SNDT Women's University, Mumbai

Undergraduate Degree / UG Programme (Syllabus as Per NEP) - Faculty of Science & Technology

Bachelor of Science (Microbiology)

B.Sc. (Microbiology)

As Per NEP – 2020

Semester – V & VI

Syllabus
(W.E.F. Academic Year 2026-27)

Terminologies

Vertical	Full-Form/Definition	Remarks	Related To Major And Minor Courses
Major (Core)	Subject Comprising Mandatory and Elective Courses, Major Specific IKS, Vocational Skill Courses, Internship/ Apprenticeship, Field Projects, Research Projects Connected to Major	Minimum 50% Of Total Credits Corresponding to Three/Four - Year UG Degree- Mandatory Courses	Related To The Major
Minor Course	Course From Same Or Different Faculty	Minimum 18-20 Credits to Be Completed in The First Three Years of UG Programme	Related To the Minor
OEC	Open Elective Courses/ Generic Courses	10-12 Credits to Be Offered in I And/Or II Year. Faculty-Wise Baskets of OEC To Be Prepared	OEC Is to Be Chosen Compulsorily from Faculty Other Than That of the Major
VSC	Vocational Skill Courses, Including Hands On Training Corresponding To The Major And/Or Minor Subject	8-10 Credits, To Be Offered in First Three Years, Wherever Applicable Vocational Courses Will Include Skills Based on Advanced Laboratory Practical's of Major	Related To the Major or Minor
SEC	Skill Enhancement Courses	06 Credits, To Be Offered in I And II Year, To Be Selected from The Basket of Skill Courses Approved by University	Related To the Major or Minor Any Relevant Skill
AEC	Ability Enhancement Courses	08 Credits, To Be Offered in I And II Year, English: 04 Credits to Be Earned in Sem - I, Modern Indian Language Of 04 Credits to Be Offered in II Year	NA
VEC	Value Education Courses	Understanding India, Environmental Science/Education, Digital and Technological Solutions, Health &	NA

		Wellness, Yoga Education, Sports, And Fitness	
IKS	Indian Knowledge System	Generic IKS Course: Basic Knowledge Of The IKS To Be Offered At First Year Level	Major-Specific IKS Courses: Advanced Information About the Major, Part of the Major Credit to Be Offered at Second- Or Third-Year Level
OJT	On-Job Training (Internship / Apprenticeship)	Corresponding To the Major Subject	Related To The Major
FP	Field Projects	Corresponding To the Major Subject	Related To the Major
CC	Co-Curricular Courses	Health And Wellness, Yoga Education Sports, And Fitness, Cultural Activities, NSS/NCC And Fine/ Applied/Visual/ Performing Arts	NA
CE	Community Engagement and Service		Related To Major
RP	Research Project	Corresponding To the Major Subject	Related To Major

Programme Template

Faculty		**Science and Technology**
Programme Degree		**B.Sc.**
Specialization		**Mathematics (2024 Pattern)**
Preamble		Microbiology is a branch of science that deals with the study of microorganisms. The study of microbiology has a wide scope, ranging from basic sciences to applied sciences. The prominent applied branches of microbiology include pharmaceutical microbiology, agricultural microbiology, food microbiology, environmental microbiology, medical microbiology, industrial microbiology, and epidemiology. Various job opportunities are available for students in the industrial, academic, government, and non-government research sectors. Students can work as Research Fellows at various national institutes, Assistant Professors in colleges, and Laboratory Technicians in government and private pathological laboratories.
Programme Specific Outcomes (PSOs)		After completing this programme, Learners will be able to
	1	Apply knowledge and technical skills to investigate a broad variety of contemporary subjects covering different areas of microbiology.
	2	Acquire critical thinking skills, including hypothesis formulation and testing, experimental design and execution, interpretation of scientific literature, and effective written and oral communication through presentations.
	3	Gain proficiency in skills required for environmental sustainability.
	4	Enable students to pursue higher studies in microbiology and allied subjects leading to postgraduate and Ph.D. degrees.
	5	Obtain employment in various national institutes, academic institutions, and government and private pathological laboratories.
	6	Demonstrate the diversity of the microbial world, evaluate its ecological roles, and explain its significance to humankind.
	7	Classify and characterize microorganisms based on their morphological, cultural, biochemical, and molecular properties.

Eligibility Criteria for Programme		Female candidates who have passed 12th Science with Physics, Chemistry, and Biology (PCB). **Note:** Admissions will be based on merit.
Intake		The programme is offered at affiliated colleges of SNDTWU.

Structure with Course Titles

B. Sc. (Microbiology)

Semester – V

Sr. No.	Course	Type of Course	Credits	Marks	Int Marks	Ext Marks
	Semester – V					
50132511	Microbial Genetics (Th)	Major (Core)	4	100	50	50
50132512	Microbial Biotechnology (Th+Pr) (2+2)	Major (Core)	4	100	50	50
51032511	Microbial diseases and traditional knowledge of medicine (Th)	IKS (Major Specific)	2	50	0	50
50232511	Genetic Engineering (Th)	Major (Elective) **(Any One)**	4	100	50	50
50232512	Bioinformatics (Th)					
50332511	Biochemistry (Th+Pr) (2+2)	Minor Stream **(Any One)**	4	100	50	50
50332512	Analytical Chemistry (Th+Pr) (2+2)					
50332513	Physical Chemistry (Th+Pr) (2+2)					
50632501	Laboratory Management (Pr)	VSC-4	2	50	50	0
51332501	Field Project (Pr)	FP	2	50	50	0
			22	**550**	**300**	**250**

Semester – VI

Sr. No.	Course	Type of Course	Credits	Marks	Int Marks	Ext Marks
	Semester - VI					
60132511	Industrial Microbiology (Th+Pr) (2+2)	Major (Core)	4	100	50	50
60132512	Recombinant DNA Technology (Th)	Major (Core)	4	100	50	50
60232511	Infectious Diseases (Th)	Major (Elective) **(Any One)**	4	100	50	50
60232512	Biostatistics (Th)					
60332511	Food Microbiology (Th)	Minor Stream	2	50	0	50
60332512	Food Chemistry and Nutraceuticals (Th)	Minor Stream	**4**	100	50	50
61232521	Internship In Microbiology dept. in Hospitals/Industry/ Pathological Labs/Multispecialty Clinics (Pr)	OJT	4	100	50	50
			22	**550**	**250**	**300**

Exit with Degree (3-year)

Course Syllabus

Semester – V

.5.1 Major (Core)

Course Titles	**Microbial Genetics (Th)**
Course Credits	**4 Credit's**
Course Outcomes	After going through the course, learners will be able to
	1. Understand mutation types and mechanisms, including spontaneous and induced mutations, and the effects of mutagens.
	2. Explore bacterial horizontal gene transfer mechanisms (transformation, transduction, conjugation) and their evolutionary significance.
	3. Analyse bacterial conjugation, focusing on conjugate plasmids like F-plasmids and Hfr cells, in both Gram-negative and Gram-positive bacteria.
	4. Examine the role of plasmids and transposable elements in bacterial genetics, including their replication, regulation, and contribution to antibiotic resistance.
Module 1 (Credit 1): Genome Organization and Mutations	
Learning Outcomes	After learning the module, learners will be able to
	1. Define genome organization and genome organization
	2. Explain type of mutations, mechanisms of mutagenesis and role of mutagen in genetics
	3. Asses the role of mutators genes and evaluate significance of detecting mutagenic agents.
	4. Design approach for studing mutation, mutagens and suppression mechanism in microorganism
Content Outline	• Genome organization: E. coli, Saccharomyces, Tetrahymena • Mutations and mutagenesis: Definition and types of Mutations; Physical and chemical mutagens; • Molecular basis of mutations; Functional mutants (loss and gain of function mutants); Uses of mutations • Reversion and suppression: True revertants; Intra- and inter-genic suppression; Ames test; Mutator Genes
Module 2 (Credit 1): Plasmids	
Learning Outcomes	After learning the module, learners will be able to
	1. Define and identify different types of plasmid
	2. Describe and explain the structure, functions, and biological

	significance of different plasmids in microorganisms
	3. Examine and interpret the significance of plasmid curing in studying microbial genetics and antibiotic resistance.
Content Outline	• Types of plasmids – F plasmid, R Plasmids, colicinogenic plasmids, Ti plasmids, linear plasmids, • yeast- 2 μ plasmid, Plasmid replication and partitioning, Host range, plasmid-incompatibility, plasmid • amplification • Regulation of copy number, curing of plasmids
Module 3 (Credit 1): Mechanisms of Genetic Exchange	
Learning Outcomes	After learning the module, learners will be able to
	1. Define and identify the different mechanisms of genetic recombination in bacteria, including transformation, conjugation, and transduction.
	2. Describe the discovery and mechanism of natural competence in transformation and its significance in bacterial gene transfer.
	3. Explain the process of bacterial conjugation, including the role of F factor, Hfr strains, and F' strains in genetic exchange.
	4. Analyze the principles of genetic mapping by recombination and co-transduction of markers in bacterial genetics.
Content Outline	• Transformation - Discovery, mechanism of natural competence • Conjugation - Discovery, mechanism, Hfr and F' strains, Interrupted mating technique and time of entry mapping • Transduction - Generalized transduction, specialized transduction, LFT & HFT lysates, Mapping by recombination and co-transduction of markers
Module 4 (Credit 1): Phage Genetics and Transposable Elements	
Learning Outcomes	After learning the module, learners will be able to
	1. Define and identify the characteristic features of T4 phage genetics and the genetic organization of bacteriophages.
	2. Describe and explain the genetic basis of the lytic and lysogenic switch in lambda phage and its significance in phage biology.
	3. Illustrate and explain the mechanisms of replicative and non-replicative transposition, including the role of the Mu transposon.
	4. Describe and compare major eukaryotic transposable elements such as yeast Ty retrotransposons, Drosophila P elements, and maize Ac/Ds elements.
	5. Apply the principles of transposition in understanding mutation,

	gene mapping, and molecular genetics research.
Content Outline	• Features of T4 genetics , Genetic basis of lytic versus lysogenic switch of phage lambda. • Prokaryotic transposable elements – Insertion Sequences, composite and non-composite transposons. • Replicative and Non replicative transposition, Mu transposon. • Eukaryotic transposable elements - Yeast (Ty retrotransposon), Drosophila (P elements), Maize (Ac/Ds). • Uses of transposes and transposition.

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE):

- Concept Mapping Assignment:
- Prepare a concept map on genome organization in E. coli, yeast (Saccharomyces), and Tetrahymena highlighting similarities and differences.
- Case Study Analysis:
- Analyze a case study on antibiotic resistance caused by mutation or plasmid transfer in bacteria.
- Project/Review Writing:
- Write a short review on bacteriophage genetics or transposable elements and their applications in genetic engineering.

Reference:

1. Primrose, S. B., & Twyman, R. (2013). Principles of gene manipulation and genomics. John Wiley & Sons.
2. Sherwood, L., Prescott, L. M., Sherwood, L. M., & Woolverton, C. J. (2017). Prescott's microbiology. McGraw-Hill Education.
3. Clark, D. P. (2018). Molecular Biology Understanding The Genetic Revolution.
4. Okoń, S., Zimowska, B., & Rai, M. (Eds.). (2024). Microbial Genetics. CRC Press, Taylor & Francis Group.

Semester – V

.5.2 Major (Core)

Course Titles	**Microbial Biotechnology (Th+Pr)**
Course Credits	**4 Credit's (2 Th + 2 Pr)**
Course Outcomes	After going through the course, learner will be able to,
	1. Understand industrial microbial processes involved in fermentation, enzyme production, and microbial metabolite synthesis for commercial applications.
	2. Examine the role of microorganisms in therapeutic, dairy, agricultural, and environmental biotechnology for improving human welfare and sustainability.
	3. Analyze microbial applications in recombinant product development, probiotics, biofertilizers, transgenic crops, and bioremediation.
	4. Apply laboratory techniques and biotechnological methods used in industrial microbiology, quality assessment, microbial screening, and intellectual property protection.
Module 1 (Credit 1) – Industrial Biotechnology.	
Learning Outcomes	After learning the module, learner will be able to,
	1. Define and explain the principles and types of fermentation and fermenter design.
	2. Describe inoculum buildup and downstream processing involved in industrial production.
	3. Explain the mechanisms of action and industrial importance of microbial enzymes such as amylases and proteases.
	4. Examine and interpret microbial production processes of primary metabolites including citric acid, ethanol, amino acids, and vitamins.
Content Outline	• Fermentation: Its types, fermenter design, inoculum buildup and downstream processing. • Industrially important microbial enzymes: Types, mode of action and industrial applications of microbial amylases and proteases. • Microbial production and applications of primary metabolites: Citric acid, Ethanol, L Glutamic acid, L Lysine, Vitamins B and applications of primary metabolites: Citric acid, Ethanol, L Glutamic acid, L Lysine, Vitamins B12 and Vitamin B2.
Module 2 (Credit 1) – Microbial Biotechnology in Therapeutic Production and - Dairy Production.	
Learning Outcomes	After learning the module, learner will be able to,
	1. Describe microbial production of therapeutic products such as

	antibiotics, hormones, vaccines, and thrombolytic agents.
	2. Explain the significance and health benefits of probiotics and prebiotics.
	3. Illustrate the microbial production and applications of bioplastics (PHB).
	4. Examine milk pasteurization and dehydrated milk production processes.
	5. Analyze the industrial production methods of dairy products such as cheese and butter.
Content Outline	• Microbial production of therapeutic recombinant products: Antibiotics (Penicillin, Streptomycin.) Hormones (insulin, human growth hormone), thrombolytic agents (streptokinase and tPA) and vaccines (Hepatitis B) • Probiotics and prebiotics: Fundamental aspects and health benefits. • Production of bioplastics: (PHB) • Milk pasteurization process and application. Dehydrated milk. • Production of Dairy products: Cheese, Butter, etc.
Module 3 (Credit 1) – Microbial Biotechnology in Agriculture and Environment Management.	
Learning Outcomes	After learning the module, learner will be able to,
	1. Define and describe different types of biofertilizers and their agricultural applications.
	2. Explain the development and significance of transgenic crops and edible vaccines.
	3. Interpret the role of single-cell proteins and algal biofuels in sustainable biotechnology.
	4. Describe and assess the cultivation and applications of edible and medicinal mushrooms.
	5. Analyze microbial biodegradation, bioremediation, and bioleaching processes in environmental management.
Content Outline	• Biofertilizers: Liquid and carrier-based biofertilizers. Mass production of Rhizobium, Acetobacter diazotrophicus, Azotobacter sp. • Development of transgenic crops: Particular emphasis on insect resistance, viral resistance and nutritional quality enhancement (Bt-Cotton, Roundup-ready crops and golden rice). • Edible vaccines, Single Cell Protein (Spirulina & Fusarium graminearum), Biodiesel production (algal biofuel). Characteristics, nutritional value and safety, substrates used,

	process examples, applications. • Biological Cultivation of edible and medicinal mushrooms: Nutritional and medicinal properties. • Microbial bioremediation: Oil spills using genetically modified organisms (GMOs). Microorganisms in the removal of heavy metals from aqueous effluents and copper bioleaching.
Module 4 (Credit 1) – Industrial Biotechnology Laboratory Techniques and Applications	
Learning Outcomes	After learning the module, learner will be able to, 1. Demonstrate immobilization techniques of microorganisms and evaluate enzyme activity. 2. Explain different methods of intellectual property protection in India relevant to biotechnology innovations. 3. Perform and interpret microbiological assays for enzyme production, milk quality testing, antibiotic sensitivity, and fermentation processes. 4. Apply laboratory techniques for microbial screening and industrial production of enzymes, antibiotics, and agricultural products.
Content Outline	• An introduction to different methods of protecting Intellectual Property in India (Patents, Copyrights, Trademarks, Geographical Indications, Industrial Design and New Plant Varieties). • Immobilization of yeast cells (Saccharomyces cerevisiae) by entrapment using calcium alginate beads/agarose/agar and determination of the invertase activity of the immobilized cells by carrying out an invertase assay. • Primary screening of soil samples to isolate microorganisms that produce hydrolytic enzymes: amylase, protease, lipase, CM cellulase. • Detection of numbers of bacteria in milk by SPC. • Determination of milk quality by methylene blue reduction test. • Alcoholic fermentation. • Penicillin production and testing of antimicrobial activity. • Antibiotic sensitivity test. • Production of wine from grapes. • Lipase production test. • Testing of nodulation ability by rhizobia.

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE):

- Assignments on syllabus topics and Group discussion.
- Preparation of various Flow Charts associated with given industrial products.
- Project on Laboratory production of any one product.

References:

1. Lohar, P. (2019). Biotechnology. MJP Publisher.
2. Das, D., & Pandit, S. (2021). Industrial biotechnology. CRC Press.
3. Barh, D. (Ed.). (2022). Biotechnology in Healthcare, Volume 1: Technologies and Innovations. Academic Press.
4. Barh, D. (Ed.). (2022). Biotechnology in Healthcare, Volume 2: Applications and Initiatives. Academic Press.
5. Bhatt, P. (2023). Industrial applications of microbial enzymes. CRC Press.
6. Chattaraj, S., & Banerjee, A. (Eds.). (2026). Industrial Biotechnology for Sustainability and Circular Economy. Newredmars Education Pvt Ltd.

Semester – V

.5.3 Indian Knowledge System (IKS) (Major Specific)

Course Titles	**Microbial Diseases and Traditional Knowledge of Medicine (Th)**
Course Credits	**2 Credit's**
Course Outcomes	After going through the course, learner will be able to,
	1. Understand the concept, types, and transmission of microbial diseases.
	2. Describe the mechanism of pathogenesis and factors affecting disease severity.
	3. Understand the concept of traditional knowledge in medicine.
	4. Elucidte major traditional systems of medicine (Ayurveda, Siddha, Unani, Folk).
	5. Evaluate the role of traditional medicine in prevention and treatment of diseases.
Module 1 (Credit 1) - Microbial Diseases	
Learning Outcomes	After learning the module, learner will be able to,
	1. Define microbial diseases and classify them.
	2. Explain the process of pathogenesis in the host body.
	3. Describe factors affecting disease severity such as virulence and host immunity.
	4. Identify signs and symptoms of microbial infections.
	5. Classify microbial diseases into bacterial, viral, fungal, and parasitic types.
Content Outline	• Introduction to Microbial Diseases: Microbial diseases are illnesses caused by microorganisms. These microorganisms include bacteria, viruses, fungi, and parasites. • Mechanism of the Pathogens in the host body: Pathogenesis o Invade tissues o Multiply inside the host o Disrupt normal body functions • The severity of disease depends on: o Virulence of the microorganism o Host immunity • This leads to signs and symptoms such as: o Fever o Inflammation

	○ Tissue damage • Major Types of Microbial Diseases ○ Bacterial diseases ○ Viral diseases ○ Fungal diseases ○ Parasitic diseases • Transmission of Microbial Diseases ○ Airborne ○ Water and food contamination ○ Direct contact ○ Vector-borne • Understanding microbial diseases is important for: ○ Prevention ○ Diagnosis ○ Treatment
Module 2 (Credit 1) - Traditional Knowledge of Medicine	
Learning Outcomes	After learning the module, learner will be able to, 1. Define and explain the concept of traditional knowledge in medicine. 2. Describe the importance of indigenous healthcare practices. 3. Explain principles of major systems: Ayurveda, Siddha, Unani, and Folk medicine. 4. Identify commonly used medicinal plants and natural resources. 5. Understand the role of traditional medicine in health promotion and disease prevention.
Content Outline	• Concept of Traditional Knowledge in Medicine: Traditional knowledge refers to the indigenous practices, beliefs, and skills developed over generations for maintaining health and treating diseases. It is deeply rooted in culture and often uses natural resources like plants, minerals, and animal products. • Major Traditional Systems of Medicine: ✓ Ayurveda: ✓ Concept: Balance of three doshas (Vata, Pitta, Kapha) ✓ Uses herbs like: Neem (antibacterial) , Turmeric (anti-inflammatory, antimicrobial), Tulsi (immune booster) ✓ Siddha: ✓ Concept: Practiced mainly in South India

	✓ Uses a combination of: Metals, Minerals and Herbs ✓ Emphasizes balance of body elements ✓ Focuses on: Prevention of diseases and Rejuvenation and longevity. ✓ Includes diet, lifestyle, and medicinal preparations for treatment. ✓ Unani System of Medicine ✓ Concept of four humors: Blood (Dam), Phlegm (Balgham), Yellow bile (Safra) and Black bile (Sauda) ✓ Health is maintained by the balance of these humors ✓ Uses natural therapies such as: Herbal medicines, Diet therapy and Regimental therapy (exercise, massage, etc.) ✓ Folk Medicine ✓ Refers to traditional healing practices followed by local communities where ✓ Knowledge is passed from generation to generation based on experience, beliefs, and cultural practices. ✓ Uses locally available natural resources such as: ▪ Plants and herbs ▪ Animal products ▪ Minerals ▪ Treatment methods may include: ▪ Herbal remedies ▪ Home-based treatments ▪ Spiritual or ritual practices • Role of Traditional Medicine in Health Promotion and Disease Prevention: ✓ Promotes overall well-being through a holistic approach (body, mind, and lifestyle) ✓ Emphasizes preventive healthcare rather than only treating diseases ✓ Helps in boosting immunity using natural herbs and remedies ✓ Encourages healthy lifestyle practices such as: Balanced diet , Regular exercise and Proper sleep ✓ Uses natural medicinal plants with antimicrobial and healing properties ✓ Helps in early management of minor ailments at home.

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE):

- Theory-Based Assignments
  - Short Notes Writing
    - Pathogenesis of Bacteria, Viruses and Parasite.
    - Modes of transmission
    - Tridosha concept
  - Long Answer Assignment
    - Explain types of microbial diseases with examples
    - Describe traditional systems of medicine in detail

- Case Study
  - Analyze a case of infectious disease and suggest prevention
  - Compare modern vs traditional treatment approaches

- Activity-Based Learning
  - Chart/Poster Making : Transmission cycle of diseases and Comparison of traditional systems
  - Herbal Survey Activity : Identify 5 medicinal plants used locally and write their uses and antimicrobial properties

- Group Discussion
  - Role of traditional medicine in modern healthcare
  - Advantages and limitations of herbal medicine.

Reference:

1. Willey, J. M., Sherwood, L. M., & Woolverton, C. J. (2014). Prescott's microbiology-/Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton.
2. Kasilo, O. M., & Nikiema, J. B. (2014). World Health Organization perspective for traditional medicine. Novel plant bioresources: Applications in food, medicine and cosmetics, 23-42.
3. Rastogi, S. (Ed.). (2019). Translational ayurveda (No. 167547). Singapore:: Springer.
4. Perveen, S., & Al-Taweel, A. (Eds.). (2019). Pharmacognosy: Medicinal Plants. BoD–Books on Demand.
5. World Health Organization. (2023). WHO international standard terminologies on Siddha medicine. World Health Organization.
6. Kaushik, R., Upadhyaya, K., & Dixit, T. (2025). Regulation of Ayurveda, Siddha and Unani (ASU) drugs: An overview of current framework, challenges and way forward. Journal of Drug Research in Ayurvedic Sciences, 10(2), 104-112.

Semester – V

.5.4 A. Major (Elective)

Course Titles	**Genetic Engineering (Th)**
Course Credits	**4 Credit's**
Course Outcomes	After going through the course, learner will be able to,
	1. Understand the principles, tools, and molecular techniques of genetic engineering, including DNA modifying enzymes and cloning vectors.
	2. Apply knowledge of recombinant DNA technology and gene cloning techniques for designing transformation and screening strategies.
	3. Analyze the applications of genetic engineering in agriculture, medicine, and genome research, including gene therapy and recombinant products.
	4. Evaluate biosafety, ethical, legal, and intellectual property issues related to genetic engineering and biotechnology.
	5. Examine advanced genome editing tools and molecular diagnostic techniques such as CRISPR-Cas9 and DNA fingerprinting.
Module 1 (Credit 1) – Fundamentals of Genetic Engineering and Molecular tools	
Learning Outcomes	After learning the module, learner will be able to,
	1. Define and explain the concept, scope, and historical development of genetic engineering.
	2. Identify and describe major DNA modifying enzymes and their role in recombinant DNA technology.
	3. Differentiate and evaluate various cloning vectors such as plasmids, bacteriophages, cosmids, BACs, YACs, and phagemids.
	4. Explain and compare prokaryotic and eukaryotic expression vector systems and their applications.
Content Outline	• Introduction & Principles: Definition, Scope and history of genetic engineering • DNA Modifying Enzymes: restriction endonucleases, DNA polymerases, ligases, polynucleotide kinase, phosphatase and nucleases • Cloning Vehicles/Vectors: Plasmids, bacteriophages, cosmids, BACs, YACs, Phagemids • Expression Vectors: Systems in prokaryotes and eukaryotes
Module 2 (Credit 1) – rDNA Technology and techniques	

Learning Outcomes	After learning the module, learner will be able to,
	1. Describe methods for isolation of genomic DNA, plasmid DNA, and cDNA synthesis.
	2. Explain and compare different transformation techniques including chemical method, electroporation, gene-gun, liposome-mediated, and Agrobacterium-mediated transformation.
	3. Illustrate and evaluate methods of selection and screening using selectable markers, reporter genes, and blue-white screening.
	4. Explain the principles and applications of DNA analysis techniques such as PCR, restriction mapping, blotting techniques, and DNA sequencing.
Content Outline	• Gene Cloning: Isolation of genomic and plasmid DNA, cDNA synthesis • Transformation Techniques: Chemical Method, electroporation, gene-gun, liposome and agrobacterium mediated transformation • Selection and Screening: Selectable markers, reporter genes, blue-white screening • DNA analysis techniques: PCR types and applications, Restriction mapping, Southern/Northern blotting, DNA sequencing methods
Module 3 (Credit 1) – Genetic Engineering Applications	
Learning Outcomes	After learning the module, learner will be able to,
	1. Explain the role of genetic engineering in agricultural and medical biotechnology.
	2. Define and compare different types of gene therapy and their therapeutic significance.
	3. Describe basic genome mapping techniques and their applications in biological research.
Content Outline	• Agricultural and Medical Biotechnology: Transgenic plants development, Production of recombinant vaccines, hormones and proteins • Gene therapy: Introduction and its types • Genome mapping: Basic techniques in genome mapping
Module 4 (Credit 1) – Safety, Regulation and Advanced Techniques	
Learning Outcomes	After learning the module, learner will be able to,
	1. Explain the concepts of GMOs, GMPs, and biosafety regulations in biotechnology.
	2. Discuss and evaluate ethical, legal, and social issues related to genetic engineering.

	3. Describe the importance of intellectual property rights (IPR), copyrights, and patents in biotechnology innovations.
	4. Explain and interpret advanced genome editing tools including CRISPR-Cas9 and genome editing technologies.
Content Outline	• GMOs & GMPs • Bio-safety and regulations: Ethical, legal • IPR and Patenting: Importance of IPR and patents in biotechnology • Advanced Tools: CRISPR-cas9, Genome editing, DNA fingerprinting

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE):

- Assignments and Group discussion.
- Research and presentation on different types of GMOs.
- Visit to the IPR center and research labs.

References:

1. Brown, T. A. (2025). Gene cloning and DNA analysis: an introduction. John Wiley & Sons.
2. Brown, T. A. (2023). Genomes 5. CRC Press.
3. Nicholl, D. S. (2023). An introduction to genetic engineering. Cambridge University Press.

Semester – V

.5.4 B. Major (Elective)

Course Titles	**Bioinformatics (Th)**
Course Credits	**4 Credit's**
Course Outcomes	After going through the course, learner will be able to,
	1. Classify and utilize various biological databases for retrieval and analysis of nucleic acid and protein data.
	2. Apply computational tools and algorithms for sequence alignment and biological data analysis.
	3. Interpret biological data using visualization tools and structural databases.
	4. Analyze gene expression data and identify biological patterns using computational approaches.
	5. Demonstrate basic skills in data handling, searching, and interpretation of bioinformatics resources.
Module 1 (Credit 1) -Introduction to Bioinformatics	
Learning Outcomes	After learning the module, learner will be able to,
	1. Define bioinformatics and describe its historical development.
	2. Explain the scope and applications of bioinformatics in biological sciences.
	3. Discuss the growth and future prospects of bioinformatics in India.
	4. Identify key application areas such as genomics, proteomics, and drug discovery
	After learning the module, learner will be able to,
Content Outline	• Introduction to bioinformatics: History of Bioinformatics, Scope of Bioinformatics. • Bioinformatics: A multidisciplinary approach and its relation with molecular biology. • Bioinformatics in India: The flourishing future and Application of Bioinformatics.
Module 2 (Credit 1) - Biological Database and Data Storage, Retrieval and Interoperability	
Learning Outcomes	After learning the module, learner will be able to,
	1. Classify biological databases into nucleic acid, protein, genome, and structural databases.
	2. Describe major databases such as: GenBank, DDBJ, EMBL, Protein Data Bank

	3. Interpret common biological file formats such as FASTA, GenBank, and PDB.
	4. Explain the concept of metadata and interoperability in biological databases.
	5. Apply search techniques including Boolean, fuzzy, and indexed searches.
Content Outline	• **General Introduction of Biological databases:** o Nucleic Acid Database:(GenBank, DDBJ and EMBL) o Protein database: (Primary, Composite and Secondary) o Specialized Genome databases: SGD, TIGR and ACeDB o Structure Classification database: CATH, CSOP, PDBsum o Structure database: PDB • **Data Storage, Retrieval and Interoperability:** Flat files, relational, object oriented databases and controlled vocabularies. File format (GenBank, DDBJ, FASTA, PDB, SwissProt) • **Introduction to Metadata and search:** Indices, Boolean, Fuzzy, Neighboring search.
Module 3 (Credit 1): Sequence Alignments and Visalization	
Learning Outcomes	After learning the module, learner will be able to,
	1. Differentiate between global and local alignment techniques.
	2. Apply pairwise alignment tools such as: BLAST, FASTA
	3. Describe the role of dynamic programming in alignment algorithms.
	4. Interpret biological data using sequence and structural visualization techniques.
Content Outline	• Introduction to Sequences, Alignment and Dynamic Programming: • Local alignment and global alignment (algorithm and example) • Pairwise alignment (BLAST and FASAT Algorithm and Tool) • Multiple sequence alignment (ClustalW algorithm and tool) • Methods for presenting large quantities of biological data: sequence viewers (Artemis, SeqVIST), 3D structure Viewers (Rasmol,ligand Explorer SPDBv, Chime, Cn3D, PyMOL), Antomical visualization.
Module 4 (Credit 1): Gene Expression and Representation of patterns and relationship	
Learning Outcomes	After learning the module, learner will be able to,
	1. Explain gene expression mechanisms in prokaryotes and

	describe transcription factor binding sites and regulatory elements.
	2. Apply probabilistic models such as the Markov chain and Bayesian inference in biological data analysis.
Content Outline	• General introduction to gene expression in prokaryotes, transcription factors binding sites. SNP, EST, STS. • Introduction to Regular Expression, Hierachies and Graphical models (including Marcov chain and Bayes notes).

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE):

- Short Assignment (Individual)
  Topic: Introduction to Bioinformatics:
  - History and evolution of bioinformatics
  - Scope and applications

- Case-Based Assignment:
  Topic: Applications of Bioinformatics
  Case: Use of bioinformatics in drug discovery or disease diagnosis
  - Explain role of computational tools
  - Discuss advantages
  - Skill: Analytical thinking

- Database Exploration Activity
  Task: Explore biological databases
  - Retrieve sequence data from:
  - GenBank
  - Protein Data Bank

Reference:

1. Waterman, M. S. (2018). Introduction to computational biology: maps, sequences and genomes. Chapman and Hall/CRC.
2. Lesk, A. M. (2019). Introduction to bioinformatics. Oxford university press.
3. Singh, D. B., & Pathak, R. K. (Eds.). (2021). Bioinformatics: methods and applications. Academic Press.
4. Ismail, H. D. (2022). Bioinformatics: a practical guide to NCBI databases and sequence alignments. Chapman and Hall/CRC.
5. Ramsden, J. (2023). Bioinformatics: an introduction. Springer Nature.

Semester – V

.5.5 A. Minor Stream

Course Titles	**Biochemistry (Th+Pr)**
Course Credits	**4 Credit's (2 Th + 2 Pr)**
Course Outcomes	After going through the course, learner will be able to,
	1. To understand metabolisms of biomolecules and their regulations.
	2. To determine biological pathways for biomolecules.
	3. To understand biological importance of nucleic acids.
	4. To understand disorders of carbohydrates, lipids and protein metabolisms.
Module 1 (Credit 1) – Carbohydrate: Metabolism, Regulation and Disorders	
Learning Outcomes	After learning the module, learner will be able to,
	1. To understand carbohydrate metabolisms.
	2. To understand mechanisms of glucose regulation.
	3. To understand endocrine influence on carbohydrate metabolism.
	4. To understand about disorders of carbohydrate metabolisms.
Content Outline	• Carbohydrate metabolism: Digestion and absorption. Glycogenesis and its regulation. Glycogenolysis and its regulation. • Glycolysis, gluconeogenesis, oxidation of pyruvate, TCA cycle and its significance, HMP pathway, Uronic acid pathway and its importance, Oxidative Phosphorylation. • Regulation of blood glucose, and Endocrine (Hormonal) influence on carbohydrate metabolism: • Disorders of carbohydrate metabolism: Diabetes mellitus and its types, glycosuria and its types,
Module 2 (Credit 1) – Lipids: Metabolism and Disorders.	
Learning Outcomes	After learning the module, learner will be able to,
	1. To understand lipid metabolism and its disorders.
	2. To understand about coronary heart diseases.
	3. To understand about ketone bodies and their regulations
Content Outline	• Biosynthesis of Lipids: Synthesis of fatty acids, biosynthesis of phospholipids. • Metabolism of lipids: triglycerides, fatty acid oxidation, sphingolipids, lipoproteins and cholesterol. Metabolism of plasma lipoproteins • Ketogenesis: Minor and major pathways, its regulation and

	effects of ketosis. • Disorders of lipid metabolism: Dyslipidemia, hyperlipoproteinemias, obesity, fatty liver, lipotropic factors and ketosis, atherosclerosis and coronary heart diseases
Module 3 (Credit 1) – Protein: Metabolisms and Disorders.	
Learning Outcomes	After learning the module, learner will be able to, 1. To understand protein metabolisms. 2. To know about synthesis of essential and non-essential amino acids. 3. To understand about inherited disorders associated with urea cycle.
Content Outline	• Amino acid and protein metabolism: Digestion and absorption Transamination, oxidative deamination, ammonia formation and transport. Urea Cycle. • Synthesis of individual amino acid: Biosynthesis of catacholamines, melanin formation, Nitrogen balance. • Disorders of Protein and amino acid metabolism: Inherited disorders associated with urea cycle, proteinuria, proteinemia, Inborn error of amino acid metabolism.
Module 4 (Credit 1) – Nucleic acids	
Learning Outcomes	After learning the module, learner will be able to, 1. To determine chemical and molecular composition of Nucleic acids. 2. To know about concept of gene. 3. To understand about different types of RNA and their structures. 4. To know about Nucleoproteins and Biological importance of nucleic acid.
Content Outline	• Chemistry of DNA: Chemical composition and molecular structure of DNA. Chromatin. DNA and Gene. • Chemistry of RNA: Chemical composition and Classes of RNA (m-RNA, t-RNA and r-RNA), their structures and functions. • Nucleoproteins and Biological importance of nucleic acids.

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE):

- Assignments on syllabus topics and Group discussion.
- Preparation of various Charts associated with given disorders.
- Presentation and Seminar.

References:

1. Harper's Biochemistry, 28th edition, Robert K Murray, Tata McGraw publishers.
2. Lehinger Principle of Biochemistry, David L Nelson, 7th edition, WH freeman Publishers.
3. Fundamental of Biochemistry by A C Deb
4. Text book of Medical Laboratory Technology by Dr. P. B. Godkar.
5. Biotechnology: Expanding horizon. Kalyani Publication. B D Singh.
6. Essential of Biotechnology. Ane Books Pvt Ltd. R C Sobti and S S Pachauri.
7. Biotechnology: Fundamentals and Applications. Student edition. S S Purohit.
8. Biotechnology, Himalaya Publishing house. Mohan P Arora.
9. Principles of gene manipulation. Blackwell Science. S B Primrose.

Semester – V

.5.5 B. Minor Stream

Course Titles	**Analytical Chemistry (Th+Pr)**
Course Credits	**4 Credit's (2 Th + 2 Pr)**
Course Outcomes	After going through the course, the learner will be able to
	1. Apply fundamental principles of analytical chemistry, including sampling, chemical calculations, and quantitative analysis, to solve real-world analytical problems.
	2. Perform and interpret volumetric and instrumental analytical techniques for qualitative and quantitative determination of chemical substances.
	3. Utilize separation techniques such as extraction and chromatography for effective isolation and analysis of components in complex mixtures
	4. Evaluate analytical data using statistical tools and operate basic analytical instruments to obtain accurate, precise, and reliable results.
	After going through the course, the learner will be able to
Module 1 (Credit 1) – Introduction to Analytical Chemistry	
Learning Outcomes	After learning the module, the learner will be able to,
	1. Understand the scope and importance of analytical chemistry.
	2. Apply appropriate sampling methods for solids, liquids, and gases, and perform sample drying and analyte solution preparation accurately
	3. Perform quantitative chemical calculations, including concentration units, ppm/ppb, dilutions, and stoichiometric analysis
	4. Analyze reaction efficiency by identifying limiting reagents and calculating theoretical and practical yields
Content Outline	• **Analytical Basics:** Scope and importance. Functions of analytical chemistry, Steps involved in the analytical process, Methods of sample collection, preservation, and preparation, Sampling techniques for solids, liquids, and gases, Drying of samples, and preparation of analyte solution. • **Chemometrics (Numerical Problems):** Concentration units (mass and volume-based), Calculation of parts per million (ppm) and parts per billion (ppb), Dilution of solutions, Concept of millimole (mmol) and kilogram mole (kgmol), Stoichiometry of chemical reactions, Limiting reagent, Theoretical and practical yield, pH calculations (acids, bases, and buffers), Formation and stability constants.

<table>
<tr><td colspan="2">Module 2 (Credit 1) – Analytical Techniques</td></tr>
<tr><td rowspan="5">Learning Outcomes</td><td>After learning the module, the learner will be able to,</td></tr>
<tr><td>1. Understand the principles and procedures of volumetric analysis.</td></tr>
<tr><td>2. Differentiate and apply various titrations.</td></tr>
<tr><td>3. Interpret titration curves and accurately determine equivalence points using suitable indicators.</td></tr>
<tr><td>4. Explain the fundamental principles of spectroscopic techniques.</td></tr>
<tr><td>Content Outline</td><td>• Volumetric Methods of Analysis: Introduction to volumetric analysis, Calibration of volumetric apparatus, Primary and secondary standards, Principles of titration
o Types of Titrations:
✓ Acid–base titrations
✓ Redox titrations
✓ Titration curves and endpoint determination
• Selection and suitability of indicators
• Introduction to instrumental analysis by spectroscopic methods:
o UV–Visible spectroscopy
o Infrared (IR) spectroscopy
o Proton Magnetic Resonance Spectroscopy (1H-NMR)</td></tr>
<tr><td colspan="2">Module 3 (Credit 1) - Separation Techniques</td></tr>
<tr><td rowspan="3">Learning Outcomes</td><td>After learning the module, the learner will be able to,</td></tr>
<tr><td>1. Understand and apply solvent extraction and solid phase extraction techniques.</td></tr>
<tr><td>2. Explain and perform planar chromatographic methods and quantitative detection techniques like Densitometric and Fluorimetric methods.</td></tr>
<tr><td>Content Outline</td><td>• Separation Methods
o Solvent Extraction: Principle and efficiency, Selectivity of extraction, Extraction systems and methods, Applications.
o Solid Phase Extraction (SPE): Principle, Procedure, Applications
o Planar Chromatography: Basic principles, Classification of chromatographic techniques, Paper chromatography: technique and applications, Thin Layer Chromatography (TLC): technique and applications.
o High Performance Thin Layer Chromatography (HPTLC): Conversion of TLC to quantitative analysis, Densitometric detection methods, Fluorimetric detection</td></tr>
</table>

	methods
Module 4 (Credit 1) – Analytical Statistics	
Learning Outcomes	After learning the module, the learner will be able to,
	1. Evaluate and interpret analytical data using statistical concepts.
	2. Understand, operate, and maintain key analytical instruments for accurate and reliable measurements.
Content Outline	• **Statistics in Analytical Chemistry**: Evaluation of analytical data, Accuracy and precision, Types of errors, Normal distribution curve, Standard deviation, Confidence limits, Graphical presentation of results, Method of averaging, Method of least squares (linear), Significant figures, Correlation analysis, Statistical hypothesis testing: o t-test o F-test o Chi-square test • **Introduction To Analytical Instruments** o pH meter: components, use, maintenance, applications o Analytical balance – Types, operation, and construction, Errors in weighing, and care of an analytical balance. o Spectrophotometer: Principle, type, components, uses, application

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE):

- Applications of Chromatography in Food or Pharmaceutical Analysis
- Principles and Uses of Spectroscopic Techniques
- Role of Analytical Chemistry in Environmental Monitoring
- Study of Analytical Instruments (e.g., Spectrophotometer)

Reference Books:

1. Textbook of Medical Laboratory Technology by Dr. P. B. Godkar, 4th edition, 2024.
2. Seamus P.J. Higson: Analytical Chemistry.
3. Douglas A. Skoog and Donald M. West: Fundamentals of Analytical Chemistry.
4. Adion A. Gordus: Schaum's Outline of Analytical Chemistry, Tata McGraw-Hill.
5. GaryD. Christian: Analytical Chemistry.
6. Freifelder and Kealy: Analytical Chemistry.

Semester – V

.5.5 C. Minor Stream

Course Titles	**Physical Chemistry (Th+Pr)**
Course Credits	**4 Credit's (2 Th + 2 Pr)**
Course Outcomes	After going through the course, learners will be able to
	1. Explain the fundamental concepts of thermodynamics, gaseous, liquid, and solid states and their applications in chemistry.
	2. Apply gas laws, kinetic theory, and equations of state to interpret the behaviour of ideal and real gases.
	3. Analyze the physical properties of liquids and solids, including viscosity, surface tension, crystal structures, and defects.
	4. Interpret ionic equilibria, acid-base reactions, buffer systems, hydrolysis, and solubility phenomena in chemical and biological systems.
	5. Perform calculations, experimental observations, and data interpretation related to physical chemistry concepts using mathematical, graphical, and analytical approaches.
Module 1:(Credit 1) Gaseous State	
Learning Outcomes	After learning the module, learners will be able to
	1. Differentiate between solid,liquid,and gaseous states based on molecular arrangement and properties
	2. Understand and apply gas laws(Boyle's,Chales'.Avogadro's) with mathematical expression
	3. Derive and use the ideal gas equation PV=nRT for calculations.
Content Outline	• Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation;collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η; variation of viscosity with temperature and pressure. • Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities. • Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor, Z, and its variation with pressure for different gases. Causes of deviation from ideal behaviour. Vander Waals equation of state, its derivation and application in explaining real gas behaviour, mention of other equations of state (Berthelot, Dietrici); virial equation of state; van der Waals equation expressed in virial form and calculation of Boyle temperature. Isotherms of real gases and their comparison with

	van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.
Module 2:(Credit 1) Liquid State	
Learning Outcomes	After learning the module, learners will be able to
	1. Describe the structure and physical properties of liquids, including vapour pressure, viscosity, and surface tension.
	2. Explain the effects of temperature and solutes on viscosity and surface tension of liquids.
	3. Demonstrate the use of laboratory instruments such as stalagmometer and Ostwald viscometer for determination of liquid properties.
	4. Prepare and dilute aqueous solutions of required concentrations and determine density experimentally.
	5. Analyze experimental data using numerical and graphical methods.
Content Outline	• Qualitative treatment of the structure of the liquid state; Radial distribution function; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. • Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases. • Qualitative discussion of structure of water.
Module 3:(Credit 1) Solid State	
Learning Outcomes	After learning the module, learners will be able to
	1. Explain the nature and classification of solids based on crystal structure and symmetry.
	2. Interpret crystal systems, Bravais lattices, Miller indices, and symmetry elements.
	3. Describe the principles of X-ray diffraction and apply Bragg's law in crystal structure analysis.
	4. Discuss crystal defects, glasses, and liquid crystals and their significance in material science.
	5. Compare structural arrangements and properties of crystalline solids.
Content Outline	• Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal

	systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. • Defects in crystals. Glasses and liquid crystals.
Module 4:(Credit 1) Ionic Equilibria	
Learning Outcomes	After learning the module, learners will be able to
	1. Differentiate between strong, weak, and moderate electrolytes and explain ionization equilibria.
	2. Calculate pH, ionization constants, hydrolysis constants, and solubility product for ionic systems.
	3. Explain buffer solutions, Henderson equation, and the importance of buffers in analytical and biological systems.
	4. Apply equilibrium principles to acid-base titrations and indicator selection.
	5. Interpret multistage equilibria and ionic reactions in chemical and biological processes.
Content Outline	• Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases,pH scale, common ion effect; dissociation constants of mono-, di- and triprotic acids (exact treatment). • Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity,buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body. • Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations. • Multistage equilibria in polyelectrolyte systems; hydrolysis and hydrolysis constants.

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE):

- Seminar / Presentation: "Deviation of Real Gases from Ideal Behaviour and Industrial Applications."
- Case Study: Comparative analysis of ideal and real gases used in medical oxygen cylinders and refrigeration systems.
- Quiz/Test: MCQs and short answers on kinetic theory, Maxwell distribution, collision frequency, and viscosity.

Reference:

1. Dalal, M. (2018). A Textbook of Physical Chemistry–Volume 1. Dalal Institute.
2. Silbey, R. J., Alberty, R. A., Papadantonakis, G. A., & Bawendi, M. G. (2022). Physical chemistry. John Wiley & Sons.
3. Kuhn, H., Waldeck, D. H., & Försterling, H. D. (2024). Principles of physical chemistry. John Wiley & Sons.

Semester – V

.5.6 Vocational Skill Courses (VSC-4)

Course Titles	**Laboratory Management (Pr)**
Course Credits	**2 Credit's**
Course Outcomes	After going through the course, learner will be able to,
	1. Demonstrate leadership, human resource management, and decision-making skills in laboratory settings.
	2. Elucidate the principles of laboratory organization, management, and workflow optimization.
	3. Apply laboratory safety measures, waste disposal protocols, and first aid practices effectively.
	4. Demonstrate leadership, human resource management, and decision-making skills in laboratory settings.
	5. Develop and implement SOPs, documentation systems, and understand medico-legal responsibilities.
Module 1 (Credit 1) - Laboratory Management I	
Learning Outcomes	After learning the module, learner will be able to,
	1. Describe types, organization, and operational structure of clinical laboratories.
	2. Apply basic financial management concepts including budgeting, cost analysis, and financial statements.
	3. Describe principles of Total Quality Management (TQM) and quality systems.
	4. Explain quality control processes including inspection, validation, and handling non-conformities.
	5. Discuss accreditation requirements and modern quality concepts like Six Sigma.
Content Outline	• General Laboratory Management, Basic concepts and Definitions, Organization and operation of laboratory, various types of laboratories. • Basic laboratory principles and procedures, Laboratory safety, the first aid measures, The responsibilities of laboratory staff, Waste disposal. • Role of managers, providing leadership by example and attitude, Human resource management, Building a positive culture, Developing a system for measuring performances. Forecasting, Planning and Decision making formulating vision and mission. • Importance of effective communication and documentation. Writing SOPs, Understanding medico-legal aspects of laboratory practice.

	• Introduction to financial management, key concepts like finance management, budgeting, test cost accounting, capital expenditure, expense report, break-even analysis, understanding balance sheet, profit and loss statement, equity and cash flow. • Re-engineering work flow and technology changes. • Fundamentals of total quality management. Quality system, Control of design, document, data, purchasing. Process control, control of inspection measuring and testing materials, concept of validation, Control of non-conforming areas. • TQM framework Control of quality records, Internal quality audits. • Current trends in laboratory accreditation, Understanding NABL and ISO regulation. The six sigma concept.
Module 2 (Credit 1) - Laboratory Management I (Practical)	
Learning Outcomes	After learning the module, learner will be able to, 1. Perform internal quality control procedures accurately. 2. Identify and control pre-analytical variables affecting test results. 3. Monitor and control analytical variables in laboratory testing. 4. Evaluate post-analytical variables and ensure accurate reporting. 5. Utilize reference materials and calibration techniques effectively.
Content Outline	• Total quality management framework • Essential elements of quality assurance program • Internal quality control • Control of pre-analytical variables • Control of analytical variales • Control of post-analytical variables • Validation of methods • Documentation of analytical protocols • Verification of reference intervals • Reference materials and calibrating definitive methods • Sources of variations in laboratory test results.

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE):

- Short Assignment: Laboratory Organization & Management
  Prepare a structured note on:

- Types of laboratories
- Organizational hierarchy
- Roles of laboratory personnel
- Evaluation: Clarity, content accuracy, presentation

- Case Study Analysis: Laboratory Safety & Error Management
  - Scenario-based case (e.g., accidental exposure/spillage)
  - Identify error and Suggest corrective & preventive actions (CAPA)
  - Evaluation: Analytical thinking, problem-solving.

- Laboratory Audit Simulation (Group Activity)
  - Conduct a mock internal audit
  - Check:
    - ✓ SOP availability
    - ✓ Documentation
    - ✓ Safety compliance
  - Submit audit report
  - Skill: Accreditation readiness

Reference:

1. McPherson, R. A., & Pincus, M. R. (2021). Henry's clinical diagnosis and management by laboratory methods E-book. Elsevier Health Sciences.
2. McClatchey, K. D. (Ed.). (2002). Clinical laboratory medicine. Lippincott Williams & Wilkins.
3. Papp, J. (2023). Quality management in the imaging Sciences-E-Book: quality management in the imaging Sciences-E-Book. Elsevier Health Sciences.
4. Garcia, L. S. (2024). Clinical laboratory management. John Wiley & Sons.
5. MANUAL, B. LABORATORY BIOSAFETY MANUAL.

Course Syllabus

Semester – VI

.6.1 Major (Core)

Course Titles	**Industrial Microbiology (Th+Pr)**
Course Credits	**4 Credit's (2 Th + 2 Pr)**
Course Outcomes	1. Course Outcomes After going through the course, learners will be able to
	2. Understand the principles, historical development, and scope of industrial microbiology and downstream processing.
	3. Demonstrate knowledge of isolation, preservation, maintenance, and improvement of industrially important microbial strains and fermentation media.
	4. Explain various fermentation processes, bioreactor systems, and control of fermentation parameters used in industrial production.
	5. Apply knowledge of industrial microbial products, fermentation techniques, and immobilized enzymes in biotechnological applications.
	6. Analyze the role of industrial microbiology in the production of pharmaceuticals, enzymes, beverages, and other value-added products.
Module 1 (Credit 1): Introduction and Isolation of Industrially Important Microbial Strains and Fermentation Media to Industrial Microbiology And Down-stream Processing	
Learning Outcomes	1. Learning Outcomes After learning the module, learners will be able to
	2. Describe the historical milestones in the development of industrial microbiology and identify sources of industrially important microorganisms.
	3. Explain the contributions of major scientists in industrial microbiology and demonstrate methods for isolation, preservation, and maintenance of industrial microbial strains.
	4. Discuss the principles and significance of downstream processing and explain techniques of strain improvement for enhanced productivity.
	5. Explain techniques of strain improvement for enhanced productivity and differentiate crude and synthetic fermentation media
Content Outline	• Brief history and developments in industrial microbiology • Cell disruption, filtration, centrifugation, solvent extraction, precipitation, lyophilization and spray drying

	• Sources of industrially important microbes and methods for their isolation, preservation and maintenance of industrial strains, strain improvement • Crude and synthetic media; molasses, corn-steep liquor, sulphite waste liquor, whey, yeast extract and protein hydrolysates
Module 2 (Credit 1): Types of Fermentation Processes, Bio-reactors and Measurement of Fermentation Parameters and Significance of batch of Fermentation	
Learning Outcomes	After learning the module, learners will be able to
	1. Compare solid-state and liquid-state fermentation methods.
	2. Differentiate batch, fed-batch, and continuous fermentation processes.
	3. Classify laboratory, pilot-scale, and production fermenters.
	4. Analyze the role of pH, temperature, dissolved oxygen, foaming, and aeration in fermentation control.
	5. Demonstrate knowledge of immobilization methods and their advantages.
	6. Evaluate large-scale applications of immobilized enzymes such as glucose isomerase and penicillin acylase.
Content Outline	• Types of fermentation processes - Solid-state and liquid-state (stationary and submerged) fermentations; batch, fed-batch (eg. baker's yeast) and continuous fermentations • Components of a typical bio-reactor, Types of bioreactors- Laboratory, pilot- scale and production fermenters, constantly stirred tank and air-lift fermenters, • Measurement and control of fermentation parameters - pH, temperature, dissolved oxygen, foaming and aeration • Industrial Production of Citric acid, ethanol, penicillin, glutamic acid and Vitamin B12 • Industrial importance of Enzymes (amylase, protease, lipase) • Microbial Fermentation of Wine, beer • Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes (glucose isomerase and penicillin acylase)
Module 3 (Credit 1): Introduction to Fermenter	
Learning Outcomes	After learning the module, learners will be able to
	1. Identify and describe the structure, parts, and functions of a fermenter (bioreactor).

	2. Explain the role and applications of fermenters in industrial microbiology and biotechnology.
	3. Demonstrate basic operational knowledge of fermenters used for microbial cultivation and product formation.
Content Outline	• Study different parts of fermenter • Uses and application fermenter
Module 4 (Credit 1): Microbial fermentation for the production and estimation (qualitative and quantitative	
Learning Outcomes	1. Perform microbial fermentation experiments for the production of industrially important metabolites and enzymes.
	2. Apply biochemical and analytical techniques for qualitative and quantitative estimation of fermentation products.
	3. Analyze and interpret experimental results related to enzyme, amino acid, organic acid, and alcohol production.
	4. Evaluate fermentation efficiency and product yield in microbial production processes.
	5. Perform microbial fermentation experiments for the production of industrially important metabolites and enzymes.
Content Outline	• Enzymes: Amylase and Protease • Amino acid: Glutamic acid • Organic acid: Citric acid • Alcohol: Ethanol

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE)

- Short Assignment: Various types fermentation processes
- Poster presentation : Differentiate batch, fed-batch, and continuous fermentation processes.
- Seminar/Presentation: Recent advances in downstream processing techniques.
- Assignment: Prepare a labeled diagram and working principle of laboratory and industrial fermenters.
- Seminar/Presentation: Applications of fermenters in food, pharmaceutical, and biotechnology industries.
- Data Analysis Activity: Evaluation of fermentation efficiency and product yield using qualitative and quantitative observations.

Reference:

1. Tortora, G. J., Funke, B. R., Case, C. L., Weber, D., & Bair, W. (2013). Microbiology: an introduction (Vol. 8). Boston:: Pearson.
2. Verma, P. (Ed.). (2022). Industrial microbiology and biotechnology (pp. 667-690). Singapore:: Springer.
3. Nehra, M., & Nain, V. (2024). Handbook of industrial food microbiology. Apple

Academic Press.
4. STANBURY, P., & WHITAKER, A. Principles of fermentation technology.
5. Casida, L. E. (2018). Industrial microbiology. New Age International Publishers.
6. Dubey, R. C., & Maheshwari, D. K. A Textbook of Microbiology (Library Hardback Edition). S. Chand Publishing.

Semester – VI

.6.2 Major (Core)

Course Titles	**Recombinant DNA Technology (Th)**
Course Credits	**4 Credit's**
Course Outcomes	After going through the course, learner will be able to,
	1. Explain the principles, tools, and enzymology involved in recombinant DNA technology and vector systems.
	2. Demonstrate knowledge of DNA isolation, library construction, and gene transfer methods used in genetic engineering.
	3. Analyze methods for selection, screening, and molecular characterization of recombinant DNA using modern molecular techniques.
	4. Evaluate genome mapping, sequencing approaches, and ethical considerations related to genetically modified organisms (GMOs) and intellectual property rights (IPR).
	After going through the course, learner will be able to,
Module 1 (Credit 1) – Basic Principles and Toolkit of rDNA Technology	
Learning Outcomes	After learning the module, learner will be able to,
	1. Describe the history, overview, and principles of recombinant DNA technology.
	2. Explain the central dogma involved in DNA manipulation.
	3. Classify nucleases and describe their mode of action in gene cloning.
	4. Explain the role of DNA modifying enzymes in recombinant DNA technology.
	5. Describe the structure and construction of vector systems such as pBR322, pUC series, and phage-based vectors.
Content Outline	• Introduction to rDNA technology: History, overview and the central dogma of DNA manipulation • Enzymology of Gene Cloning: Nucleases and their mode of action, DNA modifying enzymes • Vector systems: structure and construction of pBR322, pUC series, phage-based vectors
Module 2 (Credit 1) – Gene Isolation and Transformation Methods	
Learning Outcomes	After learning the module, learner will be able to,
	1. Demonstrate knowledge of DNA isolation and purification techniques from host cells.
	2. Differentiate methods for plasmid and viral DNA extraction.

	3. Explain the principles involved in genomic and c DNA library construction.
	4. Describe the role of reverse transcription in cDNA synthesis.
	5. Compare biological, physical, and chemical methods of gene transfer.
Content Outline	• DNA isolation and purification: Plasmid, viral DNA from host cells • Library Construction: Construction of genomic and cDNA libraries, their principles and reverse transcription • Gene Transfer strategies: Biological method, Physical/Chemical method
Module 3 (Credit 1) – Selection, Screening and Molecular analysis	
Learning Outcomes	After learning the module, learner will be able to,
	1. Differentiate direct and indirect methods for identification of recombinant clones.
	2. Explain the use of radioactive and non-radioactive markers in nucleic acid labeling.
	3. Describe molecular analysis techniques including blotting methods.
	4. Analyze the principles and applications of PCR, qPCR, and RT-PCR in gene amplification and molecular diagnostics.
	5. Evaluate the importance of molecular tools in recombinant DNA analysis.
Content Outline	• Identification of Recombinants: Direct & Indirect screening methods • Nucleic acid labeling: Methods foe labeling DNA probes using radioactive and non-radioactive markers • Molecular Analysis: Blotting techniques, PCR technology, qPCR, RT-PCR and applications in gene amplification
Module 4 (Credit 1) – Gene Mapping, Sequencing and Ethics	
Learning Outcomes	After learning the module, learner will be able to,
	1. Explain the principles of DNA sequencing methods including Sanger and Maxam-Gilbert sequencing.
	2. Describe automated sequencing technologies and their significance.
	3. Interpret genome mapping techniques using molecular markers such as RFLP, RAPD, and SSR.
	4. Differentiate chromosome walking and chromosome jumping techniques.

	5. Evaluate ethical issues, laboratory safety guidelines, handling of GMOs, and IPR related to recombinant products.
Content Outline	• DNA Sequencing: Sanger Sequencing, Maxam-Gilbert method, automated sequencing techniques • Genome mapping: Concepts of molecular markers (RFLP, RAPD, SSR), Chromosome walking and jumping • Bioethics: Guidelines for laboratory safety, handling of GMOs and IPR related to cloned products

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE):

- Assignments and Group discussion.
- Presentation on different methods of molecular analysis
- Arrange a visit to a research Centre and IPR institute.
- Chart preparation
- Debate competition on ethical issues
- Case study on ethical issues related to GMOs and GMCs

References:

Core Textbooks & Reference Books

1. Primrose, S. B., & Twyman, R. (2013). Principles of gene manipulation and genomics. John Wiley & Sons.
2. Glick, B. R., & Patten, C. L. (2022). Molecular biotechnology: principles and applications of recombinant DNA. John Wiley & Sons.
3. Brown, Terry A. Genomes 5. CRC Press, 2023.
4. Brown, T. A. (2025). Gene cloning and DNA analysis: an introduction. John Wiley & Sons.

Semester – VI

.6.3 A. Major (Elective)

Course Titles	**Infectious Disease (Th)**
Course Credits	**4 Credit's**
Course Outcomes	After going through the course, learner will be able to,
	1. Explain the principles of infection, infectious diseases, host–pathogen interactions, immunization, and diagnostic approaches in medical microbiology.
	2. Analyze the etiology, transmission, pathogenesis, clinical manifestations, diagnosis, prevention, and control of respiratory, viral, and bacterial infectious diseases.
	3. Evaluate gastrointestinal, zoonotic, and systemic infectious diseases and interpret their public health significance.
	4. Classify parasitic, helminthic, and fungal infections and assess their epidemiology, diagnosis, treatment, and preventive measures.
Module 1 (Credit 1) – Principles of Infectious Diseases, Host–Pathogen Interaction and Immunization	
Learning Outcomes	After learning the module, learner will be able to,
	1. Explain the concepts of infection and infectious diseases.
	2. Describe the host–pathogen relationship and transmission of infectious agents.
	3. Interpret the clinical approach to patients with suspected infections.
	4. Classify methods of immunization against infectious diseases.
	5. Analyze causes and significance of pyrexia of unknown origin (PUO).
Content Outline	• Host–pathogen interaction and determinants of pathogenicity • Approach to the patient with suspected infection: clinical history, specimen collection, laboratory diagnosis, interpretation of microbiological reports • Immunization against infectious diseases: active and passive immunization, vaccines, immunization schedules, herd immunity • Pyrexia of Unknown Origin (PUO): causes, diagnosis, microbiological investigations
Module 2 (Credit 1) – Respiratory, Viral and Neurological Infectious Diseases	
Learning Outcomes	After learning the module, learner will be able to,
	1. Describe the etiology, pathogenesis, diagnosis, and prevention of respiratory tract infections.

	2. Differentiate bacterial and viral infectious diseases based on symptoms and laboratory diagnosis.
	3. Analyze the epidemiology and public health burden of HIV/AIDS and tuberculosis.
	4. Explain vaccine-preventable diseases and their control measures.
	5. Interpret clinical manifestations and diagnosis of meningitis.
Content Outline	• **Respiratory and Airborne Infections** o Acute lower respiratory tract infection o Tuberculosis o Whooping cough (Pertussis) o Tetanus • **Viral Infectious Diseases** o HIV/AIDS: epidemiology, transmission, pathogenesis, diagnosis, prevention and control o Measles • **Neurological Infections** o Meningitis: bacterial and viral meningitis, diagnosis and prevention
Module 3 (Credit 1) – Gastrointestinal, Zoonotic and Systemic Infectious Diseasesb	
Learning Outcomes	**After learning the module, learner will be able to,**
	1. Explain the etiology and pathogenesis of gastrointestinal infectious diseases.
	2. Differentiate foodborne bacterial infections and intoxications.
	3. Analyze zoonotic diseases and their public health importance.
	4. Interpret laboratory diagnostic approaches for systemic infections.
	5. Evaluate prevention and control strategies for communicable diseases.
Content Outline	• **Gastrointestinal Infections** o Cholera o Dysentery (amoebic and bacillary) and food poisoning o Bacterial gastroenteritis: ✓ Escherichia coli O157 ✓ Salmonella enteritidis ✓ Campylobacter jejuni

	• **Zoonotic and Systemic Diseases**
	  o Leptospirosis (Leptospira interrogans)
	  o Brucellosis
	  o Toxoplasmosis
	  o Leprosy
	  o Systemic fungal infections

Module 4 (Credit 1) – Parasitic, Helminthic and Tropical Infectious Diseases	
Learning Outcomes	**After learning the module, learner will be able to,**
	1. Classify medically important protozoan and helminthic parasites.
	2. Describe the epidemiology, pathogenesis, and diagnosis of tropical parasitic diseases.
	3. Differentiate intestinal and tissue helminth infections.
	4. Analyze preventive and control measures for parasitic diseases.
	5. Evaluate the impact of parasitic infections on public health.

Content Outline	• **Protozoan and Tropical Diseases**
	  o Malaria
	  o Leishmaniasis
	  o Hydatid disease (Echinococcus granulosus)
	  o Lymphatic filariasis (Wuchereria bancrofti, Brugia malayi)
	  o Schistosoma species and Paragonimiasis
	• **Tapeworm Infections**
	  o Taenia saginata
	  o Taenia solium
	  o Diphyllobothrium latum
	  o Hymenolepis nana
	• **Intestinal Nematode Infections**
	  o Enterobius vermicularis
	  o Ascaris lumbricoides
	  o Trichuris trichiura
	  o Ancylostoma duodenale
	  o Strongyloides stercoralis

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE):

- Seminar on emerging infectious diseases and antimicrobial resistance.
- Poster preparation on vaccine-preventable diseases.

- Case analysis of tuberculosis diagnosis and management.
- Assignment on zoonotic disease transmission and prevention.
- Preparation of parasite life cycle charts/models.

Reference:

1. Cornelissen, C. N., Harvey, R. A., & Fisher, B. D. (2012). Microbiology (Vol. 3). Lippincott Williams & Wilkins.
2. Greenwood, D., Slack, R. C., Barer, M. R., & Irving, W. L. (2012). Medical microbiology e-book: A guide to microbial infections: Pathogenesis, immunity, laboratory diagnosis and control. with STUDENT CONSULT online access. Elsevier Health Sciences.
3. Fairbrother, R. W. (2014). A text-book of medical bacteriology. Butterworth-Heinemann.
4. Sastry, A. S., & Bhat, S. (2018). Essentials of medical microbiology. JP Medical Ltd.
5. Bandyopadhyay, P. K., Das, N. R., & Chattopadhyay, A. (2022). Biochemical, immunological and epidemiological analysis of parasitic diseases. Springer.

Semester – VI

.6.3 B. Major (Elective)

Course Titles	**Biostatistics (Th)**
Course Credits	**4 Credit's**
Course Outcomes	**After going through the course, learner will be able to,**
	1. Understand and apply probability concepts and statistical distributions relevant to biological and biomedical data analysis.
	2. Analyze discrete and continuous random variables and interpret their distributional properties in biostatistical applications.
	3. Evaluate mathematical and statistical functions of random variables, including moments, generating functions, and order statistics.
	4. Apply probability inequalities and distribution theory for solving problems in biological and health sciences.
	5. Analyze bivariate statistical distributions and relationships between biological variables using joint, marginal, and conditional probability concepts.
Module 1 (Credit 1) – Random Variables and Probability Distributions in Biostatistics	
Learning Outcomes	After learning the module, learner will be able to,
	1. Describe and interpret the properties of distribution functions and their relationship with uniform variates.
	2. Differentiate and apply univariate discrete and continuous probability distributions relevant to biological sciences.
	3. Examine the properties and applications of Bernoulli, Binomial, Poisson, Geometric, Hypergeometric, Negative Binomial, and uniform distributions in biological studies.
	4. Interpret continuous distributions such as Normal, Exponential, Gamma, Beta, Weibull, Pareto, Laplace, and Log-normal in biostatistical contexts.
Content Outline	• Random Variable (discrete and continuous), Distribution function and its properties, Relation of distribution function with uniform variate. • Review of univariate discrete and continuous distributions with special reference to bio-statistics, Bernoulli, Binomial, Poisson, Hyper-geometric, Geometric, Negative Binomial, Discrete uniform, Power series, Continuous uniform, Normal, Exponential, Gamma, Beta, Cauchy, Weibull, Pareto, Laplace and log normal (elementary properties and applications only), Truncated distributions, Compound distribution.
Module 2 (Credit 1) – Functions of Random Variables and Distribution Families	

Learning Outcomes	After learning the module, learner will be able to,
	1. Explain and apply functions of random variables and their distributions in statistical analysis.
	2. Describe exponential family distributions, location-scale families, and non-regular families.
	3. Analyze symmetric distributions and interpret their statistical properties.
Content Outline	• Functions of random variables, their distribution in univariate random variables and its applications. • Exponential family of distributions. Location and scale families, non-regular families. • Symmetric distributions, properties of symmetric distributions, non-regular families, location and scale families and examples. • Order statistics their distribution and properties. Joint and marginal distributions of order statistics.
Module 3 (Credit 1) – Expectation, Moments and Probability Inequalities	
Learning Outcomes	After learning the module, learner will be able to,
	1. Define and compute expectation, moments, probability generating functions, and moment generating functions.
	2. Apply convolution techniques to solve probability distribution problems.
	3. Explain and interpret moment inequalities including Markov, Chebyshev, Hölder, Minkowski, and Jensen inequalities.
	4. Apply probability inequalities in statistical problem-solving and biological interpretation.
Content Outline	• Expectation and moments, Probability generating function, moment generating function, convolution and example. • Moment inequalities: Markov, Chebychev, Holder, Minkowski and Jensen Inequalities with application. • Basic inequality of Liapunov's.
Module 4 (Credit 1) – Bivariate Probability Distributions and Statistical	
Learning Outcomes	**After learning the module, learner will be able to,**
	1. Define and distinguish bivariate discrete and continuous probability distributions.
	2. Explain and calculate marginal and conditional distributions of bivariate random variables.
	3. Apply Jacobian transformation techniques to derive distribution functions of transformed variables.
	4. Describe and analyze multinomial, bivariate Poisson, bivariate

	exponential, and bivariate normal distributions.
Content Outline	• Bivariate discrete and continuous distributions, marginal and conditional distributions. • Distribution functions of bivariate random variable using Jacobian of transformation. • Multinominal distribution, Bivariate Poisson, Bivariate exponential (Marshall and Olkin), Bivariate Normal distributions and their properties.

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE):

- Case Study Analysis: Analyze biological datasets using probability distributions.
- Data Interpretation Exercise: Interpret graphical and statistical data in biological contexts.
- Project: Analyze a biological dataset using statistical tools.
- Worksheet Assignment: Practice generating functions, moments, and Jacobian transformations.

Reference:

1. Arora, P. N., & Malhan, P. K. (2017). Biostatistics.
2. Daniel, W. W., & Cross, C. L. (2018). Biostatistics: a foundation for analysis in the health sciences. John Wiley & Sons.
3. Saha, I., & Paul, B. (2023). Essentials of biostatistics and research methodology. Academic Publishers.
4. Verma, V., Khan, H. T., Nath, D. C., & Land, K. C. (2025). Biostatistical Methods and Applications in Health Research. Routledge.

Semester – VI

.6.4 Minor Stream

Course Titles	**Food Microbiology (Th)**
Course Credits	**2 Credit's**
Course Outcomes	**After going through the course, learners will be able to**
	1. Explain the principles and scope of food microbiology, including microbial groups associated with food.
	2. Identify beneficial and harmful microorganisms in food and explain factors affecting microbial growth in foods.
	3. Describe food spoilage mechanisms, foodborne diseases, and microbial contamination in various food products.
	4. Apply principles of food preservation, sanitation, and quality control for maintaining food safety.
	After going through the course, learners will be able to
Module 1 (Credit 1): Fundamentals of Food Microbiology	
Learning Outcomes	1. Define food microbiology and explain its significance in food safety and public health.
	2. Identify important microorganisms associated with food.
	3. Explain intrinsic and extrinsic factors affecting microbial growth in food.
	4. Describe beneficial microorganisms and fermentation processes used in food production.
Content Outline	• **Introduction to Food Microbiology** o Definition, scope, and importance of food microbiology o History and development of food microbiology o Sources of microorganisms in food: o Soil o Water o Air o Animals and humans o Food handling and processing environment • **Microorganisms Important in Food** o Bacteria in food o Yeasts and molds o Viruses and parasites in food contamination o Beneficial microorganisms in food processing

	• **Factors Affecting Microbial Growth in Food**
	  o Intrinsic factors:
	  ✓ pH
	  ✓ Moisture content
	  ✓ Water activity
	  ✓ Nutrient availability
	  ✓ Oxidation-reduction potential
	  ✓ Natural antimicrobial substances
	  o Extrinsic factors
	  ✓ Temperature
	  ✓ Humidity
	  ✓ Atmospheric gases
	  ✓ Storage conditions
	• **Fermented Foods**
	  o Principles of food fermentation
	  o Role of microorganisms in fermentation
	  o Fermented food products:
	  ✓ Curd
	  ✓ Cheese
	  ✓ Bread
	  ✓ Vinegar
	  ✓ Fermented beverages

Module 2 (Credit 1): Microbial fragmentation for the production and estimation (qualitative and quantitative)	
Learning Outcomes	1. Explain food spoilage and contamination.
	2. Identify major foodborne pathogens and diseases.
	3. Describe food preservation techniques and their microbiological basis.
	4. Discuss sanitation and food quality assurance measures.

Content Outline	• **Food Spoilage**
	  o Definition and causes
	  o Spoilage of:
	  o Milk and dairy products
	  o Meat and poultry
	  o Fruits and vegetables

	○ Cereals and canned foods • **Foodborne Diseases and Food Poisoning** ○ Concept of foodborne infections and intoxications ○ Important foodborne pathogens: ○ Salmonella ○ Staphylococcus aureus ○ Escherichia coli ○ Clostridium botulinum ○ Listeria monocytogenes ○ Vibrio cholerae ○ Food poisoning: ○ Causes ○ Symptoms ○ Prevention • **Food Preservation Methods** ○ Heat preservation: ○ Pasteurization ○ Sterilization ○ Cold preservation: ○ Refrigeration ○ Freezing ○ Drying and dehydration ○ Chemical preservatives ○ Radiation preservation ○ Packaging and storage • **Food Hygiene and Quality Control** ○ Food sanitation and hygiene ○ Personal hygiene in food handling ○ Good Manufacturing Practices (GMP) ○ Hazard Analysis and Critical Control Point (HACCP) ○ Food safety standards and regulations

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE):

- Food Fermentation Study: Write a short note on microorganisms involved in preparation of fermented foods.

- Comparative Study: Compare different food preservation methods and their advantages/disadvantages.
- Poster/Chart Preparation: Prepare a chart showing common foodborne pathogens and diseases caused by them.
- Seminar Presentation: Present on food safety standards and quality control in food industries.
- Field-Based Assignment: Visit a food processing unit/local dairy/bakery and submit a report on hygiene and food safety practices.

Reference:

1. Frazier, William C. "Pioneer of Dairy and Food Microbiologist." Pioneers In Microbiology: The Human Side Of Science (2017): 1.
2. Dhara, D., Biswas, S., Das, S. K., & Biswas, O. (2021). Status of food safety and food security in India in the perspective of FSSAI. Indian Journal of Animal Health, 60(2), 167-173.
3. Matthews, K. R., Kniel, K. E., & Critzer, F. J. (2025). Food microbiology: an introduction. John Wiley & Sons.

Semester – VI

.6.5 Minor Stream

Course Titles	**Food Chemistry And Neutraceuticals (Th)**
Course Credits	**4 Credit's**
Course Outcomes	**After going through the course, learners will be able to**
	1. Explain the chemical composition and properties of major food constituents.
	2. Describe the role of carbohydrates, proteins, lipids, vitamins, minerals, enzymes, and water in food systems.
	3. Interpret chemical changes occurring during food processing, preservation, and storage.
	4. Apply concepts of food chemistry in quality evaluation, food safety, and nutritional assessment.
	5. Gain knowledge about functional foods and nutraceuticals along with their mode of action.
	6. Describe the health effects of various functional foods and nutraceuticals.
Module 1 (Credit 1): Fundamentals of Food Chemistry and Food Components	
Learning Outcomes	**After learning the module, learners will be able to**
	1. Explain the scope and significance of food chemistry.
	2. Describe the chemistry and functional properties of food constituents.
	3. Interpret the role of water and enzymes in food systems.
	4. Explain nutritional and physicochemical properties of foods.
Content Outline	• **Introduction to Food Chemistry** o Definition, scope, and importance of food chemistry o Chemical composition of foods o Relationship between food chemistry and nutrition • **Carbohydrates in Foods** o Classification: o Monosaccharides o Disaccharides o Polysaccharides o Structure and properties of carbohydrates o Functional role in foods

	○ Browning reactions: ○ Maillard reaction ○ Caramelization • **Proteins in Foods** ○ Structure and classification of proteins ○ Functional properties: ○ Solubility ○ Gelation ○ Emulsification ○ Foaming ○ Protein denaturation and coagulation ○ Nutritional importance • **Lipids in Foods** ○ Classification and structure ○ Fatty acids and triglycerides ○ Physical and chemical properties of fats and oils ○ Rancidity: ○ Oxidative rancidity ○ Hydrolytic rancidity • **Water and Enzymes in Foods** ○ Water activity and food stability ○ Bound and free water ○ Food enzymes and their significance ○ Enzymatic browning
Module 2 (Credit 1): Food Additives, Processing and Quality Evaluation	
Learning Outcomes	**After learning the module, learners will be able to**
	1. Explain chemical changes during food processing and storage.
	2. Describe food additives and their applications.
	3. Identify vitamins and minerals in foods and their functions.
	4. Discuss food quality assessment and food safety standards.
Content Outline	• **Vitamins and Minerals in Food** ○ Classification of vitamins: ○ Fat-soluble vitamins ○ Water-soluble vitamins

	○ Role of minerals in nutrition ○ Stability of vitamins during processing and storage • **Food Additives** ○ Definition and classification ○ Preservatives ○ Antioxidants ○ Flavouring and colouring agents ○ Sweeteners and emulsifiers • **Chemical Changes During Food Processing** ○ Effect of heat on food components ○ Changes during: ○ Cooking ○ Pasteurization ○ Drying ○ Refrigeration and freezing ○ Food deterioration and spoilage • **Food Quality and Safety** ○ Food quality parameters ○ Chemical contaminants in foods ○ Adulteration of food ○ Food labeling and standards ○ Introduction to food quality control and food safety regulations
Module 3 (Credit 1): Basics of Nutraceuticals	
Learning Outcomes	**After learning the module, learners will be able to**
	1. Define and classify nutraceuticals
	2. Describe the health impact and mode of action of probiotics and prebiotics
Content Outline	• Introduction: Definition, history, classification – Type of classification (Probiotics, probiotics and synbiotics; Nutrient vs. Non-nutrient; according to target organ; according to source or origin) • Metabolism of xenobiotics (review) Probiotics ○ Taxonomy and important features of probiotic microorganisms ○ Health effects of probiotics including mechanism of action

	○ Probiotics in various foods: fermented milk products, non-milk products etc. ○ Quality Assurance of probiotics and safety Prebiotics Definition, chemistry, sources, metabolism and bioavailability, effect of processing, physiological effects, effects on human health and potential applications in risk reduction of diseases, perspective for food applications for the following: ✓ Non-digestible carbohydrates/oligosaccharides ✓ Dietary fibre ✓ Resistant starch ✓ Gums
Module 4 (Credit 1): Health Benefits of Functional Foods and Effects of Nutrients and Spices on Health	
Learning Outcomes	**After learning the module, learners will be able to**
	1. Identify non-nutrient effects of specific nutrients
	2. Describe the active biodynamic principles and health effects of various spices and condiments
Content Outline	• Potential health benefits of the following functional foods: Definition, chemistry, sources, metabolism and bioavailability, effect of processing, physiological effects, effects on human health and potential applications in risk reduction of diseases, perspective for food applications for: ○ Polyphenols: Flavonoids, catechins, isoflavones, tannins Curcumin, Resveratrol ○ Phytoesterogens/Isoflavones ○ Phytosterols ○ Glucosinolates ○ Pigments: Lycopene, Carotenoids ○ Organosulphur compounds ○ Other components – Phytates, Protease inhibitors, saponins, Amylase inhibitors, haemagglutinins • Non-nutrient effect of specific nutrients: Proteins, Peptides and nucleotides, Conjugated linoleic acid and n3 fatty acids, Vitamins and Minerals Active biodynamic principles in spices, condiments and other plant materials and their evidence-based effects

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE):

- Case Study: Study of food adulteration and methods for detection.
- Comparative Report: Compare chemical composition of different food groups.
- Seminar Presentation: Role of food additives in food preservation.
- Poster/Chart Preparation: Classification and functions of nutrients in food.
- Case Study: Health benefits of fermented probiotic foods and quality assurance measures.
- Seminar/Presentation: Bioactive compounds such as polyphenols, carotenoids, glucosinolates, and phytosterols.

Reference:

1. Longvah, T., Anantan, I., Bhaskarachary, K., Venkaiah, K., & Longvah, T. (2017). Indian food composition tables (pp. 2-58). Hyderabad: National Institute of Nutrition, Indian Council of Medical Research.
2. Dhara, D., Biswas, S., Das, S. K., & Biswas, O. (2021). Status of food safety and food security in India in the perspective of FSSAI. Indian Journal of Animal Health, 60(2), 167-173.
3. Singh, A., Agrawal, D., & Bhardwaj, A. (2025). Changes in Dietary Guidelines by National Institute of Nutrition (NIN) and ICMR: From 2011 to 2024. Indian Journal of Community Medicine, 50(6), 1088-1089.
4. Frazier, W.C. (2017) Food Microbiology, Mc Graw Hill Inc. 5th Edition.
5. Jacquelyn G. Black, Laura J. Black. (2018) Microbiology: Principles and Explorations, 10th Edition John Wiley and Sons Inc.
6. Michael P. Doyle, Francisco Diez-Gonzalez, Colin Hill (2019): Food Microbiology, Fundamentals and Frontiers, ASM Press, Washington DC. (5th edition)
7. Willey J., Sandman K., and Wood D. (2022) Prescott's Microbiology McGraw Hill Book Company, New York, 12th Edition.