SNDT Women's University, Mumbai

Master of Science (Microbiology)

M. Sc. (Microbiology)

As per NEP-2020

Syllabus

(2023-24)

Structure with course

Year I

SN	Courses	Type of Course	Credits	Marks	Int	Ext
Semester I						
115411	Molecular Immunology (Th)	Major (Core)	4	100	50	50
115412	Bioinstrumentation Techniques & Application (Th)	Major (Core)	4	100	50	50
115423	Bioinstrumentation Techniques & Application (Pr)	Major (Core)	4	100	50	50
115414	Advanced Genetic Engineering (Th)	Major (Core)	2	50	50	0
125411/ 125412	*Microbial Physiology & Development (Th) OR. Bioenergetics & Molecular Enzymology (Th)	Major (Elective)	4	100	50	50
135411	Biostatics & Advanced Research Methodology In Microbiology (Th)	Minor Stream (RM)	4	100	50	50
End of Semester-I			**22**	**550**	**300**	**250**
Semester II						
215411	Advanced Clinical Virology (Th)	Major (Core)	4	100	50	50
215412	Food, Dairy Microbiology & Fermentation Process (Th)	Major (Core)	4	100	50	50
215423	Food, Dairy Microbiology & Fermentation Process (Pr)	Major (Core)	4	100	50	50
215414	Macromolecules & Molecular Enzymology (Th)	Major (Core)	2	50	0	50
225411/ 225412	*Bioprocess Engineering & Technology (Th) OR Agricultural Microbiology (Th)	Major (Elective)	4	100	50	50
245441	Internship	OJT	4	100	50	50
End of Semester-II			**22**	**550**	**250**	**300**
Exit with PG Diploma in Microbiology						

Year II

SN	Courses	Type of Course	Credits	Marks	Int	Ext
	Semester III					
315411	Bioinformatics, Microbial Genetics & Proteomics (Th)	Major (Core)	4	100	50	50
315422	Bioinformatics, Microbial Genetics & Proteomics (Pr)	Major (Core)	4	100	50	50
315413	Enzyme Technology (Th)	Major (Core)	4	100	50	50
315424	Enzyme Technology (Pr)	Major (Core)	2	50	0	50
325411/ 325412	* Microbial Diversity (Th) OR Environmental Microbiology (Th)	Major (Elective)	4	100	50	50
355431	Dissertation II	RP	4	100	50	50
End of semester-III			**22**	**550**	**250**	**300**
Semester IV						
415411	Recombinant DNA Technology (Th)	Major (Core)	4	100	50	50
415412	Pharmaceutical Microbiology (Th)	Major (Core)	4	100	50	50
415413	Industrial Biotechnology (Th)	Major (Core)	4	100	50	50
425411/ 425412	*Environmental Biotechnology (Th) OR Advanced Medical Microbiology (Th)	Major (Elective)	4	100	50	50
455431	Dissertation II	RP	6	150	100	50
End of Semester-IV			**22**	**550**	**300**	**250**
Exit with PG Degree in Microbiology						

*The elective subjects will be offered only if there are minimum 10 students for the respective selected course.

Semester - III

3.1 Major (Core)

Course Title	**Bioinformatics, Microbial Genetics & Proteomics (Th)**
Course Credits	**4**
Course Outcomes	After going through the course, learners will be able to apply the knowledge to
	1) **Evaluate** bioinformatics tools and databases for complex biological data analysis. 2) **Analyze** genome-wide sequence data using advanced computational methods. 3) **Design** DNA microarray workflows to interpret gene expression data. **4) Apply** proteomics techniques to analyze and quantify protein structures and functions.
Module 1 (Credit 1) - Bioinformatics & Its Applications	
Learning Outcomes	After learning this module, the learners will be able to, 1. Have knowledge and awareness of the basic principles and concept of biology, computer science and mathematics 2. Use the existing software effectively to extract information from large database and to use this information in computer modelling
Content Outline	● Database types, Pairwise & multiple alignments ● Structure -function relationship ● Sequence assembling using computers, Computer application in molecular biology ● Protein domain & human genome analysis program (BLAST, FASTA, GCC etc.) ● Search & retrieval of biological information & database sequence databank (PDB & gene bank) ● Accessing information (Network expaasy, EMBL Net, ICGEB Net)
Module 2 (Credit 1) -Whole Genome & Sequences Analysis	
Learning Outcomes	After learning this module, the learners will be able to, 1. Introduce importance of genome-wide DNA sequence analysis. 2. Acquire a grounding in the basic biology of how sequence data is acquired and analyse

Content Outline	• Preparation of ordered cosmid libraries • Bacterial artificial chromosomal libraries, Shotgun libraries & sequencing • Conventional sequencing (Sanger, Maxam & Gilbert Method) Automated Sequencing • Computational methods, homology algorithm(BLAST) for prote in and nucleic acid • Open reading frames, annotations of genes, conserved protein motif related structure /function (PROSITE, PFAME, profile scan) • DNA analysis for repeats (direct and inverted), palindrome folding program's • Use of internet
Module 3 (Credit 1) - DNA Micro array	
Learning Outcomes	After learning this module, the learners will be able to, 1. Determine whether the DNA from a particular individual contains a mutation in genes like BRCA1 and BARCA2. 2. Detect the expression of thousands of genes at the same time
Content Outline	• Printing or oligonucleotides and PCR products on glass slides, nitrocellulose paper • Whole genome analysis for global patterns of gene expression using fluorescent-labelled CDNA or end labeled RNA probes • Analysis of single polymorphism using DNA chips
Module 4 (Credit 1) - Proteome Analysis	
Learning Outcomes	After learning this module, the learners will be able to, 1. Acquire knowledge about common workflows for the large scale analysis of protein 2. Attain fundamental knowledge about quantification of proteomes 3. Recognize how to identify and quantify proteins from mass spectroscopy.
Content Outline	• Two dimensional separation of total cellular protein • Isolation and sequence analysis of individual protein spots by mass spectroscopy • Protein micro array • Advantages & disadvantages of DNA and protein micro array

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE):

Module 1: Students will conduct Comparative Genomics Analysis using freely available online resources such as NCBI BLAST and FASTA tools. They can access gene and protein sequences from public databases like GenBank and UniProt. The project involves downloading sequences, performing alignments, and interpreting results to understand evolutionary relationships and

functional implications of conserved domains.

Module 2: For Genome Annotation and Comparative Analysis, students can utilize open-access genome annotation tools such as PROSITE and PFAM. They will access genomic sequences from databases like Ensembl or UCSC Genome Browser. Annotation can be done using computational tools available online or through software packages like Artemis. Comparisons between genomes can be performed using online resources that provide comparative genomics functionalities.

Module 3: Gene Expression Profiling using DNA Microarrays can be simulated using virtual tools such as GenePattern or Bioconductor packages in R, which are freely available. Students can design virtual microarray experiments by selecting genes of interest and simulating hybridization processes. They can analyze simulated data to identify gene expression patterns and correlations. No physical microarrays are needed; all work is done using simulated or publicly available data.

Module 4: For Protein Identification and Quantification using Mass Spectrometry, students can utilize online databases like UniProt for protein sequences and tools like ProteomeXchange for mass spectrometry data. Virtual labs and software such as Mascot or MaxQuant (available in demo versions or academic licenses) can be used to simulate protein identification and quantification workflows.
Students will analyze simulated spectra to identify proteins and evaluate the performance and limitations of different proteomics techniques.

References:

1) Xiong, J. (2006). *Essential Bioinformatics*. Cambridge University Press.
2) Edward, D., Stajich, J., & Hansen, D. (2009). *Bioinformatics Tools and Application*. Springer- Verlag New York Inc.
3) Maulik, U., Bandyopadhyay, S., & Mukhopadhyay, A. (2014). *Multiobjective Genetic Algorithms for Clustering-Application in Data Mining and Bioinformatics*. Springer-Verlag Berlin.
4) Christensen, H. (2023). *Introduction to Bioinformatics in Microbiology* (2nd ed.). Springer International Publishing AG.
5) Rastogi, S.C., Rastogi, P., & Mendiratta, N. (2022). *Bioinformatics Methods and Application: Genomics, Proteomics and Drug Discovery* (5th ed.). PHI Learning.
6) Ghosh, Z., & Mallick, B. (2008). *Bioinformatics: Principle and Applications*. OUP India.
7) Rastogi, S.C., Mendiratta, N., & Rastogi, P. (2019). *Bioinformatics: Concept, Skills & Applications* (2nd ed.). CBS Publisher.
8) Gulwe, A.B. (2024). *Objectives At Glance In Bioinformatics And Biotechnology*. Pastor Publishing Ltd.
9) Sundaralingam, R., & Kunaresan, V. (2021). *Saras Bioinformatics*. Saras Publication.

3.2 Major (Core)

Course Title	**Bioinformatics, Microbial Genetics & Proteomics (Pr)**
Course Credits	**4**
Course Outcomes	After going through the course, learners will be able to –
	1. Determine knowledge about various concepts, advanced technical tools in docking, QSAR studies employed in computational drug discovery. 2. Analyze ADME response to drug response and its effect. 3. Recommended information from available databases and use them for microbial identifications and drug designing. 4. Express and stand confidently while working for their institutes as bioinformatics makes them skilled person in computing.
Module 1 (Credit 1) - Sequence Analysis	
Learning Outcomes	1. Apply bioinformatics tools and software to analyze both nucleotide and protein sequences. 2. Interpret sequence alignments to identify homologous regions, conserved motifs, and evolutionary relationships in nucleotides and proteins. 3. Extract, analyze, and interpret sequence data from public databases, gaining insights into gene function and protein structure. 4. Identify conserved regions and functional domains within sequences to predict protein functions and understand genetic variations.
Content Outline	• Sequence Analysis of Nucleotides Using Online Tools • Protein Sequence Analysis Using Bioinformatics Software
Module 2 (Credit 1) - Database Exploration	
Learning Outcomes	1. Navigate and utilize public domain databases to retrieve and analyze nucleic acid and protein sequences. 2. Interpret sequence and structural data from databases to gain insights into gene function and protein architecture. 3. Extract and analyze annotated information from nucleic acid and protein databases, enhancing understanding of their biological significance. 4. Compare sequence and structural information across different species to explore functional and evolutionary relationships.

Content Outline	• Exploring Public Domain Databases for Nucleic Acid Sequences • Exploring Protein Databases for Sequence and Structural Information
Module 3 (Credit 1) - Protein Structures	
Learning Outcomes	1. Utilize PDB and genome databases to retrieve and analyze protein structures and genome sequences. 2. Visualize and interpret 3D protein structures, identifying key features such as active sites and ligand-binding regions. 3. Annotate genome sequences to identify genes, regulatory elements, and other genomic features, using bioinformatics tools. 4. Analyze structural and functional relationships between genome sequences and protein structures to understand biological processes and evolutionary patterns.
Content Outline	• Protein Structure Determination Using PDB • Genome Sequence Analysis and Annotation
Module 4 (Credit 1) - Comparative Genomics	
Learning Outcomes	1. Use comparative genomics tools to analyze nucleotide sequences from different species, identifying evolutionary relationships. 2. Identify and analyze functional protein domains using online databases to understand their role in protein function. 3. Compare nucleotide sequences and protein domains across species to explore conservation, variation, and functional implications. 4. Interpret the evolutionary dynamics of genes and protein domains to predict functional outcomes and biological significance.
Content Outline	• Comparative Genomics of Nucleotide Sequences • Functional Analysis of Protein Domains Using Online Databases

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE):

Module 1: Sequence Analysis The objective of this project is to analyze a nucleotide or protein sequence using online tools such as BLAST or Clustal Omega. Students will select a gene or protein of interest from a public database (like NCBI), retrieve the sequence, and perform sequence alignment to identify homologous regions. They will analyze the similarities and differences in the sequences across species and interpret evolutionary relationships. This project can be done at home with a computer and internet access, requiring 5-7 days. The final output will be a report detailing the gene or protein's role and its conservation across species.

Module 2: Database Exploration In this project, students will explore public databases like GenBank, UniProt, or PDB to retrieve nucleic acid and protein sequences. The goal is to extract and analyze annotated information to understand gene functions and protein structure. Students will compare these sequences across species and interpret their

structural and functional differences. This can be completed at home with an internet-enabled computer over 7 days. The final report will describe how the extracted sequences provide insights into the biological significance and evolutionary relationships.

Module 3: Protein Structures For this project, students will use the Protein Data Bank (PDB) and genome databases to retrieve a protein structure and visualize it using PyMOL or an online 3D viewer. The objective is to identify key features such as active sites and ligand-binding regions. Additionally, students will annotate a genome sequence and connect it to the corresponding protein structure, analyzing their functional roles. This project can be done at home with a computer, taking around 7-10 days. The outcome will be a report linking protein structure with its functional and biological importance.

Module 4: Comparative Genomics The objective of this project is to use comparative genomics tools (like MEGA or MAFFT) to analyze nucleotide sequences from different species, focusing on evolutionary relationships and conservation of functional protein domains. Students will retrieve nucleotide sequences from public databases, compare them across species, and interpret the evolutionary significance of their findings. This project can be done at home using a computer with internet access and will take about 7-10 days. The final report will discuss the evolutionary dynamics of the analyzed genes or protein domains.

References:

1. Mount, D.W. (2005). *Bioinformatics Sequence and Genome Analysis* (2nd ed.). CBS Publisher.
2. Sundaralingam, R., Arumugam, N., Kumaresan, V., Gopi, A., & Meena, A. (Eds.). *Biostatistics, Computer Application and Bioinformatics*. Saras Publication.
3. Sharma, T.R. (2019). *Genome Analysis And Bioinformatics: A Practical Approach*. Dreamtech Press.
4. Keith, J. M. (2017). *Bioinformatics: Structure, Function, And Application Vol 2* (2nd ed.). Springer.
5. Abhilash, M. (2010). *Introduction to Bioinformatics and Microarray Technology*. CBS Publisher.
6. Bosu, O., & Thaukral, S.K. (2007). *Bioinformatics: Databases, Tools and Algorithms*. Oxford University Press.
7. Botwright, R. (2023). *Bioinformatics: Algorithms, Coding, Data Science And Biostatistics*. Insta Publishing.

3.3 Major (Core)

Course Title	**Enzyme Technology (Th)**
Course Credits	**4**
Course Outcomes	After going through the course, learners will be able to, 1) Analyze the role of enzymes in biological systems to enhance research in pharmaceuticals and biotechnology. 2) Apply enzyme purification techniques effectively to optimize production processes in biopharmaceutical industries. 3) Evaluate enzyme kinetics equations to develop new diagnostic tools and therapies in healthcare. 4) Synthesize applications of enzymes in various industries and clinical settings to innovate in environmental sustainability and medical treatments
Module 1 (Credit 1) - Extraction and Purification of Microbial Enzymes	
Learning Outcomes	1. To describe the role enzymes play in biological system. 2. To explain the techniques of enzyme purification with different methods
Content Outline	● Importance of enzymes purification , different sources of enzymes ● Extracellular & intracellular enzymes ● Physical and chemical methods used for the cell disintegration ● Enzyme fraction by precipitation (using temperature, salt, solvent, pH, etc.) ● Liquid-liquid extraction, ion exchange, gel electrophoresis, affinity chromatography and other purification methods ● Enzyme crystallization technique, criteria pf purity of enzymes ● Pitfalls in working with pure enzymes
Module 2 (Credit 1) - Enzyme Kinetics and Enzyme Inhibition	
Learning Outcomes	After learning this module, learners will be able to, 1. Apply the equations of enzyme kinetics. 2. Describe the methods used in enzyme kinetics. 3. Define the principles of enzyme inhibition.
Content Outline	● Steady state kinetcs, Briggs-Haldane equation Michaelis-Menten equation ● Lineweaver Burke equation, Eadle Hoffstee equation ● Irreversible, reversible, competitive, non-competitive and uncompetitive inhibition with suitable examples and their kinetics ● Allosteric inhibition, types of allosteric inhibition and their significance in metabollic regulation and kinetic study ● Study on vitamins and co-enzymes, structure, functions with suitable examples ● Metalloenzymes and Metal ion as co-factors and enzyme activators

Module 3 (Credit 1) - Immobilization of Microbial Enzymes	
Learning Outcomes	After learning this module, the learners will be able to, 1. Determine enzyme specificity. 2. Conclude role of specific enzymes in specific reaction
Content Outline	• Methods viz adsorption, covalent bonding, entrapment and membrane confinement • Analytical, therapeutic and industrial applications • Properties of immobilized enzymes
Module 4 (Credit 1) - Enzyme Engineering and Applications of Microbial Enzymes	
Learning Outcomes	After learning this module, the learners will be able to, 1. Elucidate thermostability, kinetic efficiency, pH tolerance, removal of allosteric regulation, enhanced specificity, and stereoselectivity of the product are significantly improved by using protein structural data combined with computational and bioengineering methods. 2. Determine application of enzymes in daily life.
Content Outline	• Chemical modification & site-directed mutagenesis to study the structure function relationship of industrially important enzyme • Microbial enzymes in textile, lether, wood industries & detergents • Enzymes in clinical diagnostics • Enzyme sensor for clinical process & environmental analysis • Enzymes as a therapeutic agents

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE):

Module 1: Extraction and Purification of Microbial Enzymes

Students will explore enzyme purification techniques using accessible methods. They can simulate enzyme extraction from microbial sources using online databases of enzyme sequences. Purification methods like precipitation (using temperature, pH, etc.), liquid-liquid extraction, and affinity chromatography can be simulated virtually or through laboratory software simulations. The project emphasizes understanding enzyme purity criteria and potential pitfalls in enzyme handling, enhancing practical knowledge without physical lab resources.

Module 2: Enzyme Kinetics and Enzyme Inhibition

Students will apply enzyme kinetics equations using virtual labs or simulation software that models Michaelis-Menten kinetics and inhibition types (competitive, non-competitive, etc.). They will analyze data using tools like Lineweaver-Burk plots to understand enzyme inhibition principles and their practical applications. The project involves studying the effects of cofactors and inhibitors on enzyme activity, utilizing computational tools and online resources to explore these concepts in a cost-effective manner.

Module 3: Immobilization of Microbial Enzymes

For understanding enzyme immobilization, students can explore methods like adsorption, covalent bonding, and entrapment through virtual experiments or software simulations. They

will study properties of immobilized enzymes and their applications in various industries and analytical processes. The project focuses on synthesizing knowledge about enzyme specificity and its role in specific

reactions, utilizing digital resources to explore industrial and therapeutic applications of immobilized enzymes.

Module 4: Enzyme Engineering and Applications of Microbial Enzymes

In this module, students will explore enzyme engineering techniques virtually, such as site-directed mutagenesis and computational modeling to enhance enzyme properties like thermostability and specificity. They will investigate industrial applications of microbial enzymes in sectors like textiles, detergents, and clinical diagnostics through case studies and online databases. The project will include designing enzyme sensors for clinical and environmental analysis, emphasizing practical applications without physical lab setups.

References:

1. Shanmugam, S., Sathishkumar, T., & Shanmugaprakash, M. (2012). Enzyme Technology (2nd ed.). I K International Publishing.
2. Bhatt, P. (Ed.). (2023). Industrial Application of Microbial Enzymes (1st ed.). CRC Press.
3. Vijaya Lakshmi, D. (2015). Enzyme Technology. sbw publisher.
4. Bhaskar, A., Vidhya, V. G. (2021). Enzyme Technology. Mjp Publisher.
5. Kumar, A., Garg, S. (2015). Enzymes and Enzyme Technology. Viva Books.
6. Enzyme Technology: Pacemaker of Biotechnology. (2011). Prentice-Hall of India Pvt. Ltd.

3.4 Major (Core)

Course Title	**Enzyme Technology (Pr)**
Course Credits	**2**
Course Outcomes	After going through the course, learners will be able to – 1. Interpret the methods of purification of enzymes 2. Differentiate the specificity of enzymes 3. Justify the ideas of application of enzymes in treatments and therapies 4. Express the methods that could be used in improving the enzyme activities in vivo and in vitro.
Content Outline	● Microbial production, extraction, purification & confirmation of alpha amylase/Lipase ● Determination of efficiency of enzyme purification by measuring specific activity at various stages viz, salt, precipitation, dialysis, electrophoresis etc ● Studies on enzyme activation & inhibition of extracted alpha amylase/Lipase ● Immobilization of cells & enzyme using Sodium alginate & egg albumin & measurement of enzyme activity(amylase/lipase) ● Studies on impact of Immobilization of enzyme activity in terms of temperature tolerance & Vmas & Km using various forms of alpha amylase/Lipase ● Determination of molecular weight of enzymes using PAGE technique ● Preparation of biosensors of urease & determination of its activity
Module 1 (Credit 1) - Enzyme Production and Purification	
Learning Outcomes	1. **Perform Enzyme Production and Purification:** Demonstrate the ability to produce, extract, and purify alpha amylase or lipase from microbial sources, and assess purification efficiency through various techniques. 2. **Analyze Enzyme Activity and Inhibition:** Evaluate enzyme activation, inhibition, and specific activity at different purification stages, including studies on enzyme kinetics. 3. **Apply Immobilization Techniques:** Execute enzyme immobilization using sodium alginate and egg albumin, and measure the impact on enzyme activity and stability. 4. **Assess Enzyme Characteristics:** Determine enzyme molecular weight and study the effects of immobilization on enzyme properties such as

	temperature tolerance and kinetic parameters.
Content Outline	• Microbial Production and Purification of Alpha Amylase/Lipase • Measurement of Enzyme Purification Efficiency • Studies on Enzyme Activation and Inhibition • Immobilization of Enzymes Using Sodium Alginate and Egg Albumin
Module 2 (Credit 1) - Enzyme Activity and Immobilization	
Learning Outcomes	1. **Evaluate Immobilization Effects on Enzyme Activity:** Assess how enzyme immobilization affects activity, stability, and kinetic properties. 2. **Determine Enzyme Molecular Weight:** Measure the molecular weight of enzymes using polyacrylamide gel electrophoresis (PAGE). 3. **Prepare and Measure Urease Biosensors:** Prepare urease biosensors and evaluate their activity. 4. **Compare Enzyme Activity Across Immobilization Methods:** Compare the effectiveness of different enzyme immobilization techniques in terms of activity and performance.
Content Outline	• Effect of Immobilization on Enzyme Activity • Determination of Enzyme Molecular Weight Using PAGE • Preparation and Activity Measurement of Urease Biosensors • Comparison of Enzyme Activity in Different Immobilization Methods

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE):

Assessing students on these lab course topics requires a mix of practical skills, data analysis, and theoretical understanding. Here are some assessment methods aligned with each topic:

1. **Microbial Production, Extraction, Purification & Confirmation:**
   - **Practical Skills:** Assess students' ability to culture microbes, extract enzymes, and purify them through techniques like chromatography.
   - **Report Writing:** Evaluate their lab reports detailing yield, purity, and confirmation methods (e.g., SDS-PAGE, Western blot).
2. **Efficiency of Enzyme Purification:**
   - **Calculations:** Have students calculate specific activity at different purification stages to assess their understanding of enzyme purification efficiency.
   - **Graphical Analysis:** Require them to plot purification profiles and interpret the data.
3. **Enzyme Activation & Inhibition Studies:**
   - **Experimental Design:** Design experiments to study activation/inhibition factors (e.g., temperature, pH, inhibitors). Evaluate their experimental setup and interpretation of results.
   - **Data Interpretation:** Analyze their ability to interpret enzyme kinetics data under various conditions.
4. **Enzyme Immobilization Using Sodium Alginate & Egg Albumin:**
   - **Experimental Setup:** Assess their technique in immobilizing enzymes and measuring activity post-immobilization.
   - **Comparative Analysis:** Compare immobilized enzyme properties with free enzymes in terms of activity, stability (temperature, pH).

5. **Impact of Immobilization on Enzyme Properties:**
    - **Experimental Evaluation:** Test immobilized enzyme under different conditions (temperature, substrate concentration) and analyze Km and Vmax values.
    - **Report on Findings:** Require a report discussing the impact of immobilization on enzyme kinetics.
6. **Determination of Molecular Weight Using PAGE:**
    - **Gel Interpretation:** Evaluate their ability to interpret PAGE gels to determine molecular weight.
    - **Accuracy of Calculations:** Assess their calculations of Rf values and molecular weight determination based on standard curves.
7. **Preparation of Biosensors (e.g., Urease) & Activity Determination:**
    - **Sensor Performance:** Assess the biosensor's sensitivity and specificity.
    - **Data Handling:** Evaluate their data analysis skills in determining enzyme activity from biosensor responses.

Overall Assessment Strategies:

- **Lab Reports:** Detailed reports on each experiment, including methodology, results, and discussion.
- **Practical Skills Assessment:** Direct observation of lab techniques, including pipetting, gel preparation, and spectrophotometry.
- **Quizzes/Tests:** Assess theoretical knowledge on enzyme properties, kinetics, and molecular techniques.

References:

1. Copeland, R.A. (2008). *Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis* (2nd ed.). Wiley India Pvt. Ltd.
2. *Diagnostic Enzymology (Part of Acol Series)*. (2008).
3. Khan, M.Y., & Khan, F. (Eds.). *Principles of Enzyme Technology*. PHI Learning.
4. *Enzymes: A Very Short Introduction*. (2020).
5. *Enzyme Engineering: Selective Catalysts for Applications in Biotechnology, Organic Chemistry and Life Science*. Wiley-VCH, 2023.
6. Copeland, R.A. (Ed.). (2024). *Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis* (3rd ed.). John Wiley & Sons Inc.
7. Ladler, K.J., & Bunting, P.S. (1973). *The Chemical Kinetics Of Enzyme Action* (2nd ed.). Oxford University Press.
8. Weber, G. (Ed.). (Advances in Enzyme Regulation:43). Elsevier Science & Technology.

3.5 A. Major (Elective)

Course Title	**Microbial Diversity (Th)**
Course Credits	**4**
Course Outcomes	After going through the course, learners will be able to - 1) Analyze microbial biodiversity to advance careers in biomedical research and biotechnology. 2) Synthesize knowledge in space microbiology, exploring microbial life in extreme environments. 3) Evaluate the classification and industrial applications of archaebacteria in bioprocess engineering. 4) Apply expertise in extremophile biology to innovate in environmental consulting and pharmaceutical research.
Module 1 (Credit 1) - Biodiversity & Space Microbiology	
Learning Outcomes	After learning this module, the learners will be able to, 1. Provide a diverse range of resources that humans can use to their advantage. 2. Recognize microbial diversity can aid in the mitigation of new threats such as diseases, pathogens, and viruses.
Content Outline	● Introduction to microbial biodiversity, distribution, abundance, ecological niche. ● Aims & Objectives of space research, Life detection methods (a) Evidence of metabolism (b) Evidence of photosynthesis (autotrophic & Heterotrophic) (c) ATP production (d) phosphate uptake (e) Sulphur uptake, Martein environment ● Antarctica as a model for Mars. Search for life on Mars, Viking mission, Viking landers and Biology box experiment ● Gas monitoring of astronauts microbial flora: Alteration in the load of medically important microorganisms ● Changes in mycological autoflora and changes in bacterial autoflora
Module 2 (Credit 1) - Characteristics & Classification of Archaebacteria	
Learning Outcomes	After learning this module, the learners will be able to, 1. Identify the basic classification system of bacteria. 2. Differentiate between environmental bacteria.

Content Outline	• Classification of Hyperthermophiles, habitat & ecological aspects • Extremely Thermophilic Archebacteria, Thermophily, commercial aspects of thermophiles, Application of themozymes • Classification, Habitats & application of Methanogens
Module 3 (Credit 1) - Alkalophiles & Acidophiles	
Learning Outcomes	After learning this module, the learners will be able to, 1. List the application of alkalophilic and acidophilic bacteria in different area. 2. Determine the classification of acidophilic and alkalophilic bacteria.
Content Outline	• Classification, Alkaline environment, soda lakes& desserts, Calcium alkalophily and applications • Acidophiles: Classification, Life at low pH, acidotollerance, application
Module 4 (Credit 1): Halophiles & Barrophiles	
Learning Outcomes	After learning this module, the learners will be able to, 1. Recognize the application of halophiles andbarrophiles bacteria in different area. 2. Determine the normal flora of halophilic and barrophilic bacteria.
Content Outline	• Halophiles: Classification, Deas sea, discovery basin, cell wall & membrane-purple membrane • Compatible solutes, Osmoadpatation / halotolerence, applications of halophiles and their extremozymes • Barrophiles: Classification, High-pressure habitat, life under pressure, barrophily, death under pressure

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE):

Module 1: Biodiversity & Space Microbiology

Students will explore microbial biodiversity and space microbiology using online resources and simulated experiments. They can investigate the ecological niches and distribution of microbes, and study methods for detecting life on Mars, such as ATP production and metabolism evidence. Projects may involve analyzing data from the Viking missions and exploring microbial responses to space environments, utilizing digital tools to simulate gas monitoring and changes in microbial flora.

Module 2: Characteristics & Classification of Archaebacteria

For this module, students can utilize digital databases and virtual labs to study characteristics and classifications of archaebacteria. They will explore hyperthermophiles and methanogens, understanding their habitats and ecological roles. Projects may include researching commercial applications of thermophiles and analyzing the unique biochemical adaptations of methanogens, using online resources to explore their classification and ecological significance.

Module 3: Alkalophiles & Acidophiles

Using virtual simulations and online databases, students will investigate alkalophiles and acidophiles. They will study their classifications, adaptations to extreme pH environments, and applications in various industries. Projects can focus on the biochemical mechanisms of alkalophily and acidotolerance, examining their roles in soda lakes or acidic environments. Students will explore digital resources to understand their industrial applications and ecological roles.

Module 4: Halophiles & Barrophiles

In this module, students will explore halophiles and barrophiles using digital platforms and simulated experiments. They will classify halophiles found in environments like the Dead Sea, studying their adaptations such as osmoadaptation and production of extremozymes. Projects may involve researching the applications of halophiles in biotechnology and environmental remediation, using online resources to simulate high-pressure habitats and study barrophilic adaptations to extreme pressures.

References:

1) Madhuri, A., & Susmitha, B. (2023). *Microbial Diversity*. Divya Lakshmi Publishers and Distributors.
2) Cole, M.F. (2020). *Unifying Microbial Mechanisms: Shared Strategies of Pathogenesis*. Taylor & Francis.
3) Bull, A.T. (Ed.). (2003). *Microbial Diversity and Bioprospecting* (1st ed.). American Society for Microbiology.
4) Swanson. (2022). *Microbes* (3rd ed.). Wiley.
5) Tayya, R.S. (2023). *Microbial Diversity*. S.Publisher.
6) Brown, J.W. (2014). *Principles of Microbial Diversity*. American Society for Microbiology.
7) *Genetic Diversity in Microorganisms*. (2014). InTech.
8) Sharma, M.K. (2023). *Diversity of Microbes And Cryptogams Thallophyta*.
9) Kirchman, D.L. (2018). *Processes in Microbial Ecology* (2nd ed.). Oxford University Press

3.5 B. Major (Elective)

Course Title	**Environmental Microbiology (Th)**
Course Credits	**4**
Course Outcomes	After going through the course, learners will be able to - 1) Evaluate environmental impacts and propose conservation strategies to enhance biodiversity and ecosystem resilience. 2) Manage water resources effectively by implementing efficient wastewater treatment methods and ensuring compliance with environmental standards. 3) Develop and apply innovative solutions for treating industrial effluents, reducing pollution and safeguarding environmental health. 4) Advocate for sustainable environmental policies and practices to address global challenges and promote ecological sustainability.
Module 1 (Credit 1) - Environment and Ecosystems	
Learning Outcomes	After learning this module, the learners will be able to, 1. Evaluate essential factors for survive in life 2. Determine the basic concept of life.
Content Outline	● Definitions, biotic and abiotic environment. Interaction between biotic and its eenvironment ● Environmental segments. Composition and structure of environment. ● Concept of habitat, Concept of biosphere, communities and ecosystems. Ecosystem characteristics structure and function. ● Homeostasis of ecosystem, Food chains, food webs and trophic structures. Ecological pyramids
Module 2 (Credit 1) - Effluent treatment techniques	
Learning Outcomes	After learning this module, the learners will be able to, 1. Recognize the waster water treatment plants/techniques. 2. Demonstrate the treatment schemes for effluents of dairy, distillery, tannery, sugar etc.

Content Outline	• Microbiology of wastewater and solid waste treatment: -Waste-types- solid and liquid • waste characterization, physical, chemical, biological, aerobic, anaerobic, primary, secondary and tertiary treatments. • Anaerobic processes: Anaerobic digestion, anaerobic filters, and upflow anaerobic sludge. Treatment schemes for effluents of dairy, distillery, tannery, sugar and • antibiotic industries (Types, microbes used, types of Effluent Treatment Plants). • Biochemistry of nitrate and sulphate reduction with a special reference to waste treatment, Bioconversion of Solid waste and utilization as fertilizer. Bioaccumulation of heavy metal ions from industrial effluents.
Module 3 (Credit 1) - Bioremediation of Xenobiotics	
Learning Outcomes	After learning this module, the learners will be able to, 1. Demonstrate the concept and consequences of bio - magnification. 2. Determine Genetically Modified Organisms released and its environmental impact assessment and ethical issues.
Content Outline	• Definition of recalcitrant/ xenobiotic compounds, their presence in the natural ecosystem, • Concept and consequences of biomagnification, • Microbiology of degradation of xenobiotic in the environment, ecological considerations, decay behavior, biomagnification and degradative plasmids, hydrocarbons, substituted hydrocarbons, oil pollution, surfactants and pesticides. • Genetically Modified Organisms released and its environmental impact assessment and ethical issues.
Module 4 (Credit 1) - Eutrophication and Global environmental problems	
Learning Outcomes	After learning this module, the learners will be able to, 1. Recognize the changes in the climate due to environmental factors. 2. Comprehend the concept of need of sustainable development.
Content Outline	• Concept of sustainable development. Need of sustainable development, Role of Microbial technology for achieving sustainable development, Improving and restoration of Barron/ degraded lands, • Renewable energy sources using microorganisms, Biodiversity and its conservation, Ozone depletion, UV-B, green house effect and acid rain, their impact and biotechnological approaches for management • Containment of acid mine drainage applying biomining [with reference to copper extraction from low grade ores].

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE):

Module 1: Environment and Ecosystems

Students will explore the fundamentals of ecosystems and environmental interactions using digital resources. They can analyze case studies and simulations to understand ecosystem structures, food webs, and ecological pyramids. Projects may involve creating digital models to illustrate ecosystem dynamics and researching the role of biodiversity in ecosystem resilience, promoting understanding without physical fieldwork.

Module 2: Effluent Treatment Techniques

Using virtual labs and online databases, students will investigate wastewater treatment methods for various industries. They will explore microbiological aspects of wastewater treatment, including anaerobic digestion and bioconversion of solid wastes. Projects may focus on designing treatment schemes for specific industrial effluents like dairy, distillery, and tannery wastes, utilizing digital tools to simulate treatment processes and analyze environmental impacts.

Module 3: Bioremediation of Xenobiotics

Students will study bioremediation techniques for xenobiotic compounds using virtual experiments and case studies. They will explore microbial degradation of pollutants like hydrocarbons and pesticides, assessing biotechnological approaches to environmental cleanup. Projects may involve researching genetically modified organisms (GMOs) for bioremediation and analyzing ethical considerations and environmental impact assessments of releasing GMOs into ecosystems, utilizing online resources to explore these complex topics.

Module 4: Eutrophication and Global Environmental Problems

In this module, students will explore global environmental challenges and solutions using digital platforms. They will study the impacts of eutrophication, climate change, and ozone depletion on ecosystems. Projects may focus on biotechnological approaches to sustainable development, such as microbial technologies for renewable energy and biodiversity conservation. Students will utilize online databases to research biotechnological strategies for managing acid mine drainage and restoring degraded lands, promoting sustainable practices and environmental stewardship through digital exploration.

References:

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2) Sharma, P.D. (2016). *Environmental Microbiology* (1st ed.). Rastogi Publication.
3) Stetzenbach, L.D., & Yates, M.V. (2003). *Environmental Microbiology*.
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5) Ramesh, K.V. (2019). *Environmental Microbiology*.
6) Mohapatra, P.K. (Ed.). *Textbook of Environmental Microbiology*. IK International Publishing House Pvt. Ltd.
7) Chauhan, A.K. (2017). *Microbial Environment And Bioremediation*. Discovery Publishing House Pvt Ltd.
8) Chauhan, A.K., & Varma, A. (Eds.). *Microbial Health And Environment*. IK International Publishing House Pvt. Ltd.
9) Mitchell, R., & Gu, J.-D. (2016). *Environmental Microbiology* (2nd ed.). Wiley India Pvt. Ltd. 10)Reineke, W., & Schlomann, M. (2023). *Environmental Microbiology*. Springer Spektrum.

3.6 Research Project

Course Title	**Dissertation I**
Course Credits	**4**
Course Outcomes	After going through the course, learners will be able to
	1. Demonstrate mastery of parametric and non-parametric statistical tests through application in data analysis.
	2. Evaluate and critique quantitative analysis methods, demonstrating proficiency in interpreting large and small sample tests for inferential statistics.
	3. Synthesize advanced statistical techniques such as chi- square tests, correlation, and regression to analyze complex datasets and draw meaningful conclusions.
	4. Construct comprehensive research proposals, integrating data presentation techniques and discussing experimental designs with clarity and precision
Module 1 (Credit 1) Formulation of problem	
Learning Outcomes	After learning the module, learners will be able to
	1. Recognize and undertake research problem.
Content Outline	• Identifying research gaps and formulating research questions. • Sources of research problems (literature, real-world issues, academic curiosity). • Techniques for developing research questions. • Writing clear and measurable research objectives.
Module 2 (Credit 2) Review of Literature	
Learning Outcomes	After learning the module, learners will be able to
	1. Review the existing literature
Content Outline	• Conducting comprehensive literature searches using databases and other resources. • Evaluating and selecting relevant literature. • Organizing literature into themes and developing a theoretical framework. • Writing a coherent and critical literature review.
Module 3 (Credit 1) Designing Research proposal	
Learning Outcomes	After learning the module, learners will be able to
	1. Apply critical thinking to the problem selected for research
Content Outline	• Components of a research proposal (title, abstract, introduction, etc.). • Selecting appropriate research design (exploratory, descriptive, experimental).

	• Methodology: data collection methods and sampling techniques. • Writing and structuring the research proposal.
Module 4 (Credit 1) Planning tools & techniques for data collection	
Learning Outcomes	After learning the module, learners will be able to
	1. Able to design the research work and plan the execution.
Content Outline	• Use Gantt charts, timelines, and milestones for project planning and resource allocation. • Address ethical considerations, including obtaining informed consent. • Conduct data collection through surveys, interviews, and observations, ensuring ethical guidelines. •

Assignments / Activities towards Comprehensive Continuous Evaluation (CCE):

- **Module 1:** Continuous assessment involves monitoring students' ability to identify research gaps, formulate clear research questions, and articulate measurable research objectives.
- **Module 2:** Assess students' proficiency in conducting comprehensive literature searches, evaluating and synthesizing relevant literature, and developing a coherent theoretical framework for their research.
- **Module 3:** Evaluate students' application of critical thinking in selecting appropriate research designs, developing methodologies for data collection, and structuring a research proposal effectively.
- **Module 4:** Assess students' competence in using planning tools like Gantt charts for project management, addressing ethical considerations in data collection, and applying qualitative and quantitative analysis methods to interpret research findings.

Reference:

1. Booth, W. C., Colomb, G. G., & Williams, J. M. (2008). *The craft of research*. University of Chicago Press.
2. Colquhoun, D. (2014). *Literature review and research design: A guide to effective research practice*. Routledge.
3. Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approach*. SAGE Publications.
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5. Kogon, K., Blakemore, S., & Wood, J. (2015). *Project management for the unofficial project manager: A FranklinCovey title*. BenBella Books.
6. Myers, R. H., Fuller, W. A., & Minton, J. W. (2016). *Applied statistics and the SAS programming language*. CRC Press.
7. Walliman, N. (2017). *Research methods: The basics*. Routledge.
8. Herring, J. (2016). *The ethics of research with children and young people: A practical handbook*. Palgrave Macmillan.
9. Fisher, R. A. (1925). *Statistical methods for research workers*. Oliver and Boyd.

Semester-IV

4.1 Major (Core)

Course Title	**Recombinant DNA Technology (Th)**
Course Credits	**4**
Course Outcomes	After going through the course, learners will be able to -
	1) Analyze the principles of recombinant DNA technology (RDT) to innovate in biotechnology research and development, fostering careers in genetic engineering and pharmaceutical innovation. 2) Implement gene cloning strategies to investigate molecular biology, facilitating roles in biopharmaceutical companies or academic research institutions focused on therapeutic advancements. 3) Evaluate molecular mapping techniques for genome analysis, preparing professionals for careers in genetic diagnostics, personalized medicine, and forensic science. 4) Apply genetic engineering principles to solve complex challenges in agriculture, environmental sustainability, and healthcare, enabling careers in agribusiness, environmental consultancy, and medical genetics.
Module 1 (Credit 1)- Introduction to Recombinant DNA technology	
Learning Outcomes	After learning this module, the learners will be able to, 1. Know the factors involved in RDT. 2. Determine the different types of vectors. 3. Apply the techniques of RDT for cloning.
Content Outline	● Basic techniques : Enzymes used in rDNA technology; ● Cloning vectors: plasmid (pUC19, pBR 322 and their derivatives), phage, cosmid, Phasmid (Lambda Zap); Shuttle /transfer vectors; High capacity Cloning vectors: BAC and YACs; ● Expression vectors: Prokaryotic - pET, pGEX-2T and others); ● ● Marker genes: Selectable markers and Screenable markers, non-antibiotic markers
Module 2 (Credit 1) - Gene Cloning strategies	
Learning Outcomes	After learning this module, the learners will be able to, 1. Recognize the types of cloning techniques 2. Perform screening of Gene libraries for recombinant clones.
Content Outline	● Cohesive end cloning & blunt end cloning - Shot gun cloning and directed cloning - genomic DNA cloning library and cDNA cloning library; Preparation of rDNA molecule and its transfer to appropriate host (bacteria/yeast/plphage, cosmid, Phasmid (Lambda Zap); Shuttle /transfer vectors; ● High capacity Cloning vectors: BAC and YACs; ● Expression vectors: Prokaryotic - PET, ant cell/animal

	• cell using a suitable technique: transformation, electroporation, transfection, gene gun, Particle bombardment etc. Screening of Gene libraries for recombinant clones.
Module 3 (Credit 1) - Molecular Mapping of Genome	
Learning Outcomes	After learning this module, the learners will be able to, 1. Know the use of radioactive and non-radioactive nucleotides in RDT. 2. Demonstrate the physical and chemical mapping of genes
Content Outline	• Use of radioactive and non - radioactive nucleotides for DNA probe preparation and detection of hybrids • Restriction mapping; RFLP, PCR, RT-PCR, Real time PCR and its applications • DNA micro arrays and their use in Genomics; DNA sequencing: MaxamGillbert, Sanger's method and automated sequencer; Chromosomal walking • Hybrid release and hybrid arrest translation to screen the clones - site directed mutagenesis
Module 4 (Credit 1) - Gene cloning systems And Application of Genetic Engineeringg	
Learning Outcomes	After learning this module, the learners will be able to, 1. Identify the gene cloning of organism. 2. Demonstrate the screening of genetic disease using DNA probes.
Content Outline	• Gene cloning in *E. coli* and other organisms such as *Bacillus subtilis*, *Saccharomyces cerevisiae* and other microbial eukaryotes. Gene manipulation in animals - transgenic mice and plants. • Screening of Genetic diseases using DNA probes; Gene therapy; Molecular basis of genetic diseases, genetic counseling; DNA typing and finger printing

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE):

Module 1: Introduction to Recombinant DNA Technology

Students will explore basic techniques in recombinant DNA technology (RDT) using virtual labs and online resources. They will study enzymes used in RDT and different types of vectors such as plasmids (e.g., pUC19, pBR322), phage vectors, cosmid vectors, and high-capacity vectors like BACs and YACs. Projects may involve virtual cloning experiments using expression vectors like pET and pGEX-2T, understanding marker genes, and exploring non-antibiotic selectable markers through digital simulations and case studies.

Module 2: Gene Cloning Strategies

Using virtual labs and simulation software, students will learn various gene cloning techniques. They will explore cohesive end and blunt end cloning methods, shotgun cloning, and directed cloning approaches. Projects may focus on constructing genomic DNA and cDNA libraries, utilizing digital tools to simulate the preparation of rDNA molecules and their transfer into host organisms via transformation or transfection. Students will engage in

virtual screening of gene libraries for recombinant clones using bioinformatics tools and online databases.

Module 3: Molecular Mapping of Genome

In this module, students will utilize virtual tools to explore molecular mapping techniques in genome analysis. They will study the use of radioactive and non-radioactive nucleotides for DNA probe preparation and hybrid detection. Projects may involve virtual experiments in restriction mapping, RFLP analysis, PCR, RT-PCR, and real-time PCR simulations. Students will explore DNA microarrays for genomic studies and practice DNA sequencing methods such as Maxam-Gilbert and Sanger sequencing through digital platforms. Virtual exercises in chromosomal walking and site-directed mutagenesis will enhance understanding of genetic mapping strategies.

Module 4: Gene Cloning Systems and Application of Genetic Engineering

Students will explore gene cloning systems in various organisms using digital databases and simulation tools. They will study gene manipulation in model organisms like E. coli, Bacillus subtilis, and Saccharomyces cerevisiae, and explore gene cloning in transgenic animals and plants. Projects may focus on virtual screenings for genetic diseases using DNA probes, exploring gene therapy applications, and understanding the molecular basis of genetic diseases through online resources and case studies. Students will engage in virtual exercises on DNA typing, fingerprinting techniques, and genetic counseling simulations to enhance practical skills in genetic engineering applications.

References:

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3. Watson, J. (2017). *DNA: The Story of the Genetic Revolution*. Arrow Books Ltd.
4. Datta, A.K. (2015). *Essentials of Medical Genetics*. A.R.K. Publication Kolkata.
5. Brown, T.A. (2020). *Gene Cloning & DNA Analysis: An Introduction* (8th ed.). Wiley-Blackwell.
6. Watson, J.D., Caudy, A.A., Myers, R.M., & Witkowski, J.A. (2007). *Recombinant DNA: Genes And Genomes - A Short Course* (3rd ed.). W.H. Freeman & Co Ltd.
7. Glick, B.R., & Patten, C.L. (2017). *Molecular Biotechnology: Principles and Applications of Recombinant DNA Technology* (5th ed.). American Society for Microbiology.
8. H.M., E. (2020). *Enzymology Primer for Recombinant DNA Technology*.
9. Nicholl, D.S.T. (2023). *An Introduction to Genetic Engineering* (4th ed.). Cambridge University Press.

4.2 Major (Core)

Course Title	**Pharmaceutical Microbiology (Th)**
Course Credits	**4**
Program Outcomes	After going through the course, learners will be able to - 1) **Evaluate** the ecology of microorganisms to design and maintain sterile manufacturing units, preparing for careers in pharmaceutical production and quality control. 2) **Formulate** various antimicrobial drugs and handle preservative techniques, leading to roles in drug development and pharmaceutical manufacturing. 3) **Analyze** mechanisms of action for antiviral, antifungal, and antitumor drugs to contribute to advanced therapeutic research and development in biotechnology and healthcare industries. **4) Interpret** government regulations and quality control practices to ensure compliance and innovation in pharmaceutical research and development, aligning with careers in regulatory affairs and quality assurance.
Module 1 (Credit 1) - Overview of Pharmaceutical microbiology	
Learning Outcomes	After learning this module, the learners will be able to, 1. Gain knowledge about the ecology of microorganisms 2. Design and layout of sterile manufacturing unit
Content Outline	● Ecology of microorganisms: Atmosphere, water, skin, respiratory flora of workers, raw materials, packaging, building equipment and their control measures; Design and layout of sterile manufacturing unit ● Contamination and Spoilage of Pharmaceutical products: sterile injectable and non-injectable, ophthalmologic preparation, implants
Module 2 (Credit 1) - Antibiotics & Synthetic antimicrobial Agents	
Learning Outcomes	After learning this module, the learners will be able to, 1. Recognize the important drugs used in treatment 2. Demonstrate the preparation of different drugs 3. Handle the preservative techniques of chemical disinfectants.
Content Outline	● Aminoglycosides, Beta lactams, tetracyclines. ● Antifungal antibiotics, antitumor substances ● Peptide antibiotics, Chloramphenicol ● Chemical disinfectants, antiseptics & preservatives.
Module 3 (Credit 1) - Molecular aspects of Antimicrobial Chemotherapy.	
Learning Outcomes	After learning this module, the learners will be able to,

	1. Identify the mechanism of action of antiviral drugs. **2.** Recognize the approaches and safety considerations associated with gene therapy
Content Outline	• Definition, classification, Mechanism of action and examples of antiviral (Acyclovir, zidovudine), Antifungal (amphotericin B, Fluconazole) and Antitumor (Bleomycin, ductinomycin) antibiotics. • Drug delivery system in gene therapy. Approaches and safety considerations associated with gene therapy. • Immunological problems associated to gene therapy. Pre-requisites and candidate diseases for human gene therapy.
Module 4 (Credit 1) - Regulatory Practices and Policies in Pharmaceutical Industries.	
Learning Outcomes	After learning this module, the learners will be able to, 1. Know the Government policies of R& D. 2. Demonstrate biological and legislative aspects.
Content Outline	• FDA, Govt. regulatory practices and polices. Concept of R & D and Financing R & D, Quality control and market planning. • Significance of IP, BP and USP. • Reimbursement of drugs, Biological and legislative aspects. • Rational drug design (Quantitative structure activity relation QSAR of drug) and computational aspect of drug design. • Screening and utilization of bioactive phytochemicals. • Patenting of drugs and Biological products • Regulatory aspects of QC, QA, and QM. GMP, GLP and CMP in Pharma Industry. ISO, WHO, USFDA certification. • Microbial Limit test of Pharma products. Sterility testing , pyrogen testing and LAL test of Sterile Pharma products. Sterilization- heat, D- value, Z-value and survival curve, radioactive, gaseous and filtration. Chemical and biological indicators. • Designing layout for microbiology laboratory.

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE):

Module 1: Overview of Pharmaceutical Microbiology

Project: Design a Sterile Manufacturing Unit
Students will design a sterile manufacturing unit layout for a pharmaceutical production facility. Using online resources and simulation software, they will identify key areas prone to microbial contamination such as raw materials, packaging, and equipment. They will propose control measures to prevent contamination, ensuring compliance with regulatory standards.

Students will create a detailed report with diagrams of their designed layout and explain the rationale behind their design choices.

Module 2: Antibiotics & Synthetic Antimicrobial Agents

Project: Develop an Antimicrobial Drug Preparation Plan
Students will develop a preparation plan for a selected antimicrobial drug, such as an aminoglycoside, beta-lactam, or tetracycline. They will research the drug's mechanism of action, formulation process, and preservative techniques. Using virtual labs and online databases, students will simulate the preparation process and outline steps for ensuring drug stability and efficacy. They will present their findings in a comprehensive report, including safety protocols and quality control measures.

Module 3: Molecular Aspects of Antimicrobial Chemotherapy

Project: Mechanism of Action Study for Antiviral Drugs
Students will investigate the mechanisms of action for antiviral drugs such as acyclovir and zidovudine. They will use online resources and bioinformatics tools to explore how these drugs inhibit viral replication. Students will prepare a detailed presentation that includes molecular diagrams, drug interaction pathways, and case studies of clinical applications. Additionally, they will discuss safety considerations and the latest advancements in gene therapy related to antiviral treatments.

Module 4: Regulatory Practices and Policies in Pharmaceutical Industries

Project: Regulatory Compliance Plan for a New Drug
Students will develop a regulatory compliance plan for bringing a new drug to market. They will study FDA, WHO, and USFDA regulations, and create a step-by-step guide outlining the necessary approvals, quality control, and market planning. Using case studies and current pharmaceutical industry guidelines, students will simulate the process of patenting the drug, ensuring GMP, GLP, and CMP compliance. They will present their plan in a detailed report, highlighting the significance of IP, BP, and USP standards, as well as outlining the steps for obtaining ISO certification.

References:

1. Gilmore, B.F. (2023). *Pharmaceutical Microbiology*. Wiley.
2. Wani, I. (2018). *Pharmaceutical Microbiology*. S. Vikas & Company.
3. Sheth, Z.P. (2022). *Pharmaceutical Microbiology*. CBS Publisher.
4. Chauhan. (2020). *Microbiological Methods for Environment, Food, and Pharmaceutical Analysis*. Springer.
5. Manivannan, R., Singh, B., & Patel, Y.K.K. (2022). *Pharmaceutical Microbiology*. Thakur Publication Pvt. Ltd.
6. Udaykumar, P. (2021). *Medical Pharmacology* (7th ed.). CBS Publisher & Distributors.
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8. Muniappan, M. (2022). *Textbook of Modern Pharmacology* (3rd ed.). CBS Publisher.
9. Sharma, V.N. (2015). *Essentials of Pharmacology: Basic Principles and General Concepts*. CBS PD.
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11. Ritter, J.M. (2024). *Rang & Dale's Pharmacology* (10th ed.).
12. Rataboli, P.V. (2022). *Clinical Pharmacology and Therapeutics* (3rd ed.). CBS Publisher. 14)Dhikav, V. (2019). *Last Minute Revision In Pharmacology* (4th ed.). AITBS.
13. Dhikav, V. (2022). *Drugs Classification in Pharmacology* (2nd ed.). AITBS.

4.3 Major (Core)

Course Title	**Industrial Biotechnology (Th)**
Course Credits	**4**
Program Outcomes	After going through the course, learners will be able to -
	1) **Evaluate** the ecology of microorganisms to design and maintain sterile manufacturing units, preparing for careers in pharmaceutical production and quality control. 2) **Formulate** various antimicrobial drugs and handle preservative techniques, leading to roles in drug development and pharmaceutical manufacturing. 3) **Analyze** mechanisms of action for antiviral, antifungal, and antitumor drugs to contribute to advanced therapeutic research and development in biotechnology and healthcare industries. 4) **Interpret** government regulations and quality control practices to ensure compliance and innovation in pharmaceutical research and development, aligning with careers in regulatory affairs and quality assurance.
Module 1 (Credit 1) - Industrial Fermentation Production	
Learning Outcomes	After learning this module, the learners will be able to, 1. Acquire the industrial fermentation process. 2. Determine the acid production by fermentation in industry.
Content Outline	● General methods of production, SIP ● Purification & application of organic acids: Citric acid, Lactic acid. ● Amino acid: Glutamic acid ● Antibodies: Classification, antibiotic research, isolation of new antibodies, hybrid antibodies, peptides.
Module 2 (Credit 1) - Enzymes Used in Industrial Fermentaion & Production	
Learning Outcomes	After learning this module, the learners will be able to, 1. Demonstrate the different enzymes used in industrial fermentation process. 2. Differentiate between ethanol and acetone
Content Outline	● Amylase, Polysachharides-alginate, dextran, xanthan ● Pullan, lipids. pHB, pHA. ● Biomass: SCP & SCO ● Solvents: Ethanol & Acetone
Module 3 (Credit 1) - Intellectual Property Rights	
Learning Outcomes	After learning this module, the learners will be able to, 1. Recognize the schemes of IPR. 2. Demonstrate the biological patenting.

Content Outline	• Intellectual property rights(IPR): Patients, trademarks, copy right, secrets, IPR & plant genetic resources (PGR) • Patenting of biological materials, international conventions
Module 4 (Credit 1) - Ethical Issues	
Learning Outcomes	After learning this module, the learners will be able to, 1. Recall the issues and solving methods. 2. Determine the implications of patenting.
Content Outline	• International cooperation, obligations with patient applications, implications of patenting current issue, hybridomes technology • Patenting of higher plants & animal, transgenic organism and isolated genes • Patenting of genes & DNA sequence, plant breeders right and farmers right.

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE):

Module 1: Industrial Fermentation Production

Project: Industrial Fermentation Process Design
Students will design an industrial fermentation process for the production of citric acid, lactic acid, and glutamic acid. Using open-source software and online resources, they will create a flowchart detailing each step from the initial fermentation to purification. Students will focus on scale-up processes and quality control measures. They will present a report that includes diagrams of the fermentation setup, purification techniques, and applications of the produced organic acids and antibodies.

Module 2: Enzymes Used in Industrial Fermentation & Production

Project: Comparative Study of Industrial Enzymes
Students will conduct a comparative study of different enzymes used in industrial fermentation processes, such as amylase, polysaccharides, and lipids. They will use online research tools to gather data on the production methods and applications of these enzymes. Students will prepare a detailed presentation highlighting the differences between ethanol and acetone production, including their industrial applications and economic impact. They will also discuss the production and benefits of SCP (Single Cell Protein) and SCO (Single Cell Oil).

Module 3: Intellectual Property Rights

Project: Case Study on Biological Patenting
Students will investigate the intellectual property rights (IPR) related to biological materials by conducting a case study on a recent patent in biotechnology. They will research the process of obtaining patents, trademarks, and copyrights, and analyze the legal and ethical implications. Using online databases and legal resources, students will prepare a comprehensive report that includes the steps involved in patenting biological materials and the impact of international conventions on IPR and plant genetic resources.

Module 4: Ethical Issues

Project: Analysis of Ethical Issues in Biotechnology
Students will explore the ethical issues surrounding biotechnology, including the patenting

of higher plants, animals, and isolated genes. They will use case studies and current events to identify and analyze ethical dilemmas in the field. Students will present their findings in a detailed report that includes international cooperation obligations, implications of patenting, and methods for resolving

ethical issues. They will also discuss the rights of plant breeders and farmers in the context of genetic engineering and biotechnology.

References:

1. Watson, K. (2019). *Industrial Biotechnology* (Vol. 1). CBS.
2. Watson, K. (2019). *Industrial Biotechnology* (Vol. 2). CBS.
3. Thakur, I.S. (2020). *Industrial Biotechnology: Problems and Remedies*. I K International Publishing House Pvt. Ltd.
4. Kavita. (2015). *Industrial Biotechnology* (2nd ed.).
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7. Das, D., & Pandit, S. (2021). *Industrial Biotechnology*. CRC Press.

4.4 A. Major (Elective)

Course Title	**Environmental Biotechnology (Th)**
Course Credits	**4**
Course Outcomes	After going through the course, learners will be able to - 1) **Assess** ecosystems and their significance to humans, animals, and plants, preparing for careers in environmental management and conservation. 2) **Analyze** the diversity and impact of airborne microorganisms, leading to roles in public health and environmental monitoring. 3) **Apply** knowledge of water and wastewater microbiology for quality analysis and treatment design, aligning with careers in water management and environmental consultancy. **4) Evaluate** global environmental issues like global warming, greenhouse effect, and ozone depletion, and manage e-waste, contributing to careers in environmental policy and sustainability
Module 1 (Credit 1) - Environmental Biotechnology	
Learning Outcomes	After learning this module, the learners will be able to, 1. Elucidate major habitats found on Earth's ecosystems and escalate the superiority of these ecosystems to humans, animals and plants. **2.** Designate the associations among predator and prey populations and outline the structure of food webs and trace the flow of energy through an ecosystem.
Content Outline	● Environment and their interaction; Characteristics and functions of typical ecosystem ● Types of ecosystems; Energy flow and material cycling; Food chain and food webs; Ecological pyramids.
Module 2 (Credit 1) - Aerobiology	
Learning Outcomes	After learning this module, the learners will be able to, 1. Illustrate the diversity of microorganisms in air and its significance 2. Exemplify the air quality in Indian cities-mapping of the hot spots and explore the impact of air borne microbes.
Content Outline	● Historical introduction – nomenclature of atmospheric layers; ● Microbes as source and sink of atmospheric pollutants; Diversity of microorganisms in air and their significance - Droplet nuclei and aerosol; ● Outdoor and indoor micro flora - Source of microbes and their quantification techniques; Room sanitation in hospitals, industries and pharmaceutical; Air quality in Indian cities–mapping of the hot spots, air quality monitoring and measurement ● Impact of air-borne microorganisms on living beings; Air borne diseases.
Module 3 (Credit 1) - Water microbiology and Waste water microbiology	

Learning Outcomes	After learning this module, the learners will be able to, 1. Express the role of indicative microorganisms and apply knowledge in water quality analysis and in designing blueprint for drinking water treatment. **2.** Interpret waste water and solid waste management and commentate the microbiology of xenobiotics in the environment.
Content Outline	Sources of water microflora and their quantification techniques; Water purity in industries, irrigation, potable and recreational waters. Indicator organisms and their detection; Bacteriological analysis of drinking water - Water purification; Desalinization of sea water; Water borne diseases and their control**.** Waste water management and sewage treatment: industrial, municipal and house hold wastes - BOD concepts; Treatment of tannery and slaughter house waste; Solid waste management and land filling; Marine pollution, oil spills, tar ball pollution, beach pollution Biosensors and biological indicators Microbiology of Xenobiotics in the environment – Oil pollution.
Module 4 (Credit 1) - Global Environmental Problems and their Control	
Learning Outcomes	After learning this module, the learners will be able to, 1. Manifest the major environmental changes revealing with Global warming 2. Recognize the Greenhouse effect and Ozone depletion and Express the management of e-waste.
Content Outline	• Global Environmental Changes – Global Warming, Green House Effect, Acid Rain , Ozone Depletion. • Electronic waste (e - waste): Sources, types, constituents, recycling of e–wastes; Environmental consequences and Management of e-wastes.

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE):

Module 1: Environmental Biotechnology

Project: Assess the health of a local ecosystem by conducting a field study to document habitats and key species. Analyze predator-prey relationships, food webs, and energy flow. Present findings in a report with visual aids.

Module 2: Aerobiology

Project: Conduct a survey of airborne microorganisms in various environments (indoor, outdoor). Map air quality in a selected area, identify hotspots, and assess the impact of airborne microbes on health. Present data in a detailed report.

Module 3: Water and Wastewater Microbiology

Project: Analyze the microbiological quality of local water sources. Test for indicator organisms, conduct bacteriological analysis, and propose treatment designs. Compile results in a comprehensive report with recommendations.

Module 4: Global Environmental Problems and their Control

Project: Research global environmental issues like global warming and ozone depletion. Assess the environmental and health impacts of e-waste. Propose management strategies and present findings in a detailed report.

References:

1. Allen, K. (2016). *Environmental Biotechnology*. CBS Publisher.
2. Thakur, I.S. (2013). *Environmental Biotechnology: Basic Concepts and Applications* (2nd ed.). I K International Publishing.
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4.4 B. Major (Elective)

Course Title	**Advanced Medical Microbiology (Th)**
Course Credits	**4**
Course Outcomes	After going through the course, learners will be able to -
	1) **Analyze** the role of normal human flora and infectious disease processes, preparing for careers in clinical microbiology and infectious disease research. 2) **Evaluate** disease-causing bacteria, their infection mechanisms, and treatments, leading to roles in medical diagnostics and epidemiology. 3) **Interpret** human-fungal interactions and disease mechanisms, suitable for careers in mycology and fungal pathology. 4) **Demonstrate** the pathogenesis and treatment of mycoses, including mycotoxins, aligning with roles in medical mycology and pharmaceutical development.
Module 1 (Credit 1) - Introduction to Medical Microbiology	
Learning Outcomes	After learning this module, the learners will be able to, 1. Recognize the importance of normal flora of human body and acquire knowledge on the process of infectious disease 2. Acquire the basic concepts of medical microbiology and analyze how pathogenic organisms causes the disease on human beings and animals
Content Outline	● Normal human micro flora – medically important microbes – infectious disease process – microbial virulence and virulence factors – laboratory diagnosis. ● process of sample collection, transport and examination of clinical specimens. Conventional and rapid methods for microbial diagnosis–antimicrobial susceptibility tests. Nosocomial infections, zoonotic infections. ● Antibiotic resistance among clinically important bacteria.
Module 2 (Credit 1) - Bacteriology	
Learning Outcomes	1. To compile a list of disease causing bacteria and compare their modes of infection, symptoms, diagnosis and treatment 2. Evaluate the role of pathogenic bacteria in human infections pertaining to respiratory tract, gastrointestinal tract, urinary tract, skin and soft tissue
Content Outline	Morphology, cultural characteristics, pathogenicity, lab diagnosis and treatement: *Staphylococcus aureus*, *Streptococcus pyogens, Bacillus anthracis, Corynebacterium diptheriae, Clostridium tetani, Clostridium botulinum, Mycobacterium tuberculosis, Mycobacterium leprae*
Module 3 (Credit 1) - Mycology	

Learning Outcomes	After learning this module, the learners will be able to, 1. Comprehend human-fungal interaction, which can be applied to obtain in-depth knowledge on fungal diseases and the mechanism behind the disease process 2. Review pathogenic fungi that cause disease and methods of identification for respective fungi from clinical specimens
Content Outline	● Classification of medically important fungi – Isolation and identification of fungi from clinical specimens. ● Antifungal drugs
Module 4 (Credit 1) - Mycology	
Learning Outcomes	After learning this module, the learners will be able to, **1.** Explain types of mycoses caused in humans **2.** Demonstrate modes of infection, pathogenesis, and treatment of mycoss with introduction to mycotoxins
Content Outline	● Superficial mycoses – tinea, piedra, dermatophytosis. ● Subcutaneous mycoses – mycetoma, sporotrychosis. Systemic ● Opportunistic mycoses – Histoplasmosis, Cryptococcosis, Candidiasis, Mycotoxins

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE):

Module 1: Introduction to Medical Microbiology

Project: Investigate the role of normal human flora in health and disease. Collect and analyze clinical specimens using conventional and rapid methods for microbial diagnosis. Present findings on microbial virulence factors and their implications in nosocomial and zoonotic infections.

Module 2: Bacteriology

Project: Compile a comparative study of disease-causing bacteria affecting different body systems. Focus on Staphylococcus aureus, Streptococcus pyogenes, Bacillus anthracis, and others. Analyze their morphology, pathogenicity, and treatment options based on antimicrobial susceptibility tests.

Module 3: Mycology

Project: Explore human-fungal interactions through the isolation and identification of medically important fungi from clinical specimens. Evaluate antifungal drugs and their applications in treating fungal infections. Present findings on fungal classification and diagnostic techniques.

Module 4: Mycology

Project: Investigate different types of mycoses affecting humans, including superficial, subcutaneous, and opportunistic mycoses. Study the modes of infection, pathogenesis, and treatment options, emphasizing the role of mycotoxins in fungal diseases.

Reference:

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2. Bailey, M., & Scott, E.G. (2021). Diagnostic Microbiology (15th ed.). Elsevier.
3. Procop, G.W. (2020). Koneman's Color Atlas and Textbook of Diagnostic Microbiology (7th ed.).
4. Levinson, W. (2022). Review of Medical Microbiology and Immunology (17th ed.). MGH.
5. Barer, M. (2019). Medical Microbiology (19th ed.). Elsevier UK/US.
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8. Murray, P.R. (2023). Murray's Basic Medical Microbiology: Foundations and Clinical Cases (2nd
9. ed.). Elsevier.
10. Goering, R.V. (2018). MIMs Medical Microbiology And Immunology (6th ed.). Elsevier US/UK. 10)Bauman, R.W. (2017). Microbiology With Diseases by Body System (4th ed.).
11. 11)Godkar, P.B., Dave, B., & Muley, L. (Eds.). Textbook of Medical Microbiology And Parasitology (1st ed.). Bhalani Publishing House

4.5 Research Project

Course Title	**Dissertation II**
Course Credits	**6**
Course Outcomes:	At the end of this course Learners will be able to - 1) Apply advanced data collection and analysis techniques to complete a comprehensive dissertation. 2) Analyze and synthesize research findings to validate hypotheses and achieve research objectives. 3) Evaluate the implications of dissertation results within the context of existing literature and theoretical frameworks. 4) Design and articulate a structured dissertation and research article that demonstrates scholarly rigor and innovation.
Module 1	**Data collection / finalization/ analysis** • Gather and finalize any remaining data required for the dissertation. • Ensure all data is complete, validated, and ready for analysis. • Conduct final data analysis using appropriate statistical methods. • Validate findings and ensure they align with research objectives and hypotheses.
Module 2	**Finalization of chapters of Introduction & Methodology** • Review and finalize the introduction chapter, providing a clear rationale and background for the study. • Refine the methodology chapter, detailing the research design, sampling methods, and data collection procedures. • Ensure all methodological aspects are well-documented and align with the research questions. • Incorporate any feedback or suggestions to enhance the clarity and coherence of these chapters.
Module 3	**Finalization of Results and Discussion** • Analyse and interpret the final results obtained from the data analysis. • Present findings in a clear and structured manner, using tables, graphs, and figures as needed. • Discuss the implications of the results in relation to the research questions and existing literature. • Address any unexpected findings or limitations and provide possible explanations.
Module 4	**Finalization of Summary and Conclusion** • Summarize the key findings of the dissertation in the summary chapter. • Discuss the significance of the findings and their contributions to the field of study. • Revisit the research objectives and evaluate whether they have been met. • Craft a well-rounded conclusion that reflects on the overall research journey and its implications.
Module 5	**Approval of final draft of the dissertation and research article** • Submit the final draft of the dissertation to the academic advisor or committee for review and approval. • Address any feedback or revisions requested by the advisor or committee to ensure the dissertation meets academic standards. • Simultaneously, students will prepare a research article based on their dissertation findings for submission to an international journal of high repute. • The article should be structured according to the journal's

	guidelines, emphasizing the novelty, significance, and implications of the research
Module 6	**Submission of dissertation and Viva voce** • Submit the approved dissertation to the academic institution by the specified deadline. • Ensure the dissertation adheres to all formatting and documentation requirements for final submission. • Concurrently, students will finalize the research article based on their dissertation findings for submission to the international journal. • Prepare for the viva voce (oral defense) examination, which includes defending both the dissertation and the research article before a panel of examiners. • Demonstrate in-depth knowledge, critical thinking, and the ability to articulate and defend research findings during the viva voce.

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE):

To assess the content for the course "Dissertation II," focusing on the outlined modules and course outcomes, you can use the following criteria and methods:

1. **Data Collection and Analysis (Module 1):**
   - **Criteria:** Evaluate how students gather, validate, and analyze data using advanced techniques.
   - **Methods:** Review students' final data collection plans, validation methods, and the application of appropriate statistical analyses.
   - **Assessment:** Assess the completeness, accuracy, and alignment of data with research objectives and hypotheses. Look for evidence of rigorous data handling and analysis in their final reports or presentations.
2. **Introduction & Methodology Chapters (Module 2):**
   - **Criteria:** Assess the clarity of rationale in the introduction and the robustness of the methodology.
   - **Methods:** Review the finalized introduction chapters and methodology sections. Look for thoroughness in documenting research design, sampling methods, and data collection procedures.
   - **Assessment:** Evaluate how well students incorporate feedback to enhance clarity and coherence. Ensure alignment of methodological aspects with research questions and objectives.
3. **Results and Discussion (Module 3):**
   - **Criteria:** Evaluate students' ability to analyze, interpret, and discuss research findings.
   - **Methods:** Examine the clarity and structure of how findings are presented using tables, graphs, and figures. Assess the depth of discussion on implications in relation to research questions and existing literature.
   - **Assessment:** Look for critical analysis of unexpected findings or limitations and the provision of plausible explanations. Ensure findings are effectively linked back to the research objectives.
4. **Summary and Conclusion (Module 4):**
   - **Criteria:** Assess the effectiveness of summarizing key findings and discussing their significance.
   - **Methods:** Review the summary chapter and conclusion section for comprehensive coverage of key findings' implications and contributions to the field.
   - **Assessment:** Evaluate the reflection on whether research objectives have been met and the implications discussed. Look for a well-rounded conclusion that ties together the research journey and its broader implications.
5. **Approval and Research Article Preparation (Module 5):**
   - **Criteria:** Evaluate the readiness of the dissertation draft for approval and the preparation of a research article.

- **Methods:** Review the final draft submitted for approval and assess responses to feedback for revisions. Evaluate the preparation of the research article, including adherence to journal guidelines and emphasis on novelty and significance.
- **Assessment:** Ensure the dissertation meets academic standards and that the research article is structured appropriately for journal submission. Assess the novelty and implications highlighted in the article based on dissertation findings.

6. **Submission and Viva Voce (Module 6):**
   - **Criteria:** Evaluate students' preparation for dissertation submission and defense.
   - **Methods:** Review the final submission of the dissertation and ensure compliance with formatting and documentation requirements. Assess the preparation for the viva voce examination, including defense of both the dissertation and research article.
   - **Assessment:** Evaluate students' in-depth knowledge, critical thinking, and ability to articulate and defend their research findings during the viva voce. Assess their ability to engage with questions and feedback from the panel of examiners.

Reference:

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2. Field, A. (2018). *Discovering statistics using IBM SPSS statistics* (5th ed.). SAGE Publications.
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