SNDT Women's University, Mumbai

Master of Science (Microbiology)

M. Sc. (Microbiology)

As per NEP-2020

Syllabus

(2023-24)

Programme Templete

M.Sc.Microbiology

Programme Degree		M.Sc.
Parenthesis if any (Specialization)		Microbiology
Preamble (Brief Introduction to the programme)		Microbiology is the science in which study of a variety of living organisms which are invisible to the naked eyes.The methods used to study and manipulate these minute and mostly unicellular organism differ from other organism.Microbiologists are paramedical healthcare professionals who helps in maintaining good health and healthy life style of living organisms. Microbiology is used in many aspects of daily life,including food production,biodegradation,manufacture of commercial goods and genetic engineering.
Programme Specific Outcomes (POs)	1	After completing this programme, Learner will be able to apply the knowledge of
		To become healthcare professionals for services in the field of hospital clinical laboratories,public health laboratories,blood banking & forensic laboratories.
	2	An ability for students to collaborative research and scientific theories and communication.
	3	An abilities to nurture analysis critical reasoning and use their creativity in the related areas to work effectively and efficiently in academics,pharmaceutics,chemical industries R & D.
	4	In designing & perform R & D in food industries,environmental areas,medical equipment companies and water plant.
	5	To expose students to the field of microbiology and other allied life science subjects and prepare them for promising career options in research industries and academics.
Eligibility Criteria for Programme		A. Any life science graduate with minimum score 50%. B. Science graduate with PGDMLT. C. Any agricultural technology graduate with minimum score 50%.
Intake (For SNDT WU Departments and Conducted Colleges)		60

Structure with course title

Year I

SN	Courses	Type of Course	Credits	Marks	Int	Ext
Semester I						
MIC.1101	Molecular Immunology(Th)	Major (Core)	4	100	50	50
MIC.1102	Bioinstrumentation Techniques & Application(Th)	Major (Core)	4	100	50	50
MIC.1103	Bioinstrumentation Techniques & Application(Pr)	Major (Core)	2	50	50	-
MIC.1104	Advanced Genetic Engineering(Th)	Major (Core)	4	100	50	50
MIC.1105/1106	*Microbial Physiology & Development(Th) OR. Bioenergetics & Molecular Enzymology(Th)	Major (Elective)	4	100	50	50
MIC.1107	Biostatics & Advanced Research Methodology In Microbiology(Th)	Minor Stream (RM)	4	100	50	50
End of Semester-I			**22**	**550**	**300**	**250**
Semester II						
MIC.2101	Advanced Clinical Virology(Th)	Major (Core)	4	100	50	50
MIC.2102	Food,Dairy Microbiology & Fermentation Process(Th)	Major (Core)	4	100	50	50
MIC.2103	Food,Dairy Microbiology & Fermentation Process(Pr)	Major (Core)	4	100	50	50
MIC.2104	Macromolecules & Molecular Enzymology(Th)	Major (Core)	2	50	50	-
MIC.2105	*Bioprocess Engineering & Technology(Th) OR Agricultural Microbiology(Th)	Major (Elective)	4	100	50	50
MIC.2106	Internship	OJT	4	100	50	50
End of Semester-II			**22**	**550**	**300**	**250**
Exit with PG Diploma in Microbiology						

Year II

SN	Courses	Type of Course	Credits	Marks	Int	Ext
	Semester III					
MIC.3101	Bioinformatics,Microbial Genetics & Proteomics(Th)	Major (Core)	4	100	50	50
MIC.3102	Bioinformatics,Microbial Genetics & Proteomics(Pr)	Major (Core)	4	100	50	50
MIC.3103	Enzyme Technology(Th)	Major (Core)	4	100	50	50
MIC.3104	Enzyme Technology(Pr)	Major (Core)	2	50	0	50
MIC.3105/3106	* Microbial Diversity(Th) OR Environmental Microbiology(Th)	Major (Elective)	4	100	50	50
MIC.3107	Dissertation II	RP	4	100	50	50
End of semester-III			**22**	**550**	**250**	**300**
Semester IV						
MIC.4101	Recombinant DNA Technology(Th)	Major (Core)	4	100	50	50
MIC.4102	Pharmaceutical Microbiology(Th)	Major (Core)	4	100	50	50
MIC.4103	Industrial Biotechnology(Th)	Major (Core)	4	100	50	50
MIC.4104/4105	*Environmental Biotechnology(Th) OR Advanced Medical Microbiology(Th)	Major (Elective)	4	100	50	50
MIC.4106	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.

1.1. Major (Core)

Course Title	**Molecular Immunology(Th)**
Course Credits	4
Course Outcomes	After going through the course, learners will be able to apply the knowledge of
	1. Basic understanding of the molecular aspects of Immunology.
	2.Analysis various immunological methods,immunogenetics.
	3.Study of the concept of tumor immunology and immunopathology
Module 1 (Credit 1): Immune System	
Learning Outcomes	1.Will be interpret the organs of the immune system. 2.Able to explain immune system cells & discuss active immunity and passive immunity. 3.Will be able to discuss immune response mechanisms.
Content Outline	• Organs and cells involved in immune system and immune response. • Lymphocyte their subpopulation ,their properties and functions. • Membrane bound receptors of lymph cells. • Helper T-Cell Suppression ,Lymphocyte trafficking
Module 2 (Credit 1):Antigens and Immunoglobulin	
Learning Outcomes	1.Able to discuss the concepts of antigen and antibody. 2.Will be define antigen and describe how antigens affect the adaptive defenses. 3.Able to discuss the properties of antigens.
Content Outline	• Antigens and Immunolglobulin. • Concept of haptens. • Conditions of antigenicity. • Antigens and Immunogenicity • Super antigens. • Structure,properties and classes of Immunoglobulin. • Theories of antibody formation.
Module 3 (Credit 1): Antigen-Antibody Reaction	

Learning Outcomes	1.Will be able to differentiate the antigens and antibodies combine by a process called agglutination. 2.Able to understand the fundamental reaction in the body by which the body is protected from complex foreign molecules, such as pathogens and their chemical toxins. 3.Will be analysis Antigen-antibody binding produces protective outcomes such as cross-linking, neutralization, opsonization, complement activation, immobilization, and cellular cytotoxicity.
Content Outline	• Antigen-antibody reaction by precipitation ,agglutination and complement fixation. • Non-specific immuno mechanism • **I**nflammatory reaction and hormones balance • Tissue metabolites with bacterial properties.
Module 4 (Credit 1):Expression & regulation of Immune Response:	
Learning Outcomes	1.Will be able to describe how the immune system is able to discriminate self vs. Non-self 2.Able to explain lymphocytes in human circulating blood are approximately 80 to 90 percent T cells, and 10 to 20 percent B cells. 3.Will be able to describe the methods of antibody conjugation, signal outputs, signal amplification and patient sampling commonly used in immunodiagnostic testing.
Content Outline	• Regulation of immune response. • Activation of B & T lymphocyte. • MHC registration. • Mechanism of T cells and NK cells. • Immunity and Immunoassay. • Immunodiagnostic and Immunotherapy in virology. • Serological methods for detection and quantitation of viruses.

Assignments/Activities towards Comprehensive Continuous Evaluation(CCE):

1. Demonstrate a working principle of health based organization.
2. Conduct a community survey for health assessment techniques.

References:

1. Essential of Immunology by Riott I. M. 1998. ELBS, Blackwell Scientific Publishers, London.

2. Immunology 2nd Edition by Kuby J. 1994. W. H. Freeman and Co. New York.

3. Immunology – Understanding of Immune System by Claus D. Elgert. 1996. Wiley – Liss , New York.

4. Fundamentals of Immunology by William Paul.

5. Cellular and Molecular Immunology. 3 rd Edition by Abbas.

1.2. Major (Core)

Course Title	**Bioinstrumentation Techniques and Application(Th)**
Course Credits	4
Course Outcomes	After going through the course, learners will be able to – 1.Design and build biomedical instruments that comply with the regulatory standards for medical devices. 2.Analysis the key considerations for biological signal generation and measurements. 3.Design and apply signal conditioning within the context of a biomedical device.
Module 1 (Credit 1):Basic Laboratory Instruments	
Learning Outcomes	1.Will be analyse the Laminar Airflow to separate volumes of air, or prevent airborne contaminants from entering an area. 2.Will be identify of common items as acid, base or neutral. Read a pH strip and identify as acid, base or neutral. Give characteristics of acids, bases and neutral substances. Understand what pH and pOH are measuring. 3.Will be handle the Centrifugation process.
Content Outline	• Basic laboratory instruments. • Principle and working of pH meter,Laminar air flow and centrifugation. • Types of centrifugation. • Sedimentation velocity. • Sedimentation equillibrium. • Density gradient methods and their application.
Module 2 (Credit 1):Chromatographic & Spectroscopy Technique:	
Learning Outcomes	1.Will be able to define chromatography. 2.Will be able to demonstrate an understanding of the process of chromatography. 3.Will be explain the steps involved in a chromatography investigation.
Content Outline	• Chromatographic techniques. • Theory,principle and application of following. • Paper chromatography • Thin layer chromatography • Gel filtration

	• Ion exchange • Affinity • Gas liquid • HPLC
Module 3 (Credit 1):Electrophoretic Technique	
Learning Outcomes	1.Will be able to identify key features of electrophoretic technique. 2.Will be demonstrate the principles of spectroscopic methods such as NMR, IR and UV-Vis.
Content Outline	• Electrophoretic and spectroscopic techniques • Theory,principle and application of electrophoresis. • Paper electrophoresis. • Starch gel agarose • Native and denaturing PAGE • Isoelectric focusing. • Techniques ,theory and application of UV,Visible,IR,NMR,Fluoresence,atomic absorption,CD,ORD,Mass and Raman Spectroscopy.
Module 4 (Credit 1):Radioisotopic Techniques	
Learning Outcomes	1.Will be able to study the radionuclide (radioactive nuclide, radioisotope or radioactive isotope) 2.Will be analyse the radioactive decay.
Content Outline	• Radioisotopic techniques. • Use of radioisotopic in life science • Radioactive labelling. • Principle and application of tracer techniques. • Detection and measurement of radioactivity using ionization chamber. • Proportional chamber. • Geiger Muller and Scintillation counter. • Application of autoradiography and dosimetry.

Assignments/Activities towards Comprehensive Continuous Evaluation(CCE):

1. Conduct a practical for studying the different instruments.
2. Present a report summarising role of specific instruments in biotechnology.

References:

1. Instrumental Methods of Analysis. 6th Edition by H.H. Willard, L.L. Merritt Jr. and

others. 1986. CBS Publishers and Distributors.

2. Instrumental Methods of Chemical Analysis. 1989 by Chatwal G and Anand, S.

Himalaya Publishing House, Mumbai.3. A Biologists Guide to Principles and Techniques of Practical Biochemistry. 1975 by

Williams, B.L. and Wilson, K.

3. Spectroscopy. Volume 1. Edited by B.B. Straughan and S. Walker. Chapman and Hall

Ltd.

4. Gel Electrophoresis of Proteins- A Practical Approach by Hanes.

5. Chromatography: Concepts and Contrasts- 1988 by James Miller. John Wiley and Sons. Inc., New

York.

1.3. Major (Core)

Course Title	**Bioinstrumentation Techniques and Application(Pr)**
Course Credits	**2**
Course Outcomes	After going through the course, learners will be able to – 1.Describe the applications of bioinstruments & methodology involved in biotechniques 2.Demonstrate knowledge and practical skills of using instruments in biology and medical field 3.Perform techniques involved in molecular biology and diagnosis of diseases.
Learning Outcomes	1.Will be explain the electro-analytical techniques and spectroscopic techniques. 2.Able to describe the application and methodology involved in different types of chromatographic techniques. 3.Will be able to demonstrate the usage of CD, ORD, Fluorescence, Mass, NMR, ESR and Atomic absorption spectroscopy.
Content Outline	• Studies on pH titration curves of amino acids/ acetic acid and determination of pKa values and Handerson-Hasselbach equation. • Separation of bacterial lipids/amino acids/sugars/organic acids by TLC or Paper Chromatography. • Separation of serum protein by horizontal submerged gel electrophoresis. • Study of UV absorption spectra of macromolecules (protein, nucleic acid, bacterial pigments). • Quantitative estimation of hydrocarbons/pesticides/organic Solvents /methane by Gas chromatography. • Demonstration of PCR, DNA sequencer. • Separation of haemoglobin or blue dextran by gel filtration. • Paper electrophoresis. • Density gradient centrifugation.

Assignments/Activities towards Comprehensive Continuous Evaluation(CCE):

1. Conduct a industrial visit for studying the different instruments.
2. Present a report on role of instruments technician in industries.

1.4. Major (Core)

Course Title	**Advanced Genetic Engineering (Th)**
Course Credits	4
Course Outcomes	After going through the course, learners will be able to -
	1. Understanding the basic steps of gene cloning and the role of enzymes and vectors responsible for gene manipulation, transformation and genetic engineering.☐☐
	2.Learning the detailed knowledge of gene transfer methods and identifying suitable hosts for cloning.
	3.Describes the genome mapping and sequencing and methods for gene therapy.
Module 1 (Credit 1):Recombination	
Learning Outcomes	1.Learners will be able to understand the recombination process results in genetic diversity at the gene level. 2.Able to understand recombination produces individuals as a result of the fertilization of haploid male and female gametes. 3.Able to understand recombination DNA technology comprises altering genetic material outside an organism to obtain enhanced and desired characteristics in living organisms or as their products.
Content Outline	• Recombination between hetro duplex DNA. • Protein involved in recombination • Role of recA & recBCD. • Single strand assimilation in bacteria. • Conjugation in bacteria. • Transduction generalized & specialized mechanism. • Transposomes insertion sequences & composite transponse.
Module 2 (Credit 1):Gene Expression	
Learning Outcomes	1Learners will be understand lac operon, lactose acts as an inducer. 2. Able to understand the inducer will bind to the repressor protein and render it inactive which allows transcription of the operon. 3.Will be able to understand Gene expression is the process by which the instructions in our DNA are converted into a functional product, such as a protein.
Content Outline	• Prokaryote:Operon concept. • Cordinated control structural genes.

	• Repressor protein & their functions. • Operations & other DNA elements of regulations. • Positive & negative control of an operon. • Transcriptional activator as positive regulators of gene expression. • Obstream factors. • Identifying gene under common regulations.
Module 3 (Credit 1):Isolation,Identification & Characterization of DNA Organisms	
Learning Outcomes	1.Learners will be understand restriction enzyme, a protein produced by bacteria that cleaves DNA at specific sites along the molecule. 2.Able to explain various DNA modifying enzymes used in genetic engineering. 3.Able to define the terms plasmid and vector in your own words. 4.Able to distinguish the types of plasmids covered here based on copy number, host range, and purpose. 5.Able to describe and explain blue-white selection.
Content Outline	• Restriction endonucleases,typeI,II,III. • Recognition sequences. • Properties,nomenclature of classification of type II endonucleases, their activities,restriction & mapping. • Enzymes used in genetic engineering. • DNA sequencing: De oxy method Automated sequencing. • Plasmids: Plasmids ,Vectors properties. • Promotor vectors runway plasmid vectors. • Bacteriophage as essential features organization of genome general structure. • Cloning strategies.
Module 4 (Credit 1):Clonning Vectors in E.Coli & Others Organism	
Learning Outcomes	1.Learners will be perform transformation is a key step in DNA cloning. 2.Will be understand to transformation, bacteria are selected on antibiotic plates. 3.Will be differentiate cloning vector and expression vectors
Content Outline	• E.Coli expression vectors.

	• Stability of protein fusion proteins & their applications. • Bacillus: Transformation techniques plasmid and vectors. • Expression.excretion and shuttle vectors. • Streptomyces:Transformation ,plasmid and vectors,expression vectors and phage vectors. • Yeast: Genetic markers and selection system, yeast integrating,replication,episomal vectors,yeast artificial chromosomes,expression vectors.

Assignments/Activities towards Comprehensive Continuous Evaluation(CCE):

1. Demonstrate a visual representation for pathway of assessment of genetic engineering.
2. Prepare a report on scope and application of genetic engineering.

References:

1. Benjamin lewin-gene-Vi gene-VIIOxford university press.
2. David Frider-Essentials of molecular biology.
3. J.Kendrew-Encyclopedia of molecular biologyBlackwell Pub.
4. Weaver molecular biology.
5. J D Watson,N H Hopkins,JW Roberts, Molecular Biology of the gene.

1.5. Major (Elective)

Course Title	**Microbial Physiology & Development(Th)**
Course Credits	4
Course Outcomes	After going through the course, learners will be able to -
	1. Apply the knowledge to understand the microbial physiology and to identify the microorganisms.
	2. Understand the regulation of biochemical pathway and possible process modifications for improved control over microorganisms for microbial product synthesis.
	3.Describe diversity of microorganisms, bacterial cell structure and function, microbial growth and metabolism, and the ways to control their growth by physical and chemical means.
Module 1 (Credit 1):Bacterial Photosynthesis	
Learning Outcomes	1.Learners will be describe the function and locations of photosynthetic pigments in eukaryotes and prokaryotes 2.Able to describe the major products of the light-dependent and light-independent reactions 3.Able to describe the reactions that produce glucose in a photosynthetic cell 4.Will be compare and contrast cyclic and noncyclic photophosphorylation
Content Outline	• Photosynthesis:Energy consideration in photosynthesis, light and dark reaction, electron carriers in photosynthesis, Organization of photo system I and II, cyclic and non-cyclic flow of electrons, Z scheme, Hill reaction, photolysis of water. • Bacterial photosynthesis:scope, electron carriers, Photosynthetic reaction center, cyclic flow of electrons, bacterial photophosphorylation in various groups of phototrophic bacteria, electron donors other than water in anoxygenic photosynthetic bacteria.
Module 2 (Credit 1):Bacterial Respiration	

Learning Outcomes	1.Learners will be recognise that respiration is similar to combustion and that heat energy is released. 2.Will be understand that energy in the form of ATP is used to drive reactions in cells. 3.Will be discuss which components are necessary for the production of energy. 4.Able to identify the key energy molecule of the body. Understand which type of cellular respiration produces more energy. Build a model representation of ATP and ADP. 5.Able to understand that there are two different pathways for anaerobic respiration.
Content Outline	• Bacterial Respiration: • Aerobic Respiration: Mitochondrial electron transport chain, structure and function of ATPase (bacterial and mitochondrial), generation and maintenance of proton motive force, oxidative phosphorylation, inhibitors and un-couplers of electron transport chain and oxidative phosphorylation, Atkinson's energy charge, phosphorylation potential and its significance, Energy generation in all groups of chemolithotrophs. • Anaerobic Respiration: Concept of anaerobic respiration, oxidized sulfur compounds, and nitrate as electron acceptor with respect to electron transport chain and energy generation, Biochemistry of methanogenesis, Biochemistry of ammonia oxidation, ammonia oxidation by members of Genus Nitroso group, nitrite oxidation by Nitro group of genera.
Module 3 (Credit 1):Bacterial Permeation and Bacterial Sporulation	
Learning Outcomes	1.Learners will be study the cell wall can help us understand how pathogens evade our defences and how key antibiotics such as penicillin work. 2.Will be understand sporulation occurs in organisms across the tree of life from bacteria and protozoa to plants and fungi and facilitates both survival in response to adverse growth conditions and dispersal to new, more hospitable environments.
Content Outline	• Bacterial Permeation : • Structure and organization of membrane (Glyco-conjugants and proteins in membrane systems), fluid mosaic model of membrane. • Methods to study diffusion of solutes in bacteria, passive diffusion, facilitated diffusion, different mechanisms of active diffusion (Proton Motive Force, PTS, role of permeases in transport, different permeases in E. Coli. Transport of amino acids and inorganic ions in microorganisms and their mechanisms. • Bacterial Sporulation:Sporulating bacteria, molecular architecture of spores, induction and stages of sporulation, Influence of different

	factors on sporulation. ● Cytological and macromolecular changes during sporulation. Heat resistance and sporulation.
Module 4 (Credit 1):Bacterial Chemolithotrops	
Learning Outcomes	1.The generation of energy (via ATP) and the generation of reducing power (via NADH). 2.Able to describe the role nitrogen fixation plays in distributing atmospheric nitrogen to life on the planet. 3.Able to identify ways humans and plants use nitrogen.
Content Outline	● Physiological groups of chemolithotrophs, Oxidation of molecular hydrogen by Hydrogenomonas species. Ferrous and sulfur/sulfide oxidation by Thiobacillus species. ● Biochemistry of biological nitrogen fixation, properties of nitrogenase and its regulation, ammonia assimilation with respect to glutamine synthetase, glutamate dehydrogenase, glutamate synthetase, their properties and regulation.

Assignments/Activities towards Comprehensive Continuous Evaluation(CCE):

1. Presentation and group discussion
2. Written assignments

References:

1. Microbial Physiology and Metabolism by Caldwell D.R. 1995Brown Publishers.

2. Microbial Physiology by Moat A.G. and Foster J. W. 1999. Wiley.

3.Prokaryotic Development by Brun. Y.V. and Shimkets L.J. 2000. ASM Press.

4. Advances in Microbial Physiology. Volumes. Edited by By A.H. Rose. Academic Press, New York.

5. Applied Microbial Physiology by Rhodes.

6. Biosynthesis by Smith.

1.6. Major (Elective)

Course Title	**Bioenergetics and Molecular Enzymology(Th)**
Course Credits	4
Course Outcomes	After going through the course, learners will be able to -
	1.Understand the free energy and high energy compounds.
	2.Acquire the knowledge on Biological oxidation.
	3.Outline the major pathways in carbohydrate metabolism
	4.Learn about lipid metabolism and its importance.
	5.Explore on basic reactions and its concepts in protein metabolism.
Module 1 (Credit 1):Carbohydrate catabolic pathway & Microbial Growth on C1 compound	
Learning Outcomes	1.Learners will be describe why glycolysis is not oxygen dependent 2.Will be define and describe the net yield of three-carbon molecules, ATP, and NADH from glycolysis 3.Will be explain how three-carbon pyruvate molecules are converted into two-carbon acetyl groups that can be funneled into the Krebs cycle. 4.Will be define and describe the net yield of CO_2, GTP/ATP, $FADH_2$, and NADH from the Krebs cycle 5.Will be explain how intermediate carbon molecules of the Krebs cycle can be used in a cell
Content Outline	• Carbohydrate catabolic pathways and microbial growth on C1 Compounds: EMP, HMP, ED, Phosphoketolase pathway, TCA cycle, Glyoxylate bypass. • Anaplerotic sequences, catabolism of different carbohydrates (Fructose, Lactose, Manose, Allose, Gluconate, Manitol, Sorbitol, Arabinose, Xylose), Polyol, glycol and 2,3 butanidiol metabolism, regulation of aerobic and anaerobic carbohydrate metabolism, Microbial growth on C1 Compounds (Cyanide, Methane, Methanol, methylated amines and carbon monoxide) with reference to microorganisms and biochemical reactions with enzymes involved.
Module 2 (Credit 1):Endogenous metabolism and degradation of aliphaticand aromatic compounds	
Learning Outcomes	1.Learners will be understand the aliphatic hydrocarbons are the alkanes, alkenes and alkynes. Hydrocarbons are source of energy to heat and light that engages us in our daily life and activities. 2.Will be also provide almost every plastic items, the fuel for our vehicles and a major ingredient of the food that we consume. 3.Able to understand in aliphatic compounds, reactions of functional groups are often modified very significantly by an adjacent carbonyl group.

Content Outline	• Endogenous metabolism and degradation of aliphatic and aromatic compounds. • Functions of endogenous metabolism, types of reserve materials, enzymatic synthesis, degradation and regulation of reserve materials – glycogen, polyphosphates and polyhydroxybutyrate (PHB), PHB production and its futuristic applications. Microbial degradation of aliphatic hydrocarbons (microorganisms involved, mon-terminal, biterminal oxidation of propane, decane, etc.) and aromatic hydrocarbons and aromatic compounds (via catechol, protocatechuate, meta-cleavage of catechol and protocatechuate, dissimilation of catechol and protocatechuate, homogentisate and other related pathways).
Module 3 (Credit 1):Enzyme Properties	
Learning Outcomes	1.Learners will be define the term 'enzyme' 2.Will be explain that enzymes only work on a single substrate. 3.Will be explain that enzymes function by lowering the activation energy for biochemical reactions. 4.Will be identify name and describe at least one way that cells control enzyme activity. 5.Able to explain that enzymes function by lowering the activation energy for biochemical reactions.
Content Outline	• Properties of Enzymes:Classification of enzymes into six major groups with suitable examples. Numerical classification of enzymes. • Different structural conformations of enzyme proteins (Primary, secondary, tertiary and quaternary structures). Forces that mentain protein structures. Sources of enzyme. Enzymes as biocatalysts, catalytic power, activation energy, substrate specificity, active site, theories of mechanisms of enzyme action (Induced fit and lock and key). • Mechanism of action of lysozyme, chymotrypsin and ribonuclease. Monomeric, Oligomeric and multienzyme complex, isozymes and allosteric enzymes. Extremozymes – thermostable, solventogenic and non- aqueous enzymes. Synthetic enzymes, Ribozymes and abzymes
Module 4 (Credit 1):Enzyme Kinetics	
Learning Outcomes	1.Learners will be explain working principle of enzymes 2.Learners will be explain the factors that affect enzyme activity 3.Will be explain the properties of enzyme-catalysed reactions 4.Will be discuss Michaelis-Menten kinetics 5.Will be explain the Lineweaver-Burke graphic
Content Outline	• Enzyme kinetics:Importance of enzyme kinetics, factors affecting

	rates of enzyme mediated reactions (pH, temperature, substrate concentration ,enzyme concentration and reaction time). ● Derivation of Michaelis – Menton equation and its significance in enzyme kinetic studies. Lineweaver-Burke plot, Haldane-Briggs relationship, sigmoidal kinetics steady state kinetics and transient phases of enzyme reaction.

Assignments/Activities towards Comprehensive Continuous Evaluation(CCE):

1. Visual representation of different pathways involving enzymes
2. Graphical representation of different enzyme kinetics with group discussion

References:

1. Understanding Enzymes by Trevor Palmer

2. Enzyme Kinetics by Paul Engel. 1977. John Wiley and Sons. Inc., New York.

3. Enzymes by Dixon and Webb, 3 rd Edition 1979. Academic Press, New York

4. Biochemistry by Stryer 5^{th} Edition WH Freeman 2001

5. Laboratory techniques in Biochemistry and Molecular Biology by Work and Work.

1.7. Minor Stream (Research Methodology)

Course Title	**Biostatistics and Advanced Research Methodology in Microbiology(Th)**
Course Credits	4
Course Outcomes	After going through the course, learners will be able to -
	1. Develop the ability to apply the methods while working on a research project work.
	2.Describe the appropriate statistical methods required for a particular research design.
	3.Choose the appropriate research design and develop appropriate research hypothesis for a research project.
	4. Develop a appropriate framework for research studies
Module 1 (Credit 1):Introduction of Biostatics	
Learning Outcomes	1.Learners will be recognize, describe, and calculate the measures of location of data: quartiles and percentiles. 2.Able to recognize, describe, and calculate the measures of the center of data: mean, median, and mode. 3.Able to recognize, describe, and calculate the measures of the spread of data: variance, standard deviation, and range.
Content Out line	• Introduction to Biostatistics: Basic definitions and applications. Sampling: Representative sample, sample size, sampling bias and sampling techniques. • Data collection and presentation : Types of data, methods of collection of primary and secondary data, methods of data presentation, graphical representation by histogram, polygon, ogive curves and pie diagram.
Module 2 (Credit 1):Central Tendancy:Mean,Median and Mode	
Learning Outcomes	1.Learners will be calculate the mean, median, and mode of a set of data. 2.Will be calculate the range of a data set, and recognize it's limitations in fully describing the behavior of a data set. 3.Will be calculate the standard deviation for a data set, and determine it's units. 4.Able to estimates the model using LSE. 5.Will be revaluate the regression model. 6.Will be determines standard error, variance, correlation coeficient of the estimate and interprets them.

Content Outline	• Measures of central tendency: • Mean, Median, Mode. Measures of variability: Standard deviation, standard error, range, mean deviation and coefficient of variation. Correlation and regression: Positive and negative correlation and calculation of Karl-Pearsons co-efficient of correlation. • Linear regression and regression equation and multiple linear regression, ANOVA, one and two way classification. Calculation of an unknown variable using regression equation. • Tests of significance: Small sample test (Chi-square t test, F test), large sample test (Z test) and standard error. Introduction to probability theory and distributions, (concept without deviation) binomial, poison and normal (only definitions and problems) Computer oriented statistical techniques. Frequency table of single discrete variable, bubble spot, computation of mean, variance and standard Deviations, t test , correlation coefficient
Module 3 (Credit 1):Advance Research Methodology	
Learning Outcomes	1.Learners will be demonstrate the ability to choose methods appropriate to research aims and objectives. 2.Able to understand the limitations of particular research methods. 3.Able to develop skills in qualitative and quantitative data analysis and presentation. 4.Able to develop advanced critical thinking skills.
Content Outline	• Research Methodology :Research institutes, research schemes (minor and major), preparation of research scheme proposals, formats, funding agencies. • scientific writing: research article, dissertation, review, abstract, synopsis, technical report. Literature search, analysis of scientific report, compilation of data, presentation of experimental data, tabulation, graph, diagrams, histograms, interpretation of tables, graphs, photographs, and diagrams.
Module 4 (Credit 1):Review of Literature & Report Writing	
Learning Outcomes	1.Learners will be identify the elements of a literature review and can state in writing the purpose and process of the literature review as they relate to the research process. 2. Learners can search for and access information in multiple formats and use found sources to mine for additional sources 3.Will be identify strengths and weaknesses &understand the functions of essays and reports. 4.Able to demonstrate writing skills. 5.Able to summarize accurately reflect the body of the report offer an interpretation consistent with the findings in the summary Present recommendations that are consistent with the report's purpose, evidence, and interpretations

Content Outline	• Review of Literature Essential constituents of Literature Review in Microbiology Need for Reviewing Literature What to Review and for what purpose Literature Search Procedure Sources of Literature in Microbiology Planning of Review work Note Taking, Library and documentation • Planning of Research and sampling The planning process Selection of a Problem for Research Hypothesis formation Measurement, Research design and plan Sampling Techniques or Methods Choice of sampling Techniques Sample size Sampling and Non-Sampling errors, Estimation Mean, Estimation of Standard Error and Confidence Interval • Data collection and analysis Types of Data Collection of data Processing of dsata Tabulation Graphical representation Statistical softwares used. • Report/Project writing Types of Reports Planning of Report Writing Documentation Data and Data Analysis Reporting in a Thesis Writing of project, Funding agencies.

Assignments/Activities towards Comprehensive Continuous Evaluation(CCE):

1. Recognize different Types of variables.
2. Hypothesis formations and research questions from Research readings – students identify hypothesis/research questions – Discussion
3. Construction of tools for data collection a) types of questions b) Questionnaire c) interview schedule d) observation d) scales
4. For a given topic students to frame and discuss the different possibilities of methods and tools
5. Differentiate between (a) basic and applied research (Exercise to be based on actual research papers published in accredited journals) (b) qualitative and quantitative research
6. Based on Journal contents undertake a critical appraisal of studies/research papers and discuss types of Research with examples.

References:

1. Statistics in biology, Vol. 1 by Bliss, C.I.K. (1967) Mc Graw Hill, NewYork.

2. Practical Statistics for experimental biologist by Wardlaw, A.C. (1985).

3. Statistical Methods in Biology – 2000 by Bailey, N.T. J. English Univ. Press.

4. Biostatistics – 7th Edition by Daniel

5. Fundamental of Biostatistics by Khan

6. Biostatistical Methods by Lachin

Semester II

2.1. Major (Core)

Course Title	**Advanced Clinical Virology(Th)**

Course Credits	4
Course Outcomes	After going through the course, learners will be able to -
	1.Understand the architecture of viruses, their classification and the methods used in their study.
	2.Discern the replication strategies of representative viruses from the seven Baltimore classes and comprehend the intricate interaction between viruses and host cells
	3.Comprehend the role of viruses in oncogenesis, and ways of preventing/ treating viral infections.
	4.Know how viruses can be used as tools to study biological processes, as cloning vectorsand for gene transfer.
Module 1 (Credit 1):Classification,Morphology and Cultivation of Viruses	
Learning Outcomes	1.Learners will be able to contrast differences in virus architecture and classification. 2.Will be able to identify diagram transmission and replication for medically important viruses. 3.Will be distinguish characteristics of normal cells and virus-infected cells. 4.Able to explain and apply methods used in research and diagnosis of viral diseases.
Content Outline	• Classification and Morphology of Viruses: Brief outline on discovery of viruses. Classification and nomenclature of animal and plant viruses.Cataloging the virus through virus classification schemes of ICTV / ICNV. Morphology and ultrastructure of viruses. Virus related agents, viroids and prions. • Cultivation and assay of viruses (0.8 Credits) Cultivation of viruses using embryonated eggs, experimental animals and cell cultures (Cell-lines, cell strains and transgenic systems). Purification of viruses by adsorption, precipitation, enzymes, serological methods – haeme agglutination and ELISA. Assay of viruses – Physical and Chemical methods (Electron Microscopy and Protein and Nucleic acids studies). Infectivity Assays (Plaque and end-point) Infectivity of plant viruses. Genetic analysis of viruses by classical genetic methods.
Module 2 (Credit 1):Viral Multiplication	
Learning Outcomes	1.Learners will be understand releases and replicates its genome while facilitating the manufacture of its proteins by host ribosomes. 2.Will be understand many virus infections result in no disease in the host, while at the other end of the scale a virus infection may result in fatal disease, such as rabies or AIDS. 3.Able to identify disease may be manifest as symptoms and/or signs.

Content Outline	● Viral Multiplication:Bacteriophages – Lytic and lysogenic replication Animal viruses - Mechanism of virus adsorption and entry into the host cell DNA and RNA viruses– Mechanism of genome replication Transcription, post transcriptional changes, translation, assembly, exit and maturation of progeny virions.
Module 3 (Credit 1):Viral Pathogenesis	
Learning Outcomes	1.Learners will be understand productive infections result in the formation of progeny virus and usually cause the destruction of the host cell. 2.Able to understand in some cases the host cells are not all destroyed, leading to persistent infections in which the surviving cells multiply and continue to produce progeny viruses.
Content Outline	● Pathogenesis of Viruses:Host and virus factors involved in pathogenesis, patterns of infection, pathogenesis of animal viruses Adenovirus, Herpes virus, Picorna virus, Poxvirus and Orthomyxovirus, pathogenesis of plant [TMV] Satellite viruses and their role in plant virus replication. Insect viruses [NPV] Viruses pathogenic to algae and fungi.
Module 4 (Credit 1):Control of Viruses & Emerging Viruses	
Learning Outcomes	1.Learners will be understand direct cell damage and death from viral infection may result from diversion of the cell's energy 2.Will be understand shutoff of cell macromolecular synthesis, Competition of viral mRNA for cellular ribosomes,. 3.Will be identify competition of viral promoters and transcriptional enhancers for cellular transcriptional factors such as RNA
Content Outline	● Control of Viruses and Emerging Viruses:Control of viral infections through vaccines and chemotherapeutic agents. Viruses neutralization by antibody and interferons

Assignments/Activities towards Comprehensive Continuous Evaluation(CCE):

1. Visit to different virology lab for diagnosis of diseases.
2. Prepare a report on different types of virological diseases**.**

References:

1. Medical virology 10th edition by Morag C and Tim bury M C 1994.. Churchil Livingstone , London.

2. Introduction to modern virology 4 th Edition by Dimmock N J, Primrose S. B. 1994. Blackwell scientific publications. Oxford.

3. Virology 3rd edition by Conrat H. F. ., Kimball P. C. And Levy J. A. 1994. Prentice Hall, Englewood Cliff, New Jersy.

4. Text Book on Principles of Bacteriology, Virology and Immunology, Topley and Wilson 1995.

5. Molecular Biology, Pathogenesis and Control by S. J. Flint and others. ASM Press, Washington , D. C.

6. Applied Virology. 1984. Edited by Ednord Kurstak. Academic Press Inc.

2.2. Major (Core)

Course Title	**Food and Dairy Microbiology(Th)**
Course Credits	4
Program Outcomes	After going through the course, learners will be able to -
	1.Understand the beneficial role of microorganisms in food processing and the microbiology of different types of fermented foods – pickles, bread, Idli, Tempeh etc.
	2.Study the different types of microorganisms in milk and their activities - fermented dairy products and spoilage and their applications as probiotics
	3.Understand the significance and activities of microorganisms in various food and role of intrinsic and extrinsic factors on microbial growth in foods leading to spoilage, and understand the principles underlying the preservation methods.
	4.Recognize and describe the characteristics of important food borne pathogens and Learn various methods for their isolation, detection and identification
	5.Understand of the basis of food safety regulations and discuss the rationale for the use of standard methods and procedures for the microbiological analysis of food.
Module 1 (Credit 1):Food & Dairy Microbiology	
Learning Outcomes	1.Learners will be to provide instruction in the general principles of food microbiology. 2.Students will have received adequate introduction to microbiology per sector. 3.Learners will be understand the biology and epidemiology of foodborne microorganisms of public health significance, including bacteria, yeasts, fungi, protozoa and viruses, and food spoilage microorganism.
Content Outline	● Advanced Food and dairy Microbiology:Genetically modified foods. Probiotic role of lactic acid bacteria and fermented milk products. Biosensors in food, Applications of microbial enzymes in food and dairy industry [Protease, Lipases] ● Microbial anti oxidants, biosurfactants as emulsifiers, microbial polysaccharides as stabilizers and thinkers, flavors (esters, diaacetyl, pyrazines, lactones and terpenes, monosodium glutamate and microbial colors from molds). ● Production and application of Bakers Yeast, Tea, coffee and vinegar fermentation
Module 2 (Credit 1):Food Presevation and Spoilage of Food	

Learning Outcomes	1.Will be able to compare the methods of preservation of animal food. 2.Will be able to comprehend the reason for food spoilage. 3.Will be able to comprehend the principles of preventing contamination and the removal of microorganisms methods used for food safety 4.Will be able to study the types of food spoilage. 5.Will be able to discuss the different microflora present in fresh foods. 6.Able to discuss the principle of food preservation and the different methods of food preservation.
Content Outline	● Food preservation methods and utilization of dairy waste: ● Food preservation by Radiations (UV , Gamma and microwave) ● Food preservation by low and high Temperature, chemicals and naturally occurring antimicrobials ● Biosensors in food industry. Utilization and disposal of dairy by-product - whey ● Food spoilage and Quality assurance: ● Food borne infections and intoxications; bacterial with examples of infective and toxic types –, Clostridium, Salmonella, Shigella, Staphylococcus, Campylobacter, Listeria. Mycotoxins in food (Types, structures, producer organism and its toxicity). ● Quality assurance: Microbiological quality standards of food. Government regulatory practices and policies. FDA, EPA, HACCP, ISI
Module 3 (Credit 1): Food Fermentation	
Learning Outcomes	1.Learners will be able to understand the three products have all gone through fermentation. 2.Will be able to study fermentation is a process done by microorganisms, such as bacteria and yeast, in an anaerobic environment in which they break down a sugar. 3.Able to understand the results in carbon dioxide (what gives many fermented products their fizziness) and either alcohol and/or an acid.
Content Outline	● Introduction, food fermentation, the science and technology. ● Oriental fermented foods (Soya sauce, Natto, Miso), Cerel products, mixed preparations (Idle, Dhokala, Khamang, Papadam and Jilebies), Fermented cassaea flour, fermented pea nut milk, and grape based fermented products- wine (pre fermentating, fermentative and post fermentative practices, general methods of wine preparations) , Fermented vegetables – Saurkraut, Fermented Meat – Sausages.

Module 4 (Credit 1):Industrial Food Fermentation	
Learning Outcomes	1.Learners will be explain the process of fermentation in making beer, wine, and liquors. distinguish similarities and differences in yeast fermentation. explain how distillation is used to create a higher alcohol content in liquors. 2.Will be characterize different types of beneficial microorganisms that can be incorporated in the development of fermented dairy foods. 3.Will be implement improvement strategies to develop better starters for dairy industry. 4.Will be prepare different types of fermented milk products possessing nutritional and therapeutic benefits.
Content Outline	• Taxonomy of lactic acid bacteria present in fermented products,. Acid fermented milks(Acidophilus milk, yoghurt). Slightly acid fermented milks (Cultured butter milk), Acid-alcoholic fermented milk (Kefir). Fermented milk production with extended self life (labneh). Starter cultures for fermented dairy products (Strptococcus thermophillus, Lactobacillus bulgaricus,). • Metabolism of starter cultures, biochemical changes in fermented milk (Fermentation of lactose to lactic acid, production of aromatic compounds, hydrolysis of proteins and lipids and Vit. B content).Cheese- biological entities in cheese systems (Milk, microorganisms, enzymes and other additives). Cheese production (Milk quality and composition, steps involved in mfg of cheese, preservation, Classification and nutritional aspects)

Assignments/Activities towards Comprehensive Continuous Evaluation(CCE):

1. Demonstrate the growth of microbes on specified media and list the factors affecting its growth.
2. Summarise/ Present a report on various food preservation techniques employed at the industrial level.

References:

1. Food Microbiology. 2nd Edition By Adams

2. Basic Food Microbiology by Banwart George J.

3. Food Microbiology: Fundamentals and Frontiers by Dolle

4. Biotechnology: Food Fermentation Microbiology, Biochemistry and Technology. Volume 2 by Joshi.

5. Fundamentals of Dairy Microbiology by Prajapati.

6. Essentials of Food Microbiology. Edited by John Garbult. Arnold International Students Edition.

7. Microbiology of Fermented Foods. Volume I and II. By Brian J. Wood.Elsiever Applied **Science Publication.**

2.3. Major (Core)

Course Title	**Food and Dairy Microbiology(Pr)**
Course Credits	**4**
Course Outcomes	After going through the course, learners will be able to -
	1.Perform methods for isolation, detection and identification of microorganisms in milk..
	2. Identify the spoilage microorganisms in fruits & vegetables, bread, mushrooms and analyze methods to control deterioration and spoilage
	3.Identify and analyze the microbes of canned foods.
	4.Perform and analyze the effect of temperature on the spoilage of food products.
Learning Outcomes	1.Recall the history of microorganisms in food. 2.Identify the microorganisms found in food. 3.Explain the factors that affect microbial growth in food. 4.Discuss microbial spoilage of food. 5.Experiment the techniques in control of food spoilage. 6.List foodborne diseases. 7. Differentiate foodborne infection and intoxication. 8.Practice the methods for microbial examination for food. 9.Identify the importance and properties of indicator organisms. 10.Explain the principle of quality control. 11.Discuss the role of HACCP in food safety. 12.Identify the codes of good manufacturing practices
Content Outline	• Production and estimation of lactic acid by Lactobacillus Sp. Or Streptococcus Sp. • Extraction and estimation of diacetyl. • Sauerkraut fermentation • Isolation of food poisoning bacteria/ fungi from contaminated foods, Dairy products • Extraction and detection of afla toxin for infected foods. • Preservation of potato/onion by UV radiation • Production of fermented milk by Lactobacillus acidophilus. • Rapid analytical techniques in food quality control using microbial Biosensors. • Production of Youghart.

Assignments/Activities towards Comprehensive Continuous Evaluation(CCE):

1. Demonstrate the role of each microorganism for human health.
2. Summarise the effect of preservation of potato/onion by UV radiation

2.4. Major (Core)

Course Title	Macromolecules & Molecular Enzymology(Th)
Course Credits	**2**
Course Outcomes	After going through the course, learners will be able to -
	1.Describe structure, functions and the properties of protein .
	2.Explain biosynthesis of nucleic acids, structure of DNA & RNA
	3. Have a deeper insight in to the fundamentals of enzyme structure and function and kinetics of soluble and immobilized enzymes. Discussion on current applications and future potential of enzymes
Module 1 (Credit 1):Biosynthesis of Protein & Nucleic Acid	
Learning Outcomes	1.Learners will be understand biochemical identification of the genetic material 2.Will be describe the experiments that demonstrated that DNA is the genetic material. 3.Will be explain how the contributions of Wilkins and Franklin, Watson and Crick, and Chargaff resulted in understanding the structure of DNA. 4.Will be describe the importance of covalent bonds and hydrogen bonds to the structure of a DNA molecule. 5.Will be explain the results of the Meselson-Stahl experiment and describe the predicted results if DNA replication followed the other possible models. 6.Will be describe the relationship between the structure of a DNA molecule and the means by which DNA is replicated.
Content Outline	• Classification,structure and general reaction of protein on amino acids. • Primary,secondary,tertiary & quaternary structure of protein. • Sequencing of protein,protein folding. • Regulation and metabolic disorder of amino acid. • Sources of organic nitrogen. • Flow of Nitrogen into the catabolism of amino acids. • Urea cycle & excretion of nitrogen. • Biosynthesis & regulation of nucleic acid. • Structure of DNA & RNA.
Module 2 (Credit 1):Activity of Enzymes and Applied Enzymology	

Learning Outcomes	1.Learners will be understand enzymes are the functional units of cell metabolism. 2. Learners will be understand enzymes are the proteins that speed up the metabolism in our bodies. 3.Will be understand the various classification of enzymes and the overview and definition of enzymes helps to know catalytic activity in chemical reactions
Content Outline	• Classification & nomenclature of enzymes. • Theories & mechanism of enzyme action. • Enzyme kinetics,enzyme inhibition & enzyme parameters. • Factors affecting enzyme activity & enzyme immobilization by different methods & their applications. • Uses of enzymes in different industries. • Uses of purified enzymes in biosensors. • Enzyme analysis and other application of biosensors.
1.	

Assignments/Activities towards Comprehensive Continuous Evaluation(CCE):

1. Analyze a report on different types of enzymes with its application
2. Seminar presentation on enzyme activity

References:

1. Protein Purification techniques Edt. Simon Roe, Oxford University Press.
2. Cohn & Stump-outline of Biochemistry, Wiley Easter ltd.
3. Harper's review of Biochemistry-Prentice Hall.
4. Plummer-Practical Biochemistry.
5. J.Jayaman-Practical Biochemistry.
6. Luber Stryer-Biochemistry.

2.5. Major (Elective)

Course Title	**Bioprocess Engineering & Technology**
Course Credits	4
Course Outcomes	After going through the course, learners will be able to -
	1.Explain how separations, mass transfer, fluid dynamics and biocatalysis principles are applied in bioprocessing.
	2.Assess the performance of bioprocessing operations including cell processing, product extraction and purification and troubleshoot operational problems.
	3.Demonstrate an understanding of the socio-economic context of advanced bioprocessing, such as quality control and assurance, regulatory and ethical responsibilities, in assessing complex problems.
	4.Solve open-ended problems by investigating emerging trends in the field and identifying and proposing creative processes.
Module 1 (Credit 1):Introduction to Industrial Bioprocess Engineering	
Learning Outcomes	1.Learners able to acquire a sound knowledge in mathematics and natural science and apply engineering principles in determining and solving contemporary and complex problems related to bioprocessing. 2.Will be understand the processes that take living cells or their components to make products, typically for commercial use – anything from food to biofuels to pharmaceuticals. 3.will be understand the during batch culture, a typical bacterial growth curve shows five distinct phases of growth.
Content Outline	• Introduction to Industrial Bioprocess Engineering: • Definition of bioprocess engineering, bioprocess engineer, biotechnology and bioprocess engineering, approach of biologist and engineers towards research, regulatory constraints of bioprocess. • Batch growth:(growth pattern and kinetics in batch culture, environmental factors affecting growth kinetics), Monod's equation, continuous culture, Chemostat and turbitostat (construction and working), mixed culture in nature, industrial utilization of mixed culture
Module 2 (Credit 1):Introduction of Bioreactors	
Learning Outcomes	1.Learners will be design reactors with mass transfer between two ideally mixed fluid phases, for continuous, fed-batch, batch operation. 2.Will be design photo-bioreactors with mass transfer between two ideally mixed fluid phases; 3.Will be handle various expressions for the intrinsic reaction kinetics for all reactors above; 4.Apply judicious simplifications to a reactor design model for all reactors above, to allow analytical solution; 4.Will be analyse differences between reactor types and modes of

	operation, and exploit these differences for various design goals.
Content Outline	• Bioreactors: • Design of basic bioreactor, bioreactor configuration, design features, individual parts, baffles, impellers, foam separators, spargers, culture vessel, cooling and heating devices, probes for on-line monitoring computer control of fermentation process, measurement and control of process. • Ideal batch reactor, ideal continuous flow stirred tank reactor, packed bed reactor bubble column reactor, fluidized bed bioreactor, Trickle bed reactor (Their basic construction, working, and distribution of gases)
Module 3 (Credit 1):Mass Transfer and Sterilization	
Learning Outcomes	1.Learners will be understand the elimination of toxic gases and deodorization of air. 2.Will be understand recovery of solvents and removal of ions from solution, as in demineralization of water. 3.Will be fractionization by selective adsorption of gases, vapours from gases, vapors from vapors and liquids from liquids
Content Outline	• Mass Transfer and Sterilization: • Transport phenomena in bioprocess system: Gas liquid mass transfer in cellular systems, basic mass transfer concept, Rate of metabolic oxygen utilization. • Determination on oxygen transfer rates, determination of Kla, Heat transfer, aeration / agitation and its importance. • Sterilization of bioreactors, nutrients, air supply, product and effluents, process variable and control, scale up of bioreactor.
Module 4 (Credit 1):Upstream and Downstream Process in Engineering Technology	
Learning Outcomes	1.Learners will be design and optimize biomanufacturing processes based on measured bioreaction parameters. 2.Will be utilize basic principles of Design of Experiment (DoE) for process development. 3.Will be identify the main challenges associated with fermentation scale-up and mitigate risks. 4.Will be understand and explain the bio-separation principles involved in purification of bio-products. 5.Will be evaluate concepts selection of membranes and assess the results of protein purification. 6.Will be design the method for bio-separation of proteins. 7.Will be understand the designing processes for the recovery and subsequent purification of a target therapeutic protein.

Content Outline	• Upstream processes: • Inoculum development, formulation of production media, sterilization of media, maintenance of stock culture, scale up of the process from shake flask to industrial level. • Growth of culture in fermenter , choosing cultivation methods , Modifying batch and continuous reactors, immobilization cell systems, active and passive immobilization , solid state fermentation process. • Down Stream Process: • Introduction , Recovery of particulates filtration , centrifugation , sedimentation,emerging technologies for cell recovery , product isolation , extraction , solvent extraction , aqueous two phase system , sorption , precipitation , reverse osmosis, ultra filtration. • Product recovery traits: Commercial enzymes, Intracellular foreign proteins from recombinant E. coli, polysaccharide and biogum recovery, antibiotic, organic acids, ethanol, single cell protein.

Assignments/Activities towards Comprehensive Continuous Evaluation(CCE):

1. Prepare a report on elimination process of toxic gases
2. Demonstrate protein purification by different methods
3. Visit bioprocess engineering industries for different experiment observation

References:

1. James E .Bailey and David F Ollis, Biochemical Engineering Fundamentals, McGraw
2. Hill Publication.
3. Shuler and Fikret Kargi, Bioprocess Engineering basic concepts, 2nd edition , Prentice
4. Hall Publication.
5. Stanbury PF, Whitekar, A And Hall SJ, Principles of fermentation Technology, Pergamon
6. Press.
7. Peppler and Perlmen , Microbial Technology, Vol I and II , Academic Press.
8. Cruger and Cruger , Biotechnology : A text Book of Industrial Microbiology.
9. Fermentation- A practical Approach
10. Bioprocess Technology: Fundamentals and Applications, Stockholm KTH.

2.6. Major (Elective)

Course Title	**Agricultural Microbiology(Th)**
Course Credits	4
Course Outcomes	After going through the course, learners will be able to -
	1.Know the basic principles of Agricultural Microbiology and have an understanding of the structural characteristics, the functionality and the integration of microorganisms in their natural environment.
	2.Be familiar with the experimental procedures applied in Agricultural Microbiology and be able to interpret the scientific data acquired.
	3.Be able to comprehend the potential of microorganism applications in the food industry and in the agro-biotechnological sector.
Module 1 (Credit 1):Introduction to Biofertilizers	
Learning Outcomes	1.Learners will have ability to distinguish the types of biofertilizers. 2.Will be understand the development of integrated management for best results uses both nitrogenous and phosphatic biofertilizers. 3.Will be applied to seed/seed material/seedlings/soil/waste matter/crop residues in order to increase the population. 4.Will be describe the role nitrogen fixation plays in distributing atmospheric nitrogen to life on the planet. 5.Will be identify ways humans and plants use nitrogen. 6.Will be explain the mutualistic relationship between bacteria and legumes.
Content Outline	• Introduction to biofertilizers, Biofertilization processes - Decomposition of organic matter and soil fertility and vermicomposting. Mechanism of phosphate solubilization and phosphate mobilization. • Nitrogen fixation - Free living and symbiotic nitrogen fixation. Ecto and endomycorrhizae and their importance in agriculture. Biotechnological application in nitrogen fixation.
Module 2 (Credit 1):Microorganism as Biofertilizers	
Learning Outcomes	1.Learners will be understand to fertilizers boost crop yields, but their excessive usage has hardened the soil, reduced fertility, strengthened insecticides, polluted air and water, and emitted greenhouse gases, creating health and environmental risks. 2.Will be able to promote the use of Biofertilizer technology, i.e., the addition of nutrients through the natural process of nitrogen fixation, solubilizing phosphorus, as well as the stimulation of plant growth by synthesising growth-promoting substances 3.Will be evaluate mycorrhiza as a plant symbiotes.

Content Outline	• Microorganisms as biofertilizers: • Biofertilizers and symbiotic associations; Rhizobium -taxonomy, physiology, host-*Rhizobium* interaction, mass cultivation; Associative and non symbiotic association *Azospirillum, Azotobacter*, Cyanobacteria (Nostoc and Anabaena) • Mycorrhiza and actinorrhiza in plant nutrition and stress tolerance; Interaction of mycorrhiza with *Rhizobium* and *Pseudomonas;* Commercial production of biofertilizers, formulations and BIS specifications; their applications and limitations for Indian agriculture.
Module 3 (Credit 1):Nitrogen Biofertilizers	
Learning Outcomes	1.Learners will be able to improve plant health through nitrogen fixation, growth hormone production, phosphate solubilization, plant disease management and reclamation of better soil health, Azotobacter is one of the best options to be used as biofertilizer for eco-friendly and sustainable crop production 2.Will be able to understand involvement of small scale and large scale production system. The detailed procedure includes isolation, maintenance, characterization and mass culture production. 3.Will be able to understand inoculation is the process of introducing the appropriate Rhizobium bacteria to the soil in numbers sufficient to ensure successful nodulation. This is done by coating the seed with a liquid or peat-based powder inoculant, or by treating the soil with a granular or liquid inoculant.
Content Outline	• Nitrogenous Biofertilizers:Isolation and purification of Azospirillum and Azotobacter. • Mass multiplication of Azospirillum and Azotobacter. • Formulation of inoculum of Azospirillum and Azotobacter. • Application of inoculants of Azospirillum and Azotobacter. • Isolation and purification of Rhizobium, mass multiplication and inoculum production of Rhizobium. • Methods of application of Rhizobium inoculants.
Module 4 (Credit 1):Microorganism as Biopesticids	
Learning Outcomes	1.Learners will be understand the organisms used in microbial insecticides are essentially nontoxic and nonpathogenic to wildlife, humans, and other organisms not closely related to the target pest. The safety offered by microbial insecticides is their greatest strength. 2.Will be understand the toxic action of microbial insecticides is often specific to a single group or species of insects, and this specificity means that most microbial insecticides do not directly affect beneficial insects (including predators or parasites of pests) in treated areas. 3.Will be understand the most microbial insecticides can be used in conjunction with synthetic chemical insecticides because in most cases the microbial product is not deactivated or damaged by residues of conventional insecticides. (Follow label directions concerning any limitations.)

Content Outline	• Microorganisms as biopesticides: Microbiology of plant surfaces; Principles and mechanism of biological control; biocontrol agents for insect pest and weed control. • Commercial production of biopesticides with reference to *Bacillus thuringiensis*; integrated pest management; Their applications and limitations for Indian agriculture

Assignments/Activities towards Comprehensive Continuous Evaluation(CCE):

1. Conduct a survey on different agricultural areas
2. Prepare a report on insectisides and pestisides
3. Written assignment on biofertilizers

Reference Books :

1. Bagyaraj, D.J. and A. Manjunath. 1990. Mycorrhizal symbiosis and plant growth, Univ. of Agricultural Sciences, Bangalore, India. ☐
2. Purohit, S.S., P.R. Kothari and S.K. Mathur, 1993. Basic and Agricultural Biotechnology, Agro Botanical Pub. India.
3. Subba Rao, N. S. 1988. Biological nitrogen fixation: recent developments, Mohan Primlani for Oxford and IBH Pub. Co. (P) Ltd., India.
4. Subba Rao, N.S., G.S. Venkataraman and S. Kannaiyan 1993. Biological nitrogen fixation, ICAR Pub., New Delhi.
5. Somani, L.L., S.C. Bhandari, K.K. Vyas and S.N. Saxena. 1990. Biofertilizers, Scientific Publishers - Jodhpur.

2.7.MIC.2107 Intenship(OJT)

Course Title	**Internship (OJT)**
Course Credits	4
Course Outcomes	• To apply as a trainee in different pathology lab/hospital • To criticize in different environmental plants. • To support doing work in moloecular biology laboratory as a trainee • Collaborate work in different blood bank.
Assignments/Activities towards Comprehensive Continuous Evaluation(CCE): *Gather and analyze the data for internship work. *Prepare a report on internship.	

End of semester-II

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 protein 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. Recommmended 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.
Content Outline	• Use of Internet or software for sequence analysis of nucleotides & proteins. • Studies of public domain database for nucleic acid & protein sequence. • Determination of protein structure.(PDB) • Genome sequence analysis.

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE):

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.

Web sites for Proteomics and Genomics:

A. www.geneprot.com.

B. www.hybrigenis.com

C. www.mdsproteomics.com

D. www.stromix.com

E. www.syrrx.com

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

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 Major (Elective) (A)

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 Major (Elective) (B)

Course Title	**Environmental Microbiology (Th)**
Course Credits	4
1) 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:

1) Buckley, R.G. (2019). *Environmental Microbiology*. CBS.
2) Sharma, P.D. (2016). *Environmental Microbiology* (1st ed.). Rastogi Publication.
3) Stetzenbach, L.D., & Yates, M.V. (2003). *Environmental Microbiology*.
4) Bhatia, S.C. (2007). *Handbook of Environmental Microbiology*. Atlantic Publishers & Distributors Pvt. Ltd.
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 Dissertation I

Course Title **Subject Code**	**Research Project** MIC.4106
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.

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:

1) Von Schantz, M. (2019). *From Genes to Genomes* (3rd ed.). Wiley.
2) *Biotechnology (Molecular Biology And Recombinant DNA Technology)*. (2022). Dominion Publishes.
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.
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6) Udaykumar, P. (2021). *Medical Pharmacology* (7th ed.). CBS Publisher & Distributors.
7) Sharma, H.L. (2023). *Principles of Pharmacology* (4th ed.).
8) Muniappan, M. (2022). *Textbook of Modern Pharmacology* (3rd ed.). CBS Publisher.
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10) Garg, G.R., & Gupta, S. (2022). *Review of Pharmacology* (16th ed.). Jaypee Brothers.
11) Satoskar, R.S., Rege, N.N., Tripathi, R.K., & Kamat, S.K. (2020). *Pharmacology And Pharmacotherapeutics* (26th ed.). Elsevier.
12) Ritter, J.M. (2024). *Rang & Dale's Pharmacology* (10th ed.).
13) Rataboli, P.V. (2022). *Clinical Pharmacology and Therapeutics* (3rd ed.). CBS Publisher.
14) Dhikav, V. (2019). *Last Minute Revision In Pharmacology* (4th ed.). AITBS.
15) 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.).
5) Singh, R. (2018). *Industrial Biotechnology*.
6) Kent, J.A., & Bommaraju, T.V. (2017). *Handbook of Industrial Chemistry and Biotechnology* (13th ed.). Springer.
7) Das, D., & Pandit, S. (2021). *Industrial Biotechnology*. CRC Press.

4.4 Major (Elective) (A)

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.
3) Kumar, E.P., & Kumar, E.V. (2019). *Textbook of Environmental Biotechnology*. WPI Publishing.
4) Thakur, I.S. (2019). *Environmental Biotechnology: Basic Concepts and Applications* (2nd ed.). Dreamtech Press.
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8) Bhatia, S.C. (2008). *Handbook of Environmental Biotechnology* (Vol. 1). Atlantic Publishers & Distributors Pvt. Ltd.

4.4 Major (Elective) (B)

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:

1) Sastry, A.S., & Bhat, S. (2023). Essentials of Medical Microbiology (4th ed.). Jaypee Brothers.
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 ed.). Elsevier.
9) 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) Godkar, P.B., Dave, B., & Muley, L. (Eds.). Textbook of Medical Microbiology And Parasitology (1st ed.). Bhalani Publishing House

4.5 Dissertation II

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.