SNDT Women's University, Mumbai

Master of Science (Microbiology)

M. Sc. (Microbiology)

As per NEP-2020

Syllabus

(2023-24)

Programme Template

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

Year II

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

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

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 handling 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.
3. Himalaya Publishing House, Mumbai.3. A Biologists Guide to Principles and Techniques of Practical Biochemistry. 1975 by
4. Williams, B.L. and Wilson, K.
5. Spectroscopy. Volume 1. Edited by B.B. Straughan and S. Walker. Chapman and Hall Ltd.
6. Gel Electrophoresis of Proteins- A Practical Approach by Hanes.
7. 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.

Reference:

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.
3. Himalaya Publishing House, Mumbai.3. A Biologists Guide to Principles and Techniques of Practical Biochemistry. 1975 by
4. Williams, B.L. and Wilson, K.
5. Spectroscopy. Volume 1. Edited by B.B. Straughan and S. Walker. Chapman and Hall Ltd.
6. Gel Electrophoresis of Proteins- A Practical Approach by Hanes.
7. Chromatography: Concepts and Contrasts- 1988 by James Miller. John Wiley and Sons. Inc., New York.

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.

1.3. A. 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 studying the cell wall can help us understand how pathogens evade our defenses 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.

1.5 B. 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 explaining working principle of enzymes 2. Learners will be explaining 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):

3. Visual representation of different pathways involving enzymes
4. 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 5th Edition WH Freeman 2001
5. Laboratory techniques in Biochemistry and Molecular Biology by Work and Work.

1.6 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 an 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
7. 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
8. 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.
Module 1 (Credit 1) - Lactic Acid Production and Fermentation Analysis	
Learning Outcomes	1. **Analyze** the production of lactic acid by **Lactobacillus sp.** or **Streptococcus sp.** and **understand** its role in fermentation. 2. **Recognize** and **estimate** diacetyl levels in fermented dairy products to **understand** its impact on flavor. 3. **Analyze** and **understand** microbial changes during sauerkraut fermentation. 4. **Recognize** and **understand** food poisoning bacteria or fungi from contaminated dairy products to ensure food safety.
Content Outline	• Production and estimation of lactic acid by **Lactobacillus sp.** or **Streptococcus sp.** • Extraction and estimation of diacetyl from fermented dairy products.
Module 2 (Credit 1) - Sauerkraut Fermentation and Food Safety	
Learning Outcomes	1. **Analyze** sauerkraut fermentation and microbial changes over time to understand fermentation effects on quality. 2. **Understand** and **recognize** food poisoning bacteria or fungi isolated from contaminated dairy products. 3. **Analyze** and **recognize** diacetyl levels in fermented dairy products to understand its role in flavor. 4. **Understand** and **analyze** UV radiation effects on food preservation and use microbial biosensors for rapid quality control.

Content Outline	• Sauerkraut fermentation and analysis of microbial changes over time. • Isolation and identification of food poisoning bacteria or fungi from contaminated dairy products.
Module 3 (Credit 1) - Aflatoxin Detection and UV Food Preservation	
Learning Outcomes	1. **Analyze** lactic acid production by **Lactobacillus sp.** or **Streptococcus sp.** and **understand** its role in fermentation. 2. **Recognize** and **estimate** diacetyl in fermented dairy products to **understand** its impact on flavor. 3. **Analyze** sauerkraut fermentation and **understand** microbial changes over time. 4. **Recognize** and **understand** the extraction of aflatoxins using HPLC and the effects of UV radiation on preserving potatoes and onions, including microbial load analysis.
Content Outline	• Extraction and detection of aflatoxins in infected food samples using HPLC. • Preservation of potato/onion by exposure to UV radiation and analysis of microbial load.
Module 4 (Credit 1) - Fermented Milk Production and Quality Control	
Learning Outcomes	1. **Analyze** the production of fermented milk using **Lactobacillus acidophilus** and **understand** the comparison of lactic acid content. 2. **Recognize** and **understand** the application of microbial biosensors for rapid food quality analysis in dairy products. 3. **Analyze** and **understand** sauerkraut fermentation and microbial changes over time. 4. **Recognize** and **understand** aflatoxin extraction using HPLC and the effects of UV radiation on food preservation and microbial load.
Content Outline	• Production of fermented milk using **Lactobacillus acidophilus** and comparison of lactic acid content. • Application of microbial biosensors for rapid analysis of food quality in dairy products.

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.

Reference:

1. Adams, M. R., & Moss, M. O. (2008). *Food microbiology* (3rd ed.). Royal Society of Chemistry.
2. Ray, B., & Bhunia, A. (2014). *Fundamental food microbiology* (5th ed.). CRC Press.
3. Jay, J. M., Loessner, M. J., & Golden, D. A. (2005). *Modern food microbiology* (7th ed.). Springer.
4. Frazier, W. C., & Westhoff, D. C. (2017). *Food microbiology* (5th ed.). McGraw-Hill Education.
5. Hutkins, R. W. (2006). *Microbiology and technology of fermented foods*. Wiley-Blackwell.
6. Marth, E. H., & Steele, J. L. (2001). *Applied dairy microbiology* (2nd ed.). CRC Press.
7. Forsythe, S. J. (2020). *The microbiology of safe food* (3rd ed.). Wiley-Blackwell.
8. Robinson, R. K. (2002). *Dairy microbiology handbook: The microbiology of milk and milk products* (3rd ed.). Wiley-Interscience.

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.

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. A. 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 understanding 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.

2.5 B. 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 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.

2.6 Internship (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 molecular 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