreme and engineered environments.

- Students will be able to assess the potential of extremophiles in blue biotechnology, biodegradation, and bioremediation of pollutants under high-stress environmental conditions.
- Students will be able to integrate modern approaches, including eDNA monitoring, synthetic biology, and astrobiology frameworks, to understand and apply concepts in extreme-environment microbiology.

SYLLABUS OF DSE-11

UNIT-I (14 hours)

Extreme Ecosystems and Polyextreme Microorganisms: Major extreme habitats: deep sea, hydrothermal vents, Polar Regions, hypersaline lakes, deserts, acidic and alkaline environments. Diversity, occurrence, and ecological significance of thermophiles, psychrophiles, halophiles, acidophiles, alkaliphiles, barophiles, xerophiles, and polyextremophiles. Core physiological and molecular adaptations to temperature, salinity, pH, pressure, radiation, and nutrient limitation. Microbial dark matter and uncultured lineages in extreme ecosystems; importance of single-cell approaches. Astrobiology relevance of extremophiles: survival under vacuum, radiation, desiccation and extreme temperatures; use as models for life on Mars and icy moons; planetary-protection and life-detection missions. Modern exploration and sampling approaches: remotely operated vehicles (ROVs), autonomous underwater vehicles (AUVs), deep-sea modules, and polar ice-coring systems. Impact of climate change on expansion and transformation of extreme habitats (warming oceans, salinization, desertification) and microbial responses.

Essential readings:

1. Extremophiles: From Biology to Biotechnology, edited by Ravi Durvasula & D.V. Subba Rao. CRC Press, 2018. (Chapters 1, 7, 8, 9, 11, 16).
2. **Extreme Environments: Unique Ecosystems – Amazing Microbes,** edited by Anita Pandey & Avinash Sharma. CRC Press, USA. 2021. **(Chapters 1 and 11)**
3. Astrobiology: Understanding Life in the Universe by Charles S. Cockell. 1st edition. John Wiley & Sons, Ltd., UK. 2015. (Chapter 1).

UNIT-II (15 hours)

Bioprospecting of Extreme Environments and Metagenomic Exploration: Principles of bioprospecting extreme habitats: sampling design, handling, and contamination control. Culture-dependent isolation strategies tailored to extreme conditions. Culture-independent exploration: amplicon and shotgun metagenomics; MAG recovery; functional annotation for stress-related traits. Genome-based bioprospecting: identification of genes for stability, tolerance, biosynthesis of unique metabolites, osmolytes, pigments, biosurfactants, and other novel biomolecules. Field-to-application pipeline: transition from environmental sample to candidate biomolecule of industrial or ecological relevance. Introduction to genome-resolved meta-omics (metaproteomics, metabolomics) for functional discovery in extreme microbiomes. Ethical, legal and biodiversity regulations governing extreme-environment bioprospecting (Nagoya Protocol).

Essential readings:

1. Extremophiles: From Biology to Biotechnology, edited by Ravi V. Durvasula and D. V. Subba Rao. CRC Press (Taylor & Francis), USA. 2018. (Chapters 2 and 3).
2. Bioprospecting of Novel Extremozymes From Prokaryotes – The Advent of Culture-Independent Methods by Sysoev M., Grötzinger S.W., Renn D., Eppinger J., Rueping M., and Karan R. Frontiers in Microbiology. 2021. Volume 12, Article 630013.
3. Understanding Bioinformatics by Marketa Zvelebil and Jeremy O. Baum. 2nd edition. Garland Science / Taylor & Francis, UK. 2020. (Chapters 10 and 12).

UNIT-III (8 hours)

Stress Adaptation Mechanisms and Biofilms in Extreme Settings: Cellular stress responses to heat, cold, osmotic, oxidative, pressure and solvent stress; stress regulons and protective systems. Biofilms in extreme conditions: EPS composition, structural adaptations, survival advantages, and strategies for controlling biofilms in engineered extreme systems. Microbial communities in high-stress industrial analogues: desalination plants, oilfield brines, hypersaline reactors, and high-pressure systems. Overview of cryo-electron microscopy (cryo-EM) and AI-driven protein structure prediction (AlphaFold/RosettaFold) for understanding stability determinants of extremophile proteins. Basics of synthetic biology approaches for engineering stress-resilient or chimeric extremophilic microorganisms.

Essential readings:

1. Extremophiles: From Biology to Biotechnology, edited by Ravi V. Durvasula and D. V. Subba Rao. CRC Press (Taylor & Francis), USA. 2018. Chapters 7 and 9.
2. Extremophiles: Sustainable Resources and Biotechnological Implications**, edited by Om V. Singh.** Elsevier, Netherlands. 2025. Chapter 1.
3. Protein intrinsic disorder and adaptation to extreme environments: Resilience of chaos by Vladimir N. Uversky. Journal of Molecular Biology. 2025. 14;169547.

UNIT-IV (8 hours)

Blue Biotechnology and Extreme Environment Bioremediation: Marine extremophiles and their ecological roles in deep-sea, coral reef, hydrothermal, and hypersaline marine systems. Resource potential of marine microbial communities: cold-active catalysts, osmoadapted metabolites, exopolymers, pigments, and biosurfactants. Biodegradation potential under extreme conditions: hydrocarbons, dyes, plastics, and heavy metals in hypersaline, high-temperature, and high-pressure environments. Extremophile-based bioremediation strategies: hypersaline effluents, geothermal sites, oilfield brines, and deep-sea contamination. Emerging tools: environmental DNA (eDNA) and meta-omics approaches for monitoring, profiling, and assessing extreme ecosystems.

Essential readings:

1. Marine Biotechnology: Applications in Food, Drugs and Energy edited by Se-Kwon Kim. CRC Press (Taylor & Francis), USA. 2012. (Chapters 1 and 2).
2. Extremophiles: From Biology to Biotechnology, edited by Ravi V. Durvasula and D. V. Subba Rao. CRC Press (Taylor & Francis), USA. 2018. (Chapters 2, 6, 9 and 15).
3. Extremophiles: Sustainable Resources and Biotechnological Implications**, edited by Om V. Singh.** Elsevier, Netherlands. 2025. (Chapter 5-11).

Tutorial Component (15 hours)

The tutorial will include:

1. Group discussions: Case studies and recent research articles on extremophiles, extreme ecosystems, astrobiology relevance, and microbial survival strategies under extreme physicochemical conditions.
2. Tasks based on bioprospecting workflows, metagenomic datasets, extreme-environment sampling strategies, and analysis of stress-adaptation mechanisms.
3. Flip classroom training and assessment: Presentation preparation, Q & A covering the theory taught in the main lectures.

Essential / Recommended Readings

1. Extremophiles as Astrobiological Models edited by Seckbach, J., Oren, A. and Stan-Lotter, H. Scrivener Publishing / Wiley. 2013.
2. Marine Microbiology: Ecology & Applications by Munn, C.B., Priest, F.G., Roberts, M., Seymour, J., Warwick-Dugdale, J. and Zettler, E. CRC Press (Routledge). 3rd Edition. 2023.

3. Marine Microbiome and Microbial Bioprospecting edited by Radhakrishnan, M.G. Elsevier. 2022.
4. Thermophilic Microbes in Environmental and Industrial Biotechnology edited by Satyanarayana, T., Littlechild, J. and Kawarabayasi, Y. Springer, Cham. 2nd Edition. 2019.
5. Extremophiles: From Biology to Biotechnology edited by Ravi V. Durvasula, D. V. Subba Rao. CRC Press (Taylor & Francis). 2018.
6. Microbial Biodegradation: From Omics to Function edited by Jerzy Dlugonski. Caister Academic Press. 2016.
7. Modern Tools and Techniques to Understand Microbes edited by Varma, A. and Sharma, A.K. Springer Nature, Singapore. 2017.
8. Life at Extremes: Environments, Organisms and Strategies for Survival edited by Bell, E. CABI Publishing, UK. 2012.
9. Deep-Sea Microbiology: Prokaryotes and Eukaryotes edited by Nagano, Y., Danovaro, R. and Gobet, A. Elsevier. 2021.
10. Bioprospecting for Sustainable Development edited by Singh, J., Sharma, D., Kumar, G. and Sharma, N.R. Springer. 2019.

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-12
MICROBIAL ECOLOGY

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-12: MICROBIAL ECOLOGY	4	3	1	0	B.Sc. in any branch of Life Science	NA

Learning Objectives:

- The objective of this course is to understand the basic concepts of microbial ecology and their role in the environment.
- It would also help to understand the interaction between microbes and other organism.
- It would also help the students understand the role of microbes in biogeochemical cycles and mineralization

Learning Outcomes:

Upon successful completion of the course:

- The student will be able to understand the fundamental of microbial ecology
- The student will be able to gather information about interaction of microbes with other microbes and higher organisms as well.
- The student will be able to comprehend the role of microbes in biogeochemical cycles.
- The student will be able to understand the process of Biomineralization and the process of microbial weathering.

SYLLABUS OF DSE-12

UNIT – I (10 hours)

Introduction to microbial ecology: General ecological concepts: biotic and abiotic components, ecosystem, population, community, habitat and niche. Microbial environment: Surfaces, Biofilms and Biomats. Terrestrial Environment: Components, Mineral fraction, Organic matter, microorganism, Composition of soil microbial communities, Litho echosphere-role in ecology. Aquatic Environment: Freshwater ecosystem, Marine ecosystem, lakes, rivers, Key features of aquatic environments, phototrophs and oxygen relationships, The deep sea, Hydrothermal vents.

Essential readings:

1.Microbial Ecology by Larry L. Barton and , Diana E. Northup. A JOHN WILEY & SONS, INC., PUBLICATION, 2011 (Chapter 4)

2. Brock Biology of Microorganisms by M. Madigan, K. Bender, D. Buckley, W. Sattley, D. Stahl. 15th Edition. Pearson Education. 2018 (Chapter 20)

3. Microbial Ecology: Fundamentals and Applications by R.M. Atlas, R. Bartha. 4th edition. Pearson Education, 1998. (Chapter 9)

UNIT-II (15 hours)

Population Interactions: Microbe-Microbe interactions (Neutralism, commensalism, Competition, Parasitism, Predation, Antagonism, Syntrophism) **,** Interaction between microbes and Plants (Interaction in the Rhizosphere, Mycorrhizae, Nitrogen fixing bacteria and higher plants, Bacteria supporting plant growth, Interaction with aerial plant structure, Microbial disease of plants) Microbes in sustainable agriculture (Biofertilizers, microbial inoculants, PGPR) **,** Interaction between microbes and animals (Primary and Secondary Symbionts, Microbe–Animal Interactions: Parasitism, Microbe–Animal Interactions: Mutualism, Microbial–Vertebrate Interactions, Grazing and Predation by Animals, Human microbiome), Insects and other invertebrates as microbial habitat.

Essential readings:

1. Microbial Ecology : Fundamentals and Applications by R.M. Atlas, R. Bartha. 4th edition. Pearson Education. 1998. (Chapter 3, 4 and 5)
2.Microbial Ecology by Larry L. Barton and , Diana E. Northup. A JOHN WILEY & SONS, INC., PUBLICATION, 2011 (Chapter 6, 7, 8)
3.Brock Biology of Microorganisms by M. Madigan, K. Bender, D. Buckley, W. Sattley, D. Stahl. 15th Edition. Pearson Education. 2018 (Chapter 23)
4. Microbial Inoculants in Sustainable Agricultural Productivity by D.P. Singh, H. B. Singh and R. Prabha, Springer 2016. (Chapter 2, 3, 9 12, 15)

UNIT-III (10 hours)

Microbial Roles in Biogeochemical Cycle: Oxygen and Carbon cycling: key process in oxygen and carbon cycle. Nitrogen cycling: key steps in nitrogen cycle- nitrogen fixation, nitrification, assimilation, ammonification. Sulfur cycling: Sulfur uptake by plants and microbes. Phosphorus cycling, iron cycling, cycling of manganese and selenium, Mercury transformation.

Essential readings:

1. Microbial Ecology: Fundamentals and Applications by R.M. Atlas, R. Bartha. 4th edition. Pearson Education. 1998. (Chapter 10 and 11)
2.Microbial Ecology by Larry L. Barton and , Diana E. Northup. A JOHN WILEY & SONS, INC., PUBLICATION, 2011 (Chapter 10)
3. Brock Biology of Microorganisms by M. Madigan, K. Bender, D. Buckley, W. Sattley, D. Stahl. 15th Edition. Pearson Education. 2018 (Chapter 21)

UNIT-IV (10 hours)

Biomineralization and Microbial weathering: Passive versus Active Biomineralization, Cell Characteristics and Metal Binding, Dissolution Versus Precipitation, Formation of Ores and Minerals, Microbial Participation in Silicification, Biomineralization of Ferromanganese Deposits, Microbial Carbonate Microbialites, Stromatolites

Essential readings:

1. Microbial Ecology by Larry L. Barton and , Diana E. Northup. A JOHN WILEY & SONS, INC., PUBLICATION, 2011 (Chapter 11)
2. Process in Microbial Ecology by David L. Kirchman. 2nd Edition, Oxford University Press, 2018 (Chapter 13)

Tutorial Components (15 hours)

1. Identification of unknown microorganisms from different environments by 16S rRNA sequencing and bioinformatics studies.
2. Enrichment culture techniques
3. Microbial interaction studies

Suggested Readings:

Theory:

1. Microbial Ecology: Fundamentals and Applications by R.M. Atlas, R. Bartha. 4th edition. Pearson Education, 1998.
2. Microbial Ecology by Larry L. Barton and, Diana E. Northup. A JOHN WILEY & SONS, INC., PUBLICATION, 2011
3. Brock Biology of Microorganisms by M. Madigan, K. Bender, D. Buckley, W. Sattley, D. Stahl. 15th Edition. Pearson Education. 2018.
4. Process in Microbial Ecology by David L. Kirchman. 2nd Edition, Oxford University Press 2018
5. Environmental Microbiology by Ian L. Pepper, Charles P. Gerba, Terry J. Gentry. 3rd Edition. Academic Press.2015

Tutorials:

1. Laboratory Exercises in Microbiology by Nathan Rigel and Javier Izquierdo. 12th edition. Mc Graw Hill Education. 2022.
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 ELECTIVE COURSE : DSE-13
FACETS OF PROTOZOAN 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-13: FACETS OF PROTOZOAN BIOLOGY	**4**	**3**	**1**	**0**	**BSc in any branch of Life Sciences**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The objective of this course is to introduce the students to general and specific aspects of protozoan micro-organisms.
- The students will gain knowledge and understanding about protozoan diseases in humans.
- The students will become familiar with the remarkable tactics used by *Trypanosoma* species to evade the host defense system
- They will gain knowledge about the unique modes of transcription and gene regulation in *Leishmania* species.
- They will be educated about the unusual method *Plasmodium* species employ to evade the host immune system.
- The students will become acquainted with *Tetrahymena thermophila* as a model organism which has been used to study various molecular phenomena.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will become familiar with diseases caused by protozoan micro-organisms.
- Student will be able to describe the switching of VSG gene expression in *Trypanosoma brucei* as a mechanism to evade the host defense systems.
- Student will become familiar with state-of-the-art methods used to analyze the 3D organization of genomes in the nucleus of an organism.
- Student will be able to outline the mode of transcription in *Leishmania* species.
- Student will be able to describe the use of *var* genes by *Plasmodium* species to evade the host immune system
- Student will be able to discuss important findings from studies with *Tetrahymena thermophila*.

SYLLABUS OF DSE-13

UNIT – I (9 hours)

Protozoans and human disease: Etiology, epidemiology, diagnosis, clinical manifestations and therapeutic interventions of the following protozoan diseases: giardiasis, amoebiasis, different forms of leishmaniasis, African trypanosomiasis, American trypanosomiasis, trichomoniasis, malaria, toxoplasmosis, cryptosporidiosis.

Life cycles of the parasites causing these diseases.

Essential reading:

1. Parasitic Diseases by D. Despommier, D. Griffin, R. Gwadz, P.J. Hotez, C.A. Knirsch. 7th edition. Springer-Verlag, USA. 2019. Chapters 1, 2,3,4

UNIT – II (13 hours)

Strategies used by *Trypanosoma brucei* and *Plasmodium falciparum* to evade the host defence system: Organization of the *T. brucei* genome. Role of variable surface glycoproteins (VSGs) in the host-parasite relationship. Organization of variable surface glycoprotein (VSG) genes in the *T. brucei* genome. Antigenic variation by VSG switching. Mechanisms of VSG switching: transcriptional silencing mechanism and recombination-based switching mechanism. Analysis of the 3D organization of the chromosomes of the *T. brucei* genome in the nucleus: use of chromosome conformation capture (3C) and its high-throughput version (Hi-C). Use of Assay for Transposase-Accessible Chromatin with high-throughput sequencing (ATAC-seq) to determine the 3D organization of transcriptionally active versus silent regions of the *T. brucei* genome. Role of the 3D organization of the *T. brucei* genome/ chromosomes in the nuclear space in VSG switching. Role of *Plasmodium falciparum* erythrocyte membrane protein 1 (EMP1) in virulence. Organization of *var* genes (encoding EMP1) in the genome. Structure of *var* genes and three major *var* groups. Switches in *var* gene expression: transcriptional and epigenetic mechanisms of *var* gene switch, role of long ncRNAs in regulating *var* activation, role of 3D organization of *var* genes in nuclear space.

Essential reading:

1. Trypanosomes and Trypanosomiasis edited by S. Magez and M. Radwanska. Springer. 2014. Chapter 1
2. Malaria. Biology in the Era of Eradication edited by D.F. Wirth and P.L. Alonso. Cold Spring Harbor Perspectives in Medicine. 2017. Chapter 16.

UNIT – III (13 hours)

Gene regulation, genome plasticity and RNA editing in kinetoplastids: Organization of the *Leishmania* genome. Unique polycistronic mode of transcription coupled to post-transcriptional processes including trans-splicing. Regulation of gene expression using histone variants and base J. Epigenetics mechanisms modulating transcription: roles of specific histone acetylation and methylation marks. Alternate mode of transcription from internal promoters. Plasticity of *Leishmania* genome and its implications in emerging drug resistance. Structure of the kinetoplastid cell. Organization of kinetoplast DNA: maxi and mini circles. Replication of kinetoplast DNA. Role of maxi and mini circles. RNA editing as a mode for producing mitochondrial proteins. Mechanisms of RNA editing: guide RNAs, editosomes.

Essential reading:

1. Molecular Biology of Kinetoplastid Parasites edited by H.K. Majumder. 1st edition. Caister Academic Press. 2018. Chapter 1
2. *Leishmania*: after the genome edited by P.J. Myler and N. Fassel. 1st edition. Caister Academic Press. 2008. Chapter 2

UNIT – IV (10 hours)

***Tetrahymena thermophila* as a model organism:** A model organism for studying the existence of two genetic systems in the same cell. Nuclear dimorphism: somatic and germline nuclei, roles of the two nuclei in the development cycle. Discovery of dynein, role of dynein as a molecular motor. Discovery of ribozymes. Discovery of telomerase, role of telomerase in chromosome end-replication and in ageing. Discovery of histone modifying enzymes. Study of secretory granule biogenesis. Unusual genetic code. Reversible gene amplification.

Essential reading:

1. Methods in Cell Biology: *Tetrahymena thermophila* edited by Kathleen Collins. Vol. 109. Academic Press. 2012. Chapters 2, 3, 4, 5, 6.

Tutorial Component (15 hours)

The tutorial will include: Discussion about Nobel Prize-winning work carried out in protozoan organisms. Challenges faced in developing vaccines against diseases like malaria and leishmaniasis. Mechanisms some of these parasites have developed to combat drug treatments. Cchallenges faced in trying to eradicate these diseases. Protozoan diseases in animals and their implication in human health. Tutorial for the use of genome sequence databases of *Plasmodium* and *Trypanosoma brucei* in the context of studying virulence and pathogenesis.

Recommended readings:

1. Advances in Parasitology. Book series. Vols. 119, 121, 128, 129, 130. 1st edition. Elsevier Press. 2025.

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

GENERIC ELECTIVE COURSE: GE-03
EMERGING TRENDS IN 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-03: EMERGING TRENDS IN MICROBIAL BIOTECHNOLOGY	**4**	**3**	**1**	**0**	**-**	**NA**

Learning Objectives

- The objective of this course is to introduce students to the current research and developments in microbiology.
- The students will learn about novel microbial technologies in health care, industrial, and environmental applications.
- They will become familiar with the uses of microbes in biotechnology, diagnostics, and bioenergy.
- They will explore the interaction among microbes in agriculture, industry, and biopharmaceuticals.
- The students will learn to scrutinize microbial innovations and their role in addressing global challenges.
- They will be introduced to cutting-edge research in extremophiles, bioinformatics, and synthetic biology.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students will be able to summarize recent progress in microbial applications in various sectors.
- Students will be able to analyze the role of microbes in biofuels, pharmaceuticals, and environmental sustainability.
- Students will be able to evaluate the significance of microbes in sustainable agriculture and integrated pest management.
- Students will be able to assess the impact of artificial intelligence and big data in microbiological research.
- Students will be able to explore extremophiles, microbial biosensors and diagnostics in healthcare and environmental monitoring.

SYLLABUS OF GE-03

UNIT-I (08 hours)

Emerging Microbial Strategies for Environmental and Climate Resilience: Microbes in sustainable ecology, bioremediation, and carbon sequestration. Microbial processes for greenhouse gas mitigation. The use of composts and microbial systems in waste management and ecosystem recovery. Case studies of microbes in environmental restoration and climate adaptation.

Essential reading:

1. Environmental Microbiology by E.L. Madsen. 2nd edition. Wiley, USA. 2016. (Chapters 1, 3, 8)
2. Brock Biology of Microorganisms by Madigan et al. 16th edition. Pearson, USA. 2021. (Chapters 19, 20, 21, 22)

UNIT-II (16 hours)

Emerging Technologies in Unlocking Microbial Dark Matter: Advances in high-throughput culturing techniques for novel microbes, overcoming traditional cultivation limitations through metagenomic and metatranscriptomic approaches. Applications of metagenomics, proteomics, metabolomics, and single-cell techniques in understanding microbial communities and discovering novel microbial lineages. Emerging Innovations in Extremophiles: Adaptations and Industrial Applications: Exploring the latest discoveries in extremophiles - thermophiles, psychrophiles, halophiles, acidophiles, and alkaliphiles. Advances in understanding their unique metabolic and enzymatic adaptations. Exploration of extremophiles in space research and astrobiology. Emerging applications of extremozymes in next-generation biotechnology, pharmaceuticals, and industrial processes. Optozymes: light-activated enzymes for controlled catalysis, biosensors, and synthetic biology.

Essential Reading:

1. Brock Biology of Microorganisms by Madigan et al. 16th edition. Pearson, USA. 2021. (Chapters 10, 13, 14, 17)
2. Prescott's Microbiology by Willey, Sherwood & Woolverton. 11th edition. McGraw-Hill, USA. 2020. (Chapters 16, 17, 18)
3. Environmental Microbiology by E.L. Madsen. 2nd edition. Wiley, USA. 2016. (Chapters 4.7)
4. Extremophiles: From Biology to Biotechnology, edited by Ravi Durvasula & D.V. Subba Rao. CRC Press, 2018. (Chapters 1, 7, 8, 9, 11, 16)

UNIT-III (16 hours)

Microbial Bio Energy and Sustainable Energy Technologies: Production of microbial biofuels – bioethanol, biodiesel, biohydrogen, and biogas. Microbial fuel cells (MFCs) for bioelectrochemical energy. Electrochemically aided microbial processes for biohydrogen production and valorization of black liquors. Microbial process in circular economy and waste to energy conversion. Case studies of microbial bioenergy applications. Innovations in Microbial Technology in Sustainable Agriculture: Biofertilizers, microbial pesticides, biocontrol agents. Innovations in plant-microbe interactions that enhance crop productivity and resilience to climate change. Integrated pest management (IPM) strategies using microbial consortia for effective pest control. Microbial inoculants to promote soil health and nutrient cycling.

Essential Reading:

1. Microbial Biotechnology for Bioenergy, Elsevier, 2024. (Chapters 2, 7)
2. Environmental Microbiology by E.L. Madsen. 2nd edition. Wiley, USA. 2016. (Chapter 8)

UNIT-IV (05 hours)

AI-Driven Microbial Technologies, Commercialization, and Entrepreneurship: AI-driven microbial genome analysis, predictive modeling of microbial ecosystems, and machine learning applications in drug discovery and diagnostics. Automation in synthetic biology and personalized medicine. Microbial biotechnology in industry, entrepreneurship, and commercialization. High-value microbial products, patenting, intellectual property rights (IPR), and ethical considerations. Industrial applications, and startup opportunities in microbial innovation.

Essential Reading:

1. Biotechnology Entrepreneurship (Ed. Craig Shimasaki), Elsevier, 2014. (Chapters 14, 15)
2. Mondal, R.S., Akter, L., Bhuiyan, M.N.A. (2025). *Integrating AI and ML Techniques in Modern Microbiology*. Applied IT & Engineering Review, 3(1), 1–10.

Tutorials (15 hours)

1. Tutorial sessions will include interactive discussions, case studies, and group activities.
2. The course will explore case studies of how microbes are used in the real world today in agriculture, bioenergy, and medicine.
3. Group discussions and student presentations focusing on new trends and developments in microbiology will be held.
4. In Problem-solving sessions, students will use what they learn to devise strategies to tackle global challenges — such as climate change, antibiotic resistance and sustainable resource management.

Essential/Recommended Readings

Theory:

1. Brock Biology of Microorganisms by M.T. Madigan, K.S. Bender, D.H. Buckley, and W.M. Sattley. 16th edition. Pearson, USA. 2021.
2. Prescott's Microbiology by J. Willey, L. Sherwood, and C. Woolverton. 11th edition. McGraw Hill, USA. 2020.
3. Microbial Biotechnology: Fundamentals of Applied Microbiology by A. Timmis. 2nd edition. Wiley-Blackwell, USA. 2019.
4. Industrial Microbiology by L.E. Casida. 2nd edition. Wiley, USA. 2018.
5. Environmental Microbiology by R. Mitchell, J.D. Gu. 3rd edition. Wiley-Blackwell, USA. 2016.
6. Advances in Microbial Biotechnology by R.K. Singh, S.K. Mandal, and D. Singh. 1st edition. Springer, USA. 2015.

Tutorials/Presentations & Assignments:

1. Microbiology: A Laboratory Manual by J.G. Cappuccino, N. Sherman. 11th edition. Pearson, USA. 2021.
2. Practical Handbook of Microbiology by E. Goldman, L.H. Green. 4th edition. CRC Press, USA. 2020.

3. Laboratory Manual in Microbiology by P. Gunasekaran. New Age International Publishers, India. 2019.
4. Manual of Environmental Microbiology by C.J. Hurst, R.L. Crawford, J.L. Garland, D.A. Lipson. 4th edition. ASM Press, USA. 2016.

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

GENERIC ELECTIVE: GE-04
DOWNSTREAM PROCESSING OF MICROBIAL PRODUCTS

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-04: DOWNSTREAM PROCESSING OF MICROBIAL PRODUCTS	**4**	**3**	**1**	**0**	**-**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The objective of this course is to give students an overview of different strategies used in microbial product recovery.
- The students will become familiar with different cell lysis methods and their applications in extracting intracellular and extracellular products.
- They will learn about batch filtration techniques and continuous centrifugation used at an industrial scale.
- They will develop hands-on expertise in enzyme immobilization and nanocatalyst techniques.
- They will be educated about different analytical methods used during product recovery and testing for the finished products
- They will be introduced to quality control requirements for finished products.
- The students will gain an understanding of reducing the recovery cost.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to discuss important concepts of downstream processing and their industrial application.
- Student will be able to describe the designing of different recovery processes for industrial and commodity products
- Student will be able to list different methods used in enzyme immobilization and nano biocatalysis
- Student will be familiar with various chromatography techniques used in product recovery
- Student will be able to compare various cell lysis methods

SYLLABUS OF GE-04

UNIT-I (13 hours)

Concepts of downstream processing and production of Enzymes and Biopharmaceuticals:

Introduction to the recovery operations of microbial products, Downstream Processing Equipment, challenges in bioseparation processes, Clean room classification, sterility, maintenance, decontamination, and sanitization, Differences between manufacturing processes for Enzymes and Biopharmaceuticals. Separation of cells from culture broth, clarification strategies of fermentation broth, Fermentation media conditioning, Applications of coagulation and flocculation in industries

Essential Reading:

1. Downstream Industrial Biotechnology: Recovery and Purification by Michael C. Flickinger. J. Wiley. 2013. (Chapter 1,2, 3, 4, 5, 19 & 20)
2. Principles of Fermentation Technology by P.F. Stanbury, A.Whitaker and S.J. Hall. 3rd Edition. Elsevier Science Ltd, Netherlands. 2016. (Chapter 10)
3. Modern Industrial Microbiology and Biotechnology by N. Okafor and B.C. Okeke. 2nd Edition. CRC Press, UK. 2018. (Chapter 12)

UNIT-II (16 hours)

Recovery methods for fermentation products, Enzyme immobilization and Nanobiocatalysts: Physiochemical and biological methods for cell disruption, batch filtration, ultrafiltration, membrane fouling in ultrafiltration, centrifugation, precipitation, spray drying, lyophilization, Crystallization**,** Concepts and operational principles of different chromatographic techniques (ion exchange, gel permeation, affinity and reverse phase chromatography), Design of chromatographic separations for industrial products,Methods of enzyme immobilization, Advantages and disadvantages of immobilization techniques. Large-scale applications of immobilized enzymes: glucose isomerase and penicillin acylase, Nanobiocatalysts and their reusability

Essential Reading:

1. Downstream Industrial Biotechnology: Recovery and Purification by Michael C. Flickinger. J. Wiley. 2013. (Chapter 6, 8, 12,34)
2. Principles of Fermentation Technology by P.F. Stanbury, A.Whitaker and S.J. Hall. 3rd Edition. Elsevier Science Ltd, Netherlands. 2016. (Chapter 10)
3. Modern Industrial Microbiology and Biotechnology by N. Okafor and B.C. Okeke. 2nd Edition. CRC Press, UK. 2018. (Chapter 10)

UNIT-III (6 hours)

Development of biomanufacturing processes: Differences between *E. coli*, yeast and mammalian cultures as expression hosts, Manufacturing Facilities, and cGMP biomanufacturing, Advantages and disadvantages of inclusion body processing, Recovery of Industrial and Commodity Products

Essential Reading:

1. Downstream Industrial Biotechnology: Recovery and Purification by Michael C. Flickinger. J. Wiley. 2013. (Chapter 42, 47 &48)
2. Principles of Fermentation Technology by P.F. Stanbury, A.Whitaker and S.J. Hall. 3rd Edition. Elsevier Science Ltd, Netherlands. 2016.
3. Methods in Enzymology “Refolding Solubilized Inclusion Body Proteins” by Richard R. Burgess Volume 463, 2009, Pages 259-282 (Chapter 17)

UNIT-IV (10 hours)

Quality control and Process economics: Analytical support of downstream Processing: High-performance liquid chromatography, gas chromatography, Gas chromatography-mass

spectrometry (*GC-MS*), Liquid chromatography-mass spectrometry (LC-MS), Quality assurance and control; Capital cost for downstream equipment, Process economics of production and recovery process. Effluent treatment and environment management

Essential Reading:

1. Advanced technologies in biopharmaceutical processing by Roshni L. Dutton and Jeno M. Scharer. Blackwell Publishers. 2007. (Chapter 4&5)
2. Principles of Fermentation Technology by P.F. Stanbury, A.Whitaker and S.J. Hall. 3rd Edition. Elsevier Science Ltd, Netherlands. 2016. (Chapter 11&12)
3. Modern Industrial Microbiology and Biotechnology by N. Okafor and B.C. Okeke. 2nd Edition. CRC Press, UK. 2018. (Chapter 30)

Tutorial Component (15 hours)

1. Discussion about development of industrial scale downstream processing equipment and operational challenges.
2. How to address the challenges of membrane fouling.
3. Learning of different quality control differences between industrial enzyme production and therapeutic drugs.
4. Demonstration of how combinatorial biomass processing approaches result in cost effective product recovery.
5. Assembling of lab Scale fermenters.
6. Live demonstration of HPLC and FPLC operations

Essential reading

1. Principles of Fermentation Technology by P.F. Stanbury, A.Whitaker and S.J. Hall. 3rd Edition. Elsevier Science Ltd, Netherlands. 2016. (Chapter 7, 8 & 10)
2. Modern Industrial Microbiology and Biotechnology by N. Okafor and B.C. Okeke. 2nd Edition. CRC Press, UK. 2018. (Chapter 30)
3. https://www.jove.com/v/10156/operation-of-high-performance-liquid chromatography-hplc
4. https://www.jove.com/v/10187/gas-chromatography-gc-with-flame-ionization-detection
5. https://pmc.ncbi.nlm.nih.gov/articles/PMC12094072/

Suggested Reading:

1. Downstream Industrial Biotechnology: Recovery and Purification by Michael C. Flickinger. J. Wiley. 2013.
2. Pharmaceutical Biotechnology: Concepts and Applications by Gary Walsh. J. Wiley. 2007.
3. Advanced technologies in biopharmaceutical processing by Roshni L. Dutton and Jeno M. Scharer. Blackwell Publishers. 2007.
4. Industrial Microbiology by L.E. Casida. 2nd Edition. New Age International publisher. 2019.
5. Modern Industrial Microbiology and Biotechnology by N. Okafor and B.C. Okeke. 2nd Edition. CRC Press, UK. 2018.
6. Crueger's Biotechnology: A Textbook of Industrial Microbiology by W. Crueger and K.R. Aneja. 3rd Edition. Medtech Publisher, India. 2017.
7. Biotechnology Industrial Microbiology. A textbook by W. Clarke. CBS Publishers, India. 2016.
8. Industrial Microbiology by K.L. Benson. CBS Publishers & Distributors. 2016.
9. Principles of Fermentation Technology by P.F. Stanbury, A.Whitaker and S.J. Hall. 3rd Edition. Elsevier Science Ltd, Netherlands. 2016.

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

SKILL BASED COURSE: SBC-03
MYCOLOGY & BIOCHEMICAL 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		
SBC-03: MYCOLOGY & BIOCHEMICAL 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 main objective of this course is to introduce the students to various techniques used in microbiological research.
- The course will equip the student with the skills necessary for performing several experiments involved in microbiology.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students will be able to prepare buffers and adjust the pH of a solution.
- Students will be able to analyze various data generated by spectrophotometer
- Students will be able to determine the molecular weight of proteins.
- Students will be able to pack and perform the affinity column chromatography.
- Students will be able to distinguish between budding and fission yeast
- Students will be able to perform the transformation of yeast cells

SYLLABUS OF SBC- 03

UNIT – I (30 hours)

Biochemical methods: Preparation of Tris buffer (pH 6.8 and 8.8). Preparation of 0.5 M, 100ml EDTA solution. Preparation of different Molar of HEPES/phosphate buffer solution. Instrumentation and analysis of generated data from the spectrophotometer for protein/DNA analysis. Analysis of fluorescence emission of a sample using GFP-tagged protein. To separate the components based on their densities using a density-gradient medium (e.g. sucrose). Demonstration of the ultracentrifuge for high-speed separation using bacterial cell (membrane/cytosolic fraction). **Chromatographic techniques**: Separation of the components of a mixture using paper or TLC. Analysis of data for molecular weight determination by using

gel filtration chromatography. Column packing and recombinant protein purification by using column chromatography. Analysis of different fractions of column chromatography purified protein by using SDS-PAGE.

UNIT – II (30 hours)

Identification of yeasts: Microscopic examination of budding and fission yeast. Identification and differentiation of Candida species by Chromogenic Agar. **Genetic transfer into yeast**: Preparation of media for yeast auxotroph strain. Generation of yeast-competent cells by Lithium acetate method. Transformation of yeast cells.

Essential reading:

1. Yeast Genetics: Methods and protocols by Jeffrey S. Smith and Daniel J. Burke. Springer, 2014. (Chapter 1)

Essential/recommended readings

1. Yeast Genetics: Methods and protocols by Jeffrey S. Smith and Daniel J. Burke. Springer, 2014.
2. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology by Andreas Hofmann and Samuel Clokie. 8th Edition. Cambridge University press. 2018.

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

SKILL BASED COURSE: SBC-04
ANTIMICROBIALS AND MICROSCOPY 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		
SBC-04: ANTIMICROBIALS & MICROSCOPY 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 students will learn about the physical and chemical agents that control microbial growth.
- They will become familiar with advanced antimicrobial agents.
- They will be educated about advanced microscopy in microbiology research.
- They will be introduced to the cutting-edge science of stem cell technology, and its production and various applications.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to describe the different techniques to control microbial growth.
- Student will be able to recall techniques used to detect the presence of endotoxin and microbes in sterile formulations.
- Student will be able to evaluate the advanced antimicrobial techniques.
- Student will be able to analyze and describe the importance of advanced microscopy in microbiology research.
- Student will be able to analyze and compile the differences between the two modes of bacterial lifestyles

SYLLABUS OF SBC-04

UNIT – I (30 hours)

Physical and chemical agents for controlling microbial growth and detection techniques: Temperature, osmotic pressure and radiation as physical agents; 3% Hydrogen peroxide, 70% isopropyl alcohol and 5% chlorine bleach as chemical agents. Microbial Limit test, and endotoxin analysis. **Advanced Antimicrobial Agents:** Synthesis of nanoparticles by chemical and biological methods. Basic characterization of nanoparticles. Antibacterial of nanoparticles.

Phytochemical extraction from different plants in different solvents and assessing their antibacterial and anti-viral efficacies. Assessment of combination therapies (Determination of synergy or antagonism by checkerboard assay).

Essential reading:

1. Microbiology: A laboratory manual by JG Cappucino, CT Welsh. 11th Edition. Pearson. 2017. (Chapter 41 - 46)

UNIT – II (30 hours)

Advanced Microscopy: Inverted fluorescence microscopy, confocal microscopy and SEM analysis of microbial samples. **Differentiating planktonic and sessile mode of lifestyle:** Growing biofilms of Gram-positive and Gram-negative bacteria on different substrates and in presence of different media. Assessing different antimicrobial agents against biofilms.

Essential reading:

1. Microbiology: A laboratory manual by JG Cappucino, CT Welsh. 11th Edition. Pearson. 2017. (Chapter 5-7)
2. O'Toole GA. Microtiter dish biofilm formation assay. J Vis Exp. 2011 Jan 30;(47):2437. doi: 10.3791/2437. PMID: 21307833; PMCID: PMC3182663.

Essential/recommended readings

1. Microbiology: A laboratory manual by JG Cappucino, CT Welsh. 11th Edition. Pearson. 2017.
2. 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. Washington, American Society for Microbiology Press, 2016
3. Infectious Disease Epidemiology: Theory and Practice by Nelson KE, Williams CM. 4th Edition. Jones and Bartlett, 2019.

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

RESEARCH METHODOLOGY COURSE: RM-01
ADVANCED RESEARCH METHODOLOGY

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		
RM-01: ADVANCED RESEARCH METHODOLOGY	**2**	**2**	**0**	**0**	**B.Sc. in any branch of Life Science**	**None**

Learning Objectives

The Learning Objectives of this course are as follows:

- Student will be introduced to concepts of philosophy of research
- Student will gain an understanding of the research methods and tools
- Students will learn about using logical reasoning principles to describe science

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to recall different research approaches
- Student will be able to recall different types of research methods
- Student will be able to describe experimental designs and data analysis approaches
- Student will be able to describe principles of logical reasoning in science, and ethical principles

SYLLABUS OF RM-01

UNIT- I (14 hours)

Research & Philosophy of Research: Acquiring knowledge, what is research, qualities of a researcher, history of research, induction and deduction in research, hypothesis, theory, law, facts, the scientific methods, the research process, academic research. Philosophy of research, empiricism, rationalism, skepticism, falsifiability, pseudoscience, reductionism

Research methods: Intuition, serendipity, unexpected results, ideas from other disciplines, variables in research, formal approaches to research. Major research methods, natural observation, historical research, ethnographic research, cross-sectional study, longitudinal study, cohort study, case study, correlational research, model building, action research

Essential reading:

1. Research Methodology & Scientific Writing. 2nd edition by C George Thomas (2021). Springer Publication (Chapter 1, 2, 3, 4).

UNIT- II (16 hours)

Experimental research, Collection & analysis of Data: Cause-and-effect relationships, hypothesis testing in experiments, validity of experiments, principles of experimentation, controls in experiments, experimental design, field experiments, randomized controlled trials,

paired design, requirements of a good experiment. Sampling, collection of data, observation, surveys, possible errors in research, analysis of data, descriptive statistics, inferential statistics, common statistical tests

Reasoning and Ethics in research: Arguments and premises, assumptions, statements, facts and opinions, validity and soundness of arguments, Evidences, inductive and deductive reasoning, fallacious reasoning, common fallacies. Ethical issues in research, the Nuremberg Code, concepts in ethics, fraud and misconduct in science, unscientific practices in science, and scientific values.

Essential reading:

1. Research Methodology & Scientific Writing. 2nd edition by C George Thomas (2021). Springer Publication (Chapter 5, 6, 14, 23).

Recommended readings

1. Research Methodology: The Aims, Practices & Ethics of Science. 1st edition by Peter Pruzen (2016). Springer Publication
2. Research Methodology: Methods and Techniques. 2nd edition by C. R. Kothari (2004). New Age International Publishers, India
3. Testing treatments: Better research for better healthcare. 2nd edition by Evans, I., Thornton, H., & Chalmers I (2011). London: Pinter & Martin.
4. Research Methodology A Step-by-Step Guide for Beginners. 5th edition by Ranjit Kumar (2019). SAGE Publication.
5. Research Methodology: The Aims, Practices & Ethics of Science. 1st edition by Peter Pruzen (2016). Springer Publication.
6. The Craft of Research. 4th edition by Wayne C Booth, Gregory G. Colomb, Joseph M. Williams, Joseph Bizup, William T. Fitzgerald (2016). The University of Chicago Press.

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

RESEARCH METHODOLOGY COURSE: RM-02
TOOLS FOR RESEARCH

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		
RM-02: TOOLS FOR RESEARCH	2	2	0	0	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 the students to the need for research, scientific data extraction, scientific writing, reference management tools, and the use of statistics in biology for data interpretation.
- The students will learn to extract research data from the available resources.
- They will become familiar with research writing tools.
- They will be educated about the use of modern reference organizer tools.
- They will develop a proper understanding of data collection and interpretation of data by using statistical methods.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students will be able to discuss the content of research proposals, PhD thesis/dissertation.
- Students will be able to collect/extract research content from databases.
- Students will be able to understand the importance of Scopus, PubMed, and ORCID, and analyze different research writing tools.
- Students will be able to compile the references for the different text file/data.
- Students will be able to predict the significance of the biological phenomenon on the basis of available data sets by using statistical methods.

SYLLABUS OF RM- 02

UNIT – I (14 hours)

Foundation of Research: Introduction, review of literature/background of the study, aims/objective, Problem Identification and formulation, /concept of theory, significance of the study, , Research design, materials and methods, result and discussion, graphical and tabular presentation, summary, Scope of future work. **Research data sources, extraction and writing**

tools: Artificial intelligence (AI) tools as a search engine for academic research. Abstract and citation database: Scopus, Web of Science. Health science database: PubMed. Free academic search engine: Google Scholar, Open Researcher and Contributor ID (ORCID). **Research writing tools:** Open educational resources**.** Artificial intelligence (AI) tools. Research integrity and plagiarism, the workings of plagiarism software (Turnitin).

Essential reading:

1. Research Methodology: Methods and Techniques by C. R. Kothari, New Age International Publishers, India. 2004. (Chapter 1, 2, 4, 6).
2. Using artificial intelligence in academic writing and research: An essential productivity tool by Mohamed Khalifa & Mona Albadawy, Computer Methods & Programs in Biomedicine Update 5(2024) 100145. (Review).
3. Using AI in Academic Writing and Research: A Complete Guide to Effective and Ethical Academic AI by Eldar Haber, Palgrave Macmillan Cham, Springer Nature Switzerland AG. 2025 (Chapter 3).
4. How to conduct a basic search? - Scopus tutorials (https://service.elsevier.com); https://scholar.google.com; https://info.orcid.org/video-tutorials/.
5. Scopus database: a review by F Burnham., University of South Alabama Biomedical Library, 316 BLB, Mobile, AL 36688, USA. 2006.
6. Research integrity in the era of artificial intelligence Challenges and responses by Xuhong Chen, Medicine 2024;103:27(e38811).

UNIT – II (16 hours)

Reference tool organizer: Why is there a need for reference organizers? Mendeley, EndNote, Zotero, etc. Image processing tools: High resolution, Image processing software (ImageJ, Adobe Photoshop etc.), Image representation. **Biostatistics:** Introduction to biostatistics, Frequency distribution, Variable and attribute. Measurement of Central Tendency: Mean, Median and Mode, Analysis of Variance, Standard deviation, Standard error of the mean, Chi-square test, Student's t-test, Fisher's t-test. Non parametric statistical test (WSR-Test, Mann-Whitney Test). Binomial Distribution. Testing of goodness: Null hypothesis, Alternative Hypothesis. Learning of biostatistics online tools/software for data analysis in life sciences (GraphPad).

Essential reading:

1. What Makes A Good Reference Manager? A quantitative Analysis of Bibliography Management Applications by Cai. T., Chen, C., Huang, T. and Ritter, F.E. College of Information Sciences and Technology, Pennsylvania State University, USA. 2021.
2. Reference Management by Martin Fenner, Kaja Scheliga and Sönke Bartling. Public Library of Science, San Francisco, CA, USA. S. Bartling and S. Friesike (eds.), Opening Science. 2014.
3. A Text book of Biostatistics by A.K.Sharma. 1st Edition. Discovery Publishing Pvt.Ltd. 2008. (Chapter 5,6,7,15). Introduction to Biostatistics by Pranab Kumar Banerjee. S. Chand Publishers. 2007. (Chapter 2 to 12).
4. Statistics for the Life Sciences by Myra L. Samuels, Jeffrey A. Witmer & Andrew Schaffner. 5th Edition. Pearson. 2021. (Chapter 2, 3, 4 , 5).
5. Publication Ethics in the Era of Artificial Intelligence by Zafer Kocak, Journal of Korean Medical Sciences. 2024 Aug 26;39(33):e249.

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

RESEARCH METHODOLOGY COURSE: RM-03
TECHNIQUES OF RESEARCH WRITING

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		
RM-03: TECHNIQUES OF RESEARCH WRITING	2	2	0	0	B.Sc. in any branch of Life Science	None

Learning Objectives

The Learning Objectives of this course are as follows:

- Student will be introduced to scientific writing
- Student will gain understanding of scientific presentations
- Students will learn about writing research articles and thesis

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to describe the process of research writing
- Student will be able to outline the steps in research paper writing
- Student will be able to discuss the steps in preparing and presenting research talk and posters
- Student will be able to describe the thesis writing process

SYLLABUS OF RM-03

UNIT – I (16 hours)

Research projects, Academic databases: Research projects, finding a research problem, analysis of research ideas, planning a proposal, proposal outline, presentation and evaluation of proposal. Bibliographic databases, General search engines, metasearch engines, academic search engines, citation indexes, citation analysis, online searching methods.
Writing research paper and thesis: Research papers, selecting a Journal, structure of research paper, review and peer review, copyediting and proofreading. Thesis and dissertation, parts of thesis, the abstract, thesis editing, tables, illustrations, bar diagrams, pie-charts, line graph, line drawings, photograph.

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Essential reading:

1. Research Methodology & Scientific Writing. 2nd Edition by C George Thomas (2021). Springer Publication (Chapter 7, 9, 11, 12, 13).

UNIT – II (14 hours)

Writing skills and presentation skills: Using paragraphs, titles, verbs, active or passive voice, use of articles, prepositions, relative pronouns, transitional words and phrases, economy in words, singular and plural words, commonly confused words, unnecessary phrases, avoiding clichés, punctuation marks and abbreviations, units and numbers. Conference presentation and posters, scientific meetings, planning and delivering a presentation, preparing presentation slides, poster presentation, group and panel discussion.

Plagiarism: What is plagiarism, acknowledging sources, paraphrasing, direct and indirect quotations, summarizing, plagiarism checking.

Essential reading:

1. Research Methodology & Scientific Writing. 2nd Edition by C George Thomas (2021). Springer Publication (Chapter 16, 17, 18, 19, 20, 24).

Recommended readings

1. A Student Guide to Writing Research Reports, Papers, Theses and Dissertations- by Cathal O Siochru (2023). Taylor & Francis
2. Science Research Writing: For Non-native Speakers of English by Hilary Glasman-deal. 2nd edition (2021). World Scientific Publishing Europe Ltd.
3. Write It Up: Practical Strategies for Writing and Publishing Journal Articles by Paul J. Silvia. 1st Edition (2015). APA Life tools.
4. Writing Science: how to write papers that get cited and proposals that get funded- by Joshua Schimel (2012) Oxford University Press.
5. Writing Science Right: Strategies for Teaching Scientific and Technical Writing. By Sue Neuen and Elizabeth Tebeaux (2018). Taylor and Francis

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

RESEARCH WORK: RES-01
PROJECT WORK-I

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		
RES 01: PROJECT WORK-I	6	0	0	6	B.Sc. in any branch of Life Science	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- Student will be introduced to laboratory research in Microbiology
- Student will gain an understanding of the functioning of a research lab
- Student will understand the process of conceptualizing a hypothesis, designing and performing research experiments to test that hypothesis in a Microbiology lab
- Student will understand how to analyze the data and design the next set of experiments
- Student will understand how to troubleshoot common experimental problems in a Microbiology lab

Learning Outcomes

The following four outcomes must be achieved by the end of the third Semester:

1) Research Problem identification
2) Review of literature
3) Research design formulation
4) Commencement of experimentation, fieldwork, or similar tasks

RESEARCH WORK: RES-02
PROJECT WORK-II

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		
RES-2: DISSERTATION-II	**6**	**0**	**0**	**6**	**B.Sc. in any branch of Life Science**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- Student will be introduced to laboratory research in the field of Microbiology
- Student will gain an understanding of the functioning of a research lab
- Student will understand the process of conceptualizing a hypothesis, designing and performing research experiments to test that hypothesis in a Microbiology lab
- Student will understand how to analyze the data and design the next set of experiments
- Student will understand how to troubleshoot common experimental problems in a Microbiology lab
- Student will learn how to write a dissertation/ thesis summarizing the work
- Student will learn how to present and explain the work

Learning Outcomes

The following three outcomes must be achieved by the end of fourth Semester:

1) Completion of experimentation/ fieldwork
2) Submission of dissertation
3) Research output in the form of any one of the following –
    i. Prototype or product development/ patent
    ii. Any other scholastic work as recommended by the BRS and approved by the Research Council *(thesis submission followed by presentation and defense of same)*
    iii. Publication in a reputed Journals such as Scopus-indexed journals or other similar-quality journals
    iv. Book or Book Chapter in a publication by a reputed publisher

RESEARCH WORK: RES-03
DISSERTATION - I

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		
RES-03: DISSERTATION-I	**10**	**0**	**0**	**10**	**B.Sc. in any branch of Life Science**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- Student will be introduced to laboratory research in the field of Microbiology
- Student will gain an understanding of the functioning of a research lab
- Student will understand the process of conceptualizing a hypothesis, designing and performing research experiments to test that hypothesis in a Microbiology lab
- Student will understand how to analyze the data and design the next set of experiments
- Student will understand how to troubleshoot common experimental problems in a Microbiology lab

Learning Outcomes

The following four outcomes must be achieved by the end of third Semester

1) Research Problem identification
2) Review of literature
3) Research design formulation
4) Phase I of research (for e.g. Initial phase of research experimentation, completion of pilot project etc.)

RESEARCH WORK: RES-04
DISSERTATION - II

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		
RES-04: DISSERTATION-II	**16**	**0**	**0**	**16**	**B.Sc. in any branch of Life Science**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- Student will be introduced to laboratory research in the field of Microbiology
- Student will gain an understanding of the functioning of a research lab
- Student will understand the process of conceptualizing a hypothesis, designing and performing research experiments to test that hypothesis in a Microbiology lab
- Student will understand how to analyze the data and design the next set of experiments
- Student will understand how to troubleshoot common experimental problems in a Microbiology lab
- Student will learn how to write a dissertation/ thesis summarizing the work
- Student will learn how to present and explain the work

Learning Outcomes

The following **three** outcomes must be achieved by the end of fourth Semester

1) **Phase II** of research - Final phase of experimentation/ fieldwork
2) Dissertation/ project report submission
3) Attain **at least one** of the following outcomes:
   i. Developed a prototype or product which meets the **Technology Readiness Level 3/4** (TRL-3 or TRL-4) as defined by CSIR
   ii. Publication in Scopus indexed journals #
   iii. Patent
   iv. Any other scholastic work as recommended by the BRS and approved by the Research Council *(thesis submission followed by presentation and defense of same)*
   v. Publication of a book by a reputed publisher (National/International) as recommended by the BRS and approved by the Research Council.

 # Publication must be in Scopus-indexed journals and the authors have to be the student concerned and his/her supervisor(s). Addition of any author [other than the student and supervisor(s)] in the publication has to be with the permission of the Chairperson, Research Council. This permission must be mandatorily taken prior to commencement of Phase-II of the research.