Vivekanand Education Society's
College of Arts, Science and Commerce (Autonomous)

Sindhi Society, Chembur, Mumbai, Maharashtra – 400 071.

Re-accredited by NAAC "A Grade" in 3rd Cycle (CGPA 3.26)
Best College Award – Urban Area, University of Mumbai (2012-13)
Recipient of FIST Grant (DST) , STAR College Grant (DBT) , and
Recipient of Pradhan Mantri Uchchatar Shiksha Abhiyan (PM-USHA) grant (2023-26)

Affiliated to the

University of Mumbai

Syllabus for

Program: T.Y.B.Sc. (Biotechnology)

(Program code: VESUSBT)

As per Choice Based Credit System (CBCS)
with effect from Academic Year 2026 - 2027

The NEP-2020 presents a chance for India's higher education system to change its teaching focus from one that is very unilateral to one that is holistic. It offers skill-based education, where the programs, courses, and supplemental activities are designed backward to achieve graduation qualities and learning attributes. The learning outcomes-based curriculum framework for a B.Sc. in Biotechnology is designed to give students a thorough grounding in the field and to support them as they successfully pursue further education and research in it while being equipped with the necessary skills at various stages. An effort has been made to incorporate the usage of a gradual build-up of knowledge and contemporary technologies to aid the teaching-learning process for students.The curriculum framework takes into account the need to uphold knowledge and skill standards that are globally competitive in biotechnology and related courses, as well as the development of scientific orientation, an inquiring spirit, problem-solving abilities, and human and professional values that encourage rational and critical thinking in the students. This degree offers a wide range of prospects in several disciplines, including both traditional and applied parts of biotechnology.

Program Outcomes (PO):

On completing B.Sc. (Biotechnology) will be able to:

PO1	Demonstrate analytical skills in applying appropriate science principles and methodologies to solve a wide range of problems.
PO2	Design, carry out experiments, and analyze results by accounting uncertainties in different quantities measured using various scientific instruments.
PO3	Acquire the ability to correlate and draw various inferences.
PO4	Be able to apply the learnings in the academic course to an industrial setup.

Program Specific Outcomes (PSO's)

On completion of B.Sc. (Biotechnology), the student will be able to:

PSO1	Apply the basics of biotechnology to build a strong foundation that will allow them to comprehend emerging and advanced engineering concepts in life sciences.
PSO2	Acquire expertise in the field of biotechnology so that it may be used in industry and research.
PSO3	By integrating disciplinary and interdisciplinary components of biotechnology, students will be able to gain technological knowledge.
PSO4	Recognize the significance of bioethics, intellectual property rights, entrepreneurship, communication, and managerial skills in developing the future generation of Indian industrialists.

T.Y.B.Sc. (BIOTECHNOLOGY)

SEMESTER V

Course Code	Types of Courses	Subject Name	Credits	Subject Type
UMMBTS5-301	Major	Medical Microbiology II	2	Theory
UMMBTS5-302	Major	Fermentation Technology	2	Theory
UMMBTS5-303	Major	Tissue Culture Techniques	2	Theory
UMMBTS5-304	Major	Practicals Based on UMMBTS5-301 & UMMBTS5-302	2	Practical
UMEBTS5-311	Major Elective	Industrial Biotechnology I	2	Theory
UMEBTS5-312	Major Elective	Introduction to Biostatistics	2	Theory
UMNBTS5-316	Minor	Biochemistry III	2	Theory
UMNBTS5-317	Minor	Practicals Based on UMNBTS5-316	2	Practical
UVSBTS5-326	VSC	Bioinformatics	2	Theory
UVSBTS5-327	VSC	Practicals Based on UVSBTS5-326	2	Practical
UFPBTS5-371	FP	Field project	2	
		Total Credits	22	

T.Y.B.Sc. (BIOTECHNOLOGY)
SEMESTER VI

Course Code	Types of Courses	Subject Name	Credits	Subject Type
UMMBTS6-301	Major	Industrial Biotechnology II	2	Theory
UMMBTS6-302	Major	Environmental Biotechnology	2	Theory
UMMBTS6-303	Major	rDNA Technology	2	Theory
UMMBTS6-304	Major	Instrumentation II	2	Theory
UMMBTS6-305	Major	Practicals of Industrial Biotechnology II and Environmental Biotechnology	2	Practical
UMEBTS6-311	Elective	Genetics	2	Theory
UMEBTS6-312	Elective	Agri Biotechnology and Bioremediation	2	Theory
UMNBTS6-316	Minor	Biochemistry III	2	Theory
UMNBTS6-317	Minor	Practicals of Instrumentation and Biochemistry	2	Practical
UJTBTS6-373	OJT	On Job Training	4	
		Total Credits	22	

T.Y.B.Sc. (BIOTECHNOLOGY)

SEMESTER V

Course Code	Course Title	Credits	No. of Lectures
UMMBTS5-301	**Major - Medical Microbiology II**	**2**	**30**

Course Objectives :
CO1: To understand the morphology, pathogenicity, transmission, laboratory diagnosis, prevention, and treatment of major bacterial, viral, and protozoan pathogens causing human diseases.
CO2: To study the epidemiology, life cycles, clinical manifestations, and control measures of important infectious diseases including tuberculosis, diphtheria, syphilis, HIV/AIDS, amoebiasis, giardiasis, and malaria.
CO3: To acquire knowledge of the principles of antimicrobial chemotherapy, including classification, mechanisms of action, selective toxicity, and therapeutic applications of antimicrobial agents.
CO4: To understand antimicrobial resistance, its mechanisms, transmission, and the rational use of antimicrobial, antifungal, and antiviral drugs in disease management.
Learning Outcomes: At the end of the course, the learner will be able to
LO1: Describe the morphology, pathogenicity, laboratory diagnosis, prevention, and treatment of major bacterial, viral, and protozoan pathogens of medical importance.
LO2: Explain the transmission, life cycle, clinical features, and control strategies of infectious diseases such as tuberculosis, diphtheria, syphilis, HIV/AIDS, amoebiasis, giardiasis, and malaria.
LO3: Classify antimicrobial agents and explain their mechanisms of action, spectrum of activity, and therapeutic significance.
LO4: Analyze the development and spread of antimicrobial resistance and evaluate the appropriate use of antibacterial, antifungal, and antiviral agents for effective disease control.

Unit I **Causative organism 2**	**Respiratory Tract:** ***Mycobacterium tuberculosis*** (3 Lectures) Morphology, Pathogenicity, laboratory diagnosis, Vaccines, and treatment in brief. ***Corynebacterium diphtheriae*** Morphology, antigenic structure, pathogenicity, laboratory diagnosis, Vaccines, treatment in brief (2 Lectures) **Sexually Transmitted diseases:** **Syphilis** *Treponema pallidum* :Morphology, Cultivation, Antigenic structure, Pathogenicity, lab diagnosis, treatment (2 Lectures) **HIV** Structure, viral genes, and antigens. Pathogenicity, clinical features of HIV infection, AIDS, detection of HIV infection, prophylaxis(3 Lectures) **Protozoan diseases** **Amebiasis***(Entamoeba histolytica)* Introduction, morphology, lifecycle, transmission, diagnosis, and treatment (1.5 lectures) **Giardiasis** *(Giardia lamblia)*	**1**	**15**

	Morphology, habitat, life-cycle, transmission, diagnosis, and treatment (1.5 lectures) **Malaria** Habitat, transmission, life cycle in humans and mosquitoes, incubation period, diagnosis, prophylaxis, and treatment. (2 lectures)		
Unit II Chemotherapeutic agents	**Discovery and design of antimicrobial agents** (1 lecture) **Classification** of antibacterial agents, selective toxicity, MIC, MLC (2 lectures) **Inhibition of cell wall synthesis** (Mode of action for): Beta-lactam antibiotics: Penicillin, Cephalosporins; Glycopeptides: Vancomycin; Polypeptides: Bacitracin (2 lectures) Injury to the plasma membrane: Polymyxin (1 lecture) **Inhibition of protein synthesis:** Aminoglycosides, Tetracyclines Chloramphenicol, Macrolides, Erythromycin (2 lectures) **Inhibition of Nucleic acid synthesis**: Quinolones, Rifampicin, Metronidazole (2 lectures) **Antimetabolites**: Sulphonamides, Trimethoprim (1 lecture) Drug Resistance: Mechanism, Origin, and Transmission of Drug Resistance (1 lecture) Use and misuse of antimicrobial agents (1 lecture) Antifungal drugs, Antiviral drugs (2 lectures)	**1**	**15**
References	1. Ananthanarayan and Paniker's textbook of microbiology 10th edition. 2. Tortora, Microbiology and Introduction, 9th edition. 3. Jawetz, Melnick, & Adelberg's Medical Microbiology 26th edition 4. Prescott, Harley, and Klein's Microbiology, 7th edition by Joanne M.Willey, Linda M. Sherwood & Christopher J.Woolverton 5. Mim's Medical Microbiology & Immunology 5th edition.		

Course Code	Course Title	Credits	No. of Lectures
UMEBTS5-302	**Major-Fermentation Technology**	**2**	**30**

Course Objectives:

CO1:To introduce the microbiology of milk, including spoilage organisms and preservation methods.
CO2:To explain industrial fermentation processes for the production of acids, amino acids, antibiotics, ethanol, wine, and beer.
CO3:To develop an understanding of applied microbiology in food and fermentation industries.
CO4:To explain the basic mushroom (Agaricus) cultivation technique.

Learning Outcomes:

LO1:Explain the microbiology of milk, including normal flora, microbial enumeration methods, and factors affecting the bacteriological quality of milk and dairy processing technologies such as preservation methods, pasteurization, starter cultures, and the production of fermented dairy products like cheese, butter, yogurt, and buttermilk.

LO2:Analyze the microbial production processes of industrially important products such as citric acid, lysine, ethanol, penicillin, and streptomycin. LO3:Understand the principles and applications of biotransformation, mushroom cultivation and fermentation processes involved in wine and beer production.			
Unit I **Dairy Technology**	Milk: Normal flora, changes in raw milk - 2 lectures; Enumeration - 1 lecture; Factors affecting bacteriological quality - 1 lecture; Dairy technology Preservation methods - 2 lectures; Pasteurization- 1 lecture; Starter Cultures - 2 lectures; Fermented products-Production process and spoilage of Cheese: Swiss and Cheddar - 2 lectures; Butter - 2 lectures; Yogurt - 1 lectures and Buttermilk -1 lecture	**1**	**15**
Unit II **Fermentation Processes**	Production of: Citric acid: 2 lectures Mushroom cultivation (Agaricus): -2 lectures Biotransformation-1 lecture Lysine: -1 lecture Ethanol production- 1 lecture Penicillin and semisynthetic penicillins Streptomycin: 3 lecture Wine – 3 lectures Beer - 2 lectures	**1**	**15**
References	1. Casida L. E., "Industrial Microbiology" (2009) Reprint, New Age International (P) Ltd, Publishers, New Delhi. 2. Stanbury P. F., Whitaker A. & Hall S. J., (1997), "Principles of Fermentation Technology", 2nd Edition, Aditya Books Pvt. Ltd, New Delhi. 3. Stanbury P. F., Whitaker A. & Hall S. J 3rd edition (2017) "Principles of Fermentation Technology" 4. H. K. Das., "Text book of Biotechnology", 2nd and 3rd edition. 5. A textbook of biotechnology R. C. Dubey 4th edition. S. Chand. 6. H. A. Modi, (2009). ''Fermentation Technology'' Vol. 1 & 2, Pointer Publications, India 5. Microbiology", 2nd edition, Panima Publishing Corporation, New Delhi. 6. Prescott and Dunn's ''Industrial Microbiology'' (1982) 4th edition, McMillan Publishers. 7.Hugo and Russell, 7 th edition, Blackwell Science 8.Textbook of biotechnology by R.C.Dubey		

Course Code	Course Title	Credits	No. of Lectures
UMMBTS5-303	**Major - Tissue Culture Techniques**	**2**	**30**
Course Objectives: CO1:To introduce the principles, history, and applications of plant and animal tissue culture and their significance in biotechnology research and industry. CO2:To develop an understanding of laboratory techniques, aseptic practices, media preparation, and			

equipment used in plant and animal tissue culture.
CO3:To study advanced plant tissue culture techniques such as callus culture, protoplast culture, somatic hybridization, somatic embryogenesis, micropropagation, embryo culture, and cryopreservation.
CO4:To understand the establishment, maintenance, and preservation of animal cell and tissue cultures, including media requirements, culture systems, and storage methods.
Learning Outcomes: Upon successful completion of this course, students will be able to:
LO1:Explain the historical development, principles, and applications of plant and animal tissue culture techniques.
LO2:Demonstrate knowledge of laboratory facilities, instruments, culture vessels, media components, and aseptic procedures required for successful tissue culture.
LO3:Describe and evaluate plant tissue culture methods including meristem culture, callus culture, cell suspension culture, protoplast fusion, somatic embryogenesis, micropropagation, embryo culture, and cryopreservation.
LO4:Differentiate between various types of animal tissue cultures, explain media requirements and growth conditions, and apply methods for cell culture maintenance, preservation, and storage.

Unit I **Plant Tissue Culture**	**History** of plant cell, tissue, organ culture, and research work in India. (1 Lecture) **Laboratory techniques,** Methodology of plant cell, tissue, and organ culture, Meristem culture, Callus culture (4 Lectures) Isolation, benefits of cell (suspension) culture, and 2 examples of secondary metabolites. **Protoplast culture**: Protoplast fusion and somatic hybridization, Somatic embryogenesis, encapsulated seeds, micropropagation, Somaclonal variation, pollen culture (6 Lectures) Embryo culture (2 Lectures) Cryopreservation (2 Lectures)	**1**	**15**
Unit II **Animal Tissue Culture**	**Basics of Animal Tissue Culture** (Historical background, Advantages of tissue culture, limitations, major differences in vitro, types of tissue culture) (1 Lecture) Equipment needed for tissue culture, laboratory, Incubator, Autoclave, Hot air oven, refrigerators and -20°C deep freezer, Inverted microscope, glassware washing facility, Water purification, Centrifuge, Laminar flow benches (hoods), CO_2 incubator, Balances, pH meter, vortex mixer, magnetic stirrer, research microscope, Pipetting devices, media filtration assembly, controlled rate freezing of cells and liquid N, storage facility and hemocytometer. (5 Lectures) Glassware and plasticware used for Tissue Culture, substrate material for growing cells, Tissue culture vessels (2 Lectures) Tissue culture media: Properties and special requirements of media, Balanced salt solutions, **Complete media**: composition of frequently used media, Commonly used antibiotics, Requirement of serum and growth factors, Conditioned medium, serum-free media (3 Lectures)	**1**	**15**

	Type of tissue culture: Organ and Organotypic Cultures, primary cultures, and culture of cell line (3 Lectures) Cryopreservation and storage (1 Lecture)		
References	1. Advanced Biotechnology by R C Dubey 2. R. Ian Freshney - Culture of Animal 3. Principles and Practice of Animal Tissue Culture - Sudha Gangal 4. Introduction to Plant Tissue Culture by M.K.Razdan		

Course Code	Course Title	Credits
UMMBTS5-304	**Major - Practicals Based on UMMBTS5-301 & UMMBTS5-302**	**2**

1. Antibiotic sensitivity testing using the Disc diffusion method
2. Synergism of antibiotics
3. Acid-fast staining of *Mycobacterium tuberculosis*
4. Study of different stages of the malaria parasite
5. Minimum inhibitory concentration of an antibiotic
6. Minimum Lethal Concentration of an antibiotic
7. Antibiotic sensitivity testing using the ditch plate
8. Estimation of Milk protein: Pyne's method
9. Microbial analysis of Milk by MBRT and RRT
10. Phosphatase test in Milk
11. Alcohol estimation by the dichromate method
12. Effect of temperature and pH on alcohol production

Course Code	Course Title	Credits	No. of Lectures
UMEBTS5-311	**Major Elective - Industrial Biotechnology I**	**2**	**30**

Course Objectives

CO1: To understand the principles of inoculum development, fermentation process parameters, and their importance in industrial biotechnology.
CO2: To study the measurement, monitoring, and control of critical bioprocess variables using various sensor probes and instrumentation.
CO3: To acquire knowledge of strain improvement techniques for enhancing the production of primary and secondary metabolites in industrial microorganisms.
CO4: To understand the application of classical and molecular approaches for developing stable, high-yielding industrial strains with desirable characteristics.

Learning Outcomes

LO1: At the end of the course, the learner will be able to:
LO2: Understand the principles of inoculum development and monitor key fermentation process parameters such as temperature, pH, flow, pressure, foam, and dissolved oxygen.
LO3: Apply methods for the measurement and control of process variables using different sensor probes in

fermentation systems. LO4: Understand microbial strain improvement strategies, including mutagenesis, recombination, feedback regulation, and the characteristics of an ideal industrial strain.			
Unit I **Inoculum Development and process Parameter measurement**	**Introduction to Inoculum development** (1 lecture); Bacterial and fungal inoculum development with one example each (2 lectures) **Introduction to process parameter** (1 lecture) **Methods of measuring process variables and control**: Principle, working, and the significance of the following process control sensor probes Temperature (1 lecture) pH (2 lecture) Flow (Gas and liquid) (3 lectures) Pressure (2 lectures) Foam (1 lectures) DO and CO_2 (2 lectures)	**1**	**15**
Unit II **Strain Improvement**	**Introduction to strain improvement (2 lectures)** Criteria for an Ideal Industrial Strain **Strategies of strain improvement for primary and secondary metabolites (11 lectures)** 1. Selection of induced mutants (Primary Metabolites): Modification of permeability, isolation of mutants (feedback inhibitors/repressors), use of auxotrophs 2. Selection of induced mutants (Secondary Metabolites): Isolation of auxotrophic and resistant mutants, revertant mutants 3. Use of recombination systems: Parasexual cycle and protoplast fusion 4. Recombinant DNA techniques: Heterologous proteins and native products **Modifying properties other than yield (2 lectures)** 1. Selection of stable strains: 2. Resistance to infection (phage) 3. Non-foaming strains 4. Tolerance to medium components 5. Morphologically favorable strains 6. Tolerance to low oxygen tension	**1**	**15**
References	1. Fermentation technology by Stanbury and Whittaker. 2. Industrial microbiology by Casida, L. E		

Course Code	Course Title	Credits	No. of Lectures
UMEBTS5-312	**Major Elective- Introduction to Biostatistics**	**2**	**30**
Course Objectives: CO1: To introduce the fundamental concepts, importance, and applications of statistics in biological sciences			

and research.
CO2: To develop skills in organizing, representing, and interpreting biological data using appropriate statistical and graphical methods.
CO3: To understand and apply measures of central tendency, dispersion, correlation, and regression for the analysis of biological data.
CO4: To enable students to perform hypothesis testing using appropriate statistical tests and interpret the results for scientific decision-making.
Learning Outcomes: By the end of the course, the student will be able to
Upon successful completion of this course, students will be able to:
LO1: Explain the basic concepts of biostatistics, types of data, frequency distributions, and sampling methods used in biological research.
LO2: Organize and present biological data using tables, graphs, histograms, frequency polygons, and other statistical representations.
LO3: Calculate and interpret measures of central tendency, dispersion, correlation, and regression for analyzing biological datasets.
LO4: Apply statistical hypothesis testing using Z-test, t-test, and Chi-square test, and interpret the significance of results in biological investigations.

Unit I Measures of Central Tendency & Dispersion	**Definition and Importance of Statistics in Biology** (2 lectures) Types of Data, Normal and Frequency Distribution (2 lectures) **Representation of Data and Graphs** (Bar Diagrams, Pie Charts, Histograms, Polygons, and Curves) (5 lectures) **Types of population sampling** Measures of Central Tendency (For Raw, Ungrouped & Grouped Data): Mean, Median, Mode (4 lectures) Measures of Dispersion: Range, Variance, Coefficient of Variance.Standard Deviation. Standard Error. (3 lectures)	**1**	**15**
Unit II: Significance testing	Theory and problems based on- coefficient of correlation and regression analysis (4 lectures) Steps in testing a statistical hypothesis (3 lectures) **Parametric Tests**: Z Test – Single Mean and Two Means (3 lectures) t-Test – Single Mean, Paired and Unpaired; (2 lectures) Chi-Square test (3 lectures)	**1**	**15**
References	1. Biostatistics by Arora and Malhan 2. Introductions to Biostatistics by Mahajan		

Course Code	Course Title	Credits	No. of Lectures
UMNBTS5-316	**Minor - Biochemistry III**	**2**	**30**

Course Objectives:
CO1: To provide a comprehensive understanding of enzyme structure, classification, properties, mechanisms of action, and factors affecting enzyme activity.
CO2: To develop knowledge of enzyme kinetics, inhibition mechanisms, cofactors, and their roles in regulating biochemical reactions.

CO3: To study the major metabolic pathways involved in carbohydrate metabolism and their regulation under physiological conditions.
CO4: To understand cellular energy production through electron transport and oxidative phosphorylation, including the impact of metabolic disorders and inhibitors.
Learning Outcomes: Upon successful completion of this course, students will be able to:
LO1: Explain the classification, nomenclature, chemical nature, properties, and mechanisms of action of enzymes, including enzyme specificity and active sites.
LO2: Analyze enzyme kinetics using the Michaelis–Menten model and differentiate between various types of enzyme inhibition and regulatory mechanisms.
LO3: Describe the sequence of reactions, regulation, energy yield, and associated metabolic disorders of glycolysis, gluconeogenesis, the citric acid cycle, and the pentose phosphate pathway.
LO4: Explain the electron transport system and oxidative phosphorylation, evaluate the role of inhibitors, and interpret their significance in cellular energy metabolism.

Unit I **Enzymology**	**Definition, Classification, Nomenclature,** (1 Lecture) Chemical Nature, (1 Lecture) Properties of Enzymes, (2 Lectures) Mechanism of Enzyme Action (2 Lectures) Active Sites, Enzyme Specificity, (1 Lecture) Effect of pH, Temperature (1 Lecture) Substrate Concentration on Enzyme Activity, Enzyme Kinetics, Michaelis-Menten Equation, (3 Lectures) **Types of Enzyme Inhibitions** - Competitive, Uncompetitive, Non-Competitive, Allosteric Modulators, (3 Lectures) Co-Factors, Zymogens (1 Lecture)	**1**	**15**
Unit II **Carbohydrate Catabolism**	**Glycolytic Pathway** and its Regulation, (3 Lectures) **Citric Acid Cycle** and its Regulation; (3 Lectures) Gluconeogenesis; (2 Lectures) Pentose Phosphate Pathway; (2 Lectures) (Sequence of Reactions, Regulation, Energy Yield and Metabolic disorders of the above pathways) **Electron Transport System** : Electron Transport and Oxidative Phosphorylation. (4 Lectures) Inhibitors of ETS. (1 Lecture)	**1**	**15**
References	1. Lehninger's Principles of Biochemistry by Nelson and Cox 4th Edition		

Course Code	Course Title	Credits
UMNBTS5-317	**Minor - Practicals Based on UMNBTS5-316**	**2**

1. Detection of amylase in potato extract
2. Effect of pH on enzyme activity
3. Effect of temperature on enzyme activity
4. Effect of substrate concentration on enzyme activity
5. Effect of inhibitor concentration on enzyme activity
6. Isolation of mitochondria

7. Detection of lactate dehydrogenase in serum
8. Detection of Blood Glucose

Course Code	Course Title	Credits	No. of Lectures
UVSBTS5-326	**VSC - Bioinformatics**	**2**	**30**

Course Objectives:

CO1: To introduce the fundamental concepts of computers, algorithms, and their applications in bioinformatics.

CO2: To develop an understanding of biological databases and their classifications, including primary, secondary, and composite databases.

CO3: To familiarize students with bioinformatics tools such as BLAST for retrieving biological sequence information.

CO4: To explain sequence alignment techniques, including pairwise and multiple sequence alignment methods used in biological analysis.

CO5: To enable students to visualize and interpret protein structures using molecular visualization software such as RasMol/RasWin.

Learning Outcomes:

By the end of the course, the student will be able to:

LO1:Define fundamental concepts of computers, algorithms, and bioinformatics.

LO2:Explain the classification and functions of biological databases and genomic resources.

LO3:Use BLAST to retrieve and compare biological sequences from databases.

LO4:Perform pairwise and multiple sequence alignments and interpret similarities between sequences.

LO5:Analyze protein structures and phylogenetic relationships using visualization tools and alignment results.

Unit I Introduction to computers and biological databases	**Introduction to computers:** Overview and functions of a computer system, Input and output devices, and Storage devices (3 lectures) Algorithm (2 lectures) Introduction to MS Word, Excel, and PowerPoint (3 lectures) **Basics of Bioinformatics** Introduction to bioinformatics, the scope of bioinformatics, and the Internet (1 lecture) **Biological Databases:** Classification of databases: raw and processed databases; primary (NCBI), secondary (PIR), and tertiary or composite (KEGG) databases; structure and sequence databases. (2 lectures) **Specialized Databases**: Protein pattern databases; Protein structure and classification databases (CATH/SCOP) (2 lectures) **Genome information resources:** DNA Sequence databases, specialized genomic Resources (1 lecture) Protein databases based on composition, motifs, and patterns (1 lecture)	**1**	**15**

Unit II BLAST, sequence alignment and visualisation	**BLAST and Sequence Alignment** BLAST and its types (2 lectures) Retrieving a sequence using BLAST (1 lecture) **Pairwise Alignment:** Identity and similarity, global and Local alignment, and pairwise database searching (4 lectures) **Multiple Sequence Alignment:** Goal of multiple sequence alignment: Computational complexity; manual methods; simultaneous methods; progressive methods; databases of multiple alignments; secondary database searching; analysis packages, and MSA and phylogenetic Trees (7 lectures) **Protein structure visualization software:** Rasmol/Raswin (1 lecture)	**1**	**15**
References	1. Goel, A. (2010). Computer Fundamentals. India: Pearson Education. 2. Computer Literacy BASICS: A Comprehensive Guide to IC3 3. Concept on Bioinformatics- Rajendra Prasad Pangeni 4. Bioinformatics methods and applications- S.C. Rastogi 5. http://www.rasmol.org/software/RasMol_2.7.5_Manual.html		

Course Code	Course Title	Credits
UVSBTS5-327	**VSC - Practicals Based on UVSBTS5-326**	**2**

1. Making a MS Word document
2. Making a PPT
3. Use of MS Excel for data analysis
4. Writing algorithm
5. Familiarization with NCBI, EMBL, DDBJ, PIR, and KEGG Databases.
6. Classification of Proteins using CATH/SCOP.
7. Visualization of PDB Molecules using Swiss-PROT/Rasmol.
8. Use of NCBI BLAST Tools
9. Pairwise and Multiple Sequence Alignment
10. Construction of Phylogeny

T.Y.B.Sc. (BIOTECHNOLOGY)
SEMESTER VI

Course Code	Course Title	Credits	No. of Lectures
UMMBTS6-301	**Major - Industrial Biotechnology II**	**2**	**30**

Course Objectives:

CO1: To introduce the microbiology of milk, including spoilage organisms and preservation methods.
CO2: To explain industrial fermentation processes for the production of acids, amino acids, antibiotics, ethanol, wine, and beer.
CO3: To develop an understanding of applied microbiology in food and fermentation industries.
CO4: To impart hands-on knowledge of basic mushroom (Agaricus) cultivation techniques.

Learning Outcomes:

After successful completion of this course, students will be able to:
LO1: Explain the principles of microbial fermentations and their industrial applications.
LO2: Apply molecular biology techniques to enzyme technology, animal tissue culture, and plant tissue culture.
LO3:Illustrate the industrial production processes of citric acid, lysine, ethanol, mushrooms, wine, beer, penicillin, semisynthetic penicillins, streptomycin, and biotransformation products.

Unit I **Dairy Technology**	Milk: Normal flora, changes in raw milk (2 lectures) Enumeration (1 lecture) Factors affecting bacteriological quality (1 lecture) Dairy technology Preservation methods (2 lectures) Pasteurization (1 lecture) Starter Cultures (2 lectures) Fermented products-Production Process and spoilage of Cheese: Swiss and Cheddar (2 lectures) Butter (2 lectures) Yogurt (1 lecture) and Buttermilk (1 lecture)	**1**	**15**
Unit II **Fermentation Processes**	Production of: Citric acid (2 lectures) Mushroom cultivation (Agaricus) (2 lectures) Biotransformation (1 lecture) Lysine: (1 lecture) Ethanol production (1 lecture) Penicillin and semisynthetic penicillins Streptomycin (3 lecture) Wine (3 lectures) Beer (2 lectures)	**1**	**15**
References	1. Casida L. E., "Industrial Microbiology" (2009) Reprint, New Age International (P) Ltd, Publishers, New Delhi. 2. Stanbury P. F., Whitaker A. & Hall S. J., (1997), "Principles of Fermentation Technology", 2nd Edition, Aditya Books Pvt. Ltd, New Delhi. 3. Stanbury P. F., Whitaker A. & Hall S. J 3rd edition (2017) "Principles of Fermentation Technology" 4. H. K. Das., "Text book of Biotechnology", 2nd and 3rd edition. 5. A textbook of		

	biotechnology R. C. Dubey 4th edition. S. Chand. 6. H. A. Modi, (2009). ‘’Fermentation Technology’’ Vol. 1 & 2, Pointer Publications, India 5. Microbiology", 2nd edition, Panima Publishing Corporation, New Delhi. 6. Prescott and Dunn's ‘’Industrial Microbiology’’ (1982) 4th edition, McMillan Publishers. 7.Hugo and Russell, 7 th edition, Blackwell Science 8.Textbook of biotechnology by R.C.Dubey

Course Code	Course Title	Credits	No. of Lectures
UMMBTS6-302	**Major - Environmental Biotechnology**	**2**	**30**

Course Objectives:

CO1: To provide an understanding of bioreactor principles and systems used in wastewater treatment, including aerobic, anaerobic, membrane, and immobilized enzyme reactors.

CO2: To highlight the importance of innovative bioreactor designs for improving treatment efficiency.

CO3: To study the biodegradation of industrial wastes from leather, dye, paper & pulp, dairy, distillery, and oil spills.

CO4: To develop the ability to analyze wastewater and apply suitable bioreactor strategies for sustainable environmental management.

Learning Outcomes:

LO1: Understand aerobic, anaerobic, and advanced bioreactor systems and their applications.

LO2:Compare and apply different treatment processes to industrial effluents such as leather, dye, dairy, and oil spills.

LO3: Analyze wastewater characteristics to select suitable treatment methods.

LO4: Evaluate innovative bioreactor designs for sustainability and efficiency.

Unit I **Bioreactors for Wastewater Treatment**	**Bioreactor for wastewater treatment** Introduction (1 Lecture) Aerobic biological treatment (5 Lectures) Anaerobic biological treatment(3 Lectures) Periodic biological reactors (2 Lectures) Membrane biorectors(2 Lectures) Use of immobilised enzymes and (1 Lecture) Innovative bioreactor (1 Lecture)	**1**	**15**
Unit II **Industrial Effluent Treatment**	Biodegradation of waste from (Traditional and Novel methods used by the respective industries) Leather industry (3 Lectures) Dye (3 Lectures) Paper & pulp industry (2 Lectures) Dairy (2 Lectures) and Distillery (2 Lectures) Removal of oil spillage and grease deposits (3 Lectures)	**1**	**15**
References	1. Environmental Biotechnology Allan Scragg Oxford University press 2. Environmental Biotechnology (Basic concepts and applications) Indu Shekhar Thakur IK International 3. Environmental Biotechnology (Industrial pollution management) S.D. Jogdand Himalaya Publishing House		

Course Code	Course Title	Credits	No. of Lectures
UMMBTS6-303	**Major - rDNA Technology**	**2**	**30**

Course Objectives:

CO1: To introduce students to the principles and components of Polymerase Chain Reaction (PCR) and its variations.

CO2: To familiarize students with DNA sequencing techniques.

CO3: To introduce advanced genome-editing technologies such as RNA interference (RNAi), Zinc Finger Nucleases (ZNF), TALENs, and CRISPR-Cas systems.

Learning Outcomes:

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

LO1: Explain the fundamental principles and applications of PCR and its different types, including reverse transcriptase-PCR and Real-Time PCR.

LO2: Demonstrate knowledge of various DNA sequencing techniques and their applications in molecular biology research.

LO3: Discuss the significance of human genome mapping and its implications for genetic diseases and personalized medicine.

LO4: Compare and contrast different genome-editing technologies.

Unit I **Nucleic Acid Amplification Methods**	Target amplification : PCR - General Principle (2 lectures); Components of a typical PCR Reaction (2 lectures); Experimental Design; Primer Designing; Control of PCR contamination and mispriming; PCR Product Clean-up and Detection PCR Types: Reverse Transcriptase and Real Time PCR (2 lectures) Probe amplification: Ligase Chain Reaction (1 lecture) Primer designing using in silico methods (1 lecture)	**1**	**15**
Unit II **Gene Sequencing and Editing**	Maxam Gilbert's method, Sanger's dideoxy method, Automated DNA sequencing, Pyrosequencing (5 lectures) Human genome mapping and its implications in health and disease (3 lectures) RNAi, ZNF(Zinc finger nucleases), TALENS(Transcription Activator Like Effector Nucleases), CRISPER/Cas system(Clustered Regularly Interspersed Repeats) (6 lectures) Applications of the gene editing tools (1 lecture)	**1**	**15**
References	1. Molecular diagnostics- Fundamentals, methods and clinical applications – Buckingham and Flaws F.A. Davis Company Philadelphia. 2. i-Genetics by Peter Russell 5th Edition 3. Gene Cloning and DNA Analysis 2nd Edition T.A. Brown. 4. Parama Majumdar, Geetanjali Harale, Suman Ganger, Sheetal Pareshi, 'Zin Finger Nuclease Based Genome Editing in Enhancement of Antidiabetic Activity of Plants: Prospective Applications' Antidiabetic Potential of Plants in the Era of Omics, Deepu Pandita, Anu Pandita and Chander Bhanu, AAP, 2023, 373-402.		

	5. Geetanjali Harale, Sheetal Pardeshi, Parama Majumdar, Suman Ganger, 'Transcription Activator-Like Effector Nucleases (TALENs): Genome editing tool to explore enhanced activity of antidiabetic plants' Antidiabetic Potential of Plants in the Era of Omics, Deepu Pandita, Anu Pandita and Chander Bhanu, AAP, 2023, 403-428. 6. Suman Ganger, Geetanjali Harale, and Parama Majumdar, 'Clustered Regularly Interspaced Short Palindromic Repeats/CRISPR-Associated (CRISPR/Cas) Systems: Discovery, Structure, Classification, and General Mechanism' CRISPR/Cas-Mediated Genome Editing in Plants, Deepu Pandita and Anu Pandita, AAP, June 2023, 65-98 7. Genomics Cantor C.R., and Smith C.L. John Wiley & Sons. (1999)

Course Code	Course Title	Credits	No. of Lectures
UMMBTS6-304	**Major - Instrumentation II**	**2**	**30**

Course Objectives:

CO1: Develop a strong foundation in centrifugation techniques by introducing the principles of sedimentation, centrifuge instrumentation, and methods used for the separation and purification of biological samples.

CO2: Provide comprehensive knowledge of radioactivity by explaining the nature, types, and characteristics of ionizing radiation and their applications in biological sciences.

CO3: Familiarize students with radiation detection techniques including Geiger–Müller counters, scintillation counters, and autoradiography for qualitative and quantitative biological investigations.

CO4: Develop the ability to apply centrifugation and radioactive tracer techniques in research, diagnostics, and various fields of biotechnology and life sciences.

Learning Outcomes:

LO1: Explain the basic principles of sedimentation

LO2: Differentiate between various centrifugation techniques

LO3: Define radioactivity and describe the characteristics of alpha, beta, and gamma radiation.
Explain the nature and biological effects of different types of ionizing radiation.

LO4: Describe the various techniques in biology that use radioactivity.

Unit I Centrifugation	Basic principles of sedimentation (4 lectures) Instrumentation (Desktop centrifuge, ultracentrifuge, analytical centrifuge, rotors) (3 Lectures) Differential Centrifugation (1 Lecture) Density Gradient Centrifugation (4 Lectures) Preparation of density gradients (2 Lectures) Zonal Rotors (1 Lectures)	**1**	**15**
Unit II Radiation Biology	Introduction to radioactivity (1 Lecture) Types of radiations and their characteristics (3 Lectures) Nature of radioactivity (2 Lecture) Detection Techniques using GM Counter and its types (3 Lectures) Scintillation counter and its types (3 Lectures) Autoradiography, principle and applications (2 Lectures)	**1**	**15**

	Applications of Tracer techniques in Biology (Lecture)		
References	Principles and Techniques of Biochemistry and Molecular Biology by Wilson and Walker 7th Edition		

Course Code	Course Title	Credits
UMMBTS6-305	**Major - Practicals of Industrial Biotechnology II and Environmental Biotechnology**	**2**

1. Estimation of Milk protein-Pynes method
2. Microbial analysis of Milk by MBRT and RRT
3. Phosphatase test in Milk
4. Study the effect of heavy metals on the growth of bacteria.
5. Determination of Total Solids from an effluent sample.
6. Study of physico-chemical parameters of an industrial effluent sample.
    a. BOD
    b. COD
7. Bioassay of an antibiotic (Streptomycin / Penicillin)

Course Code	Course Title	Credits	No. of Lectures
UMEBTS6-311	**Major Elective - Genetics**	**2**	**30**

Course Objectives:

CO1: To introduce students to the structure, packaging, and variations of chromosomes in relation to genetic disorders.

CO2: To familiarize students with the mechanisms of sex determination, dosage compensation, and the chromosomal basis of inheritance.

CO3: To develop an understanding of genetic linkage, recombination, and gene mapping techniques.

CO4: To train students in interpreting inheritance patterns and pedigree analysis in humans.

Learning Outcomes:

LO1: By the end of the course, students will be able to:

LO2: Understand the structure, packaging, and variations of chromosomes in relation to genetic disorders.

LO3: Explain sex determination, dosage compensation, and the chromosomal basis of inheritance.

LO4: Analyze genetic linkage, recombination, and mapping techniques.

LO5: Interpret inheritance patterns and pedigrees in humans.

Unit I Chromosomal basis of Inheritance, Genetic recombination, Chromosome Mapping and Pedigree Analysis	**Chromosomal basis of inheritance (5 lectures)** Chromosome theory of inheritance, Genetic linkage - Morgan's experiments with *Drosophila,* Sex chromosomes, Sex linkage, X-linked inheritance, Gene and chromosome segregation in meiosis, Non-disjunction analysis of sex-related traits in humans. **Genetic recombination (5 lectures)** Mechanism of recombination-breakage and reunion, breakage and copy, types of recombination: General and Holliday model	**1**	**15**

	Chromosomal Mapping : (5 lectures) Tetrad Analysis; Two-point Cross; Three-point Cross; Pedigree Analysis		
Unit II Cytogenetics	**Structure of Chromosome (4 lectures)** Heterochromatin,Euchromatin, Polytene Chromosomes. Chromosome packaging **Variation in Chromosomal Structure and Number: (5 lectures)** Deletion, duplication, inversion,Translocation, Aneuploidy, Euploidy, andPolyploidy and Syndromes-Klinefelter,Turner, Cri-du-Chat, Trisomy-21, Trisomy 18 and Trisomy 13. **Sex Chromosome and Sex Determination: (5 lectures)** Mechanisms of Sex Determination (XX-XY, ZZ-ZW, XX-XO) Dosage Compensation and Barr Body. Introduction of softwares used in cytogenetics. (1Lecture)	**1**	**15**
References	**1.** i-Genetics by Peter Russell 5th Edition 2. i-Genetics by Peter Russell 3rd Edition		

Course Code	**Course Title**	**Credits**	**No. of Lectures**
UMEBTS6-312	**Major Elective - Agri biotechnology and Bioremediation**	**2**	**30**
Course Objectives: CO1: To understand the role of beneficial microbes in agriculture, including nitrogen fixation, phosphate solubilization, plant growth promotion, and microbial inoculants. CO2: To study the development and application of biopesticides, such as *Bacillus thuringiensis*, insect viruses, and entomopathogenic fungi. CO3: To explore microbial bioremediation techniques for pollution control in both solid and liquid environments. **Learning Outcomes:** LO1: Understand the role of microbes in enhancing soil fertility and promoting plant growth through nitrogen fixation, mycorrhizal associations, and other plant growth-promoting traits. LO2: Gain knowledge of microbial inoculant formulations, biocontrol mechanisms, and biopesticide applications in sustainable agriculture. LO3: Apply principles of bioremediation, including biosorption, microbial leaching, and microbial roles in metal recovery and pollution mitigation.			
Unit I Agribiotechnology	**Biofertilizer**: Nitrogen-fixing Rhizobacteria -Symbiotic Nitrogen fixers. (3 lectures) Nonsymbiotic Nitrogen Fixers Plant Growth Promoting microorganisms-Phosphate-Solubilizing Microbes (PSM), **Phytohormones** and Cytokinins, Induced Systemic Resistance (4 lectures) **Plant Growth Promotion by Fungi**--Mycorrhizae Arbuscular Mycorrhizae Ectomycorrhizae (3 lectures) **Microbial Inoculants** -- Inocula, Carriers, and Applications,	**1**	**15**

	Monoculture and Co-culture Inoculant Formulations Biocontrol, Polymicrobial Inoculant Formulations (3 lectures) **Biopesticides** – types, Bacillus thuringiensis, insect viruses, and entomopathogenic fungi (characteristics, physiology, mechanism of action, and application) (2 Lectures)		
Unit II Bioremediation	Introduction, constraints, and priorities of Bioremediation, Biostimulation of naturally occurring microbial activities, Bioaugmentation, in situ, ex situ, intrinsic & engineered bioremediation (5 lecture) Solid phase bioremediation - land farming, prepared beds, soil piles. (2 lecture) Phytoremediation. Composting, Bioventing & Biosparging; Liquid phase bioremediation- suspended bioreactors, fixed biofilm reactors (3 lecture) Bioremediation of toxic metal ions: biosorption and bioaccumulation principles. (2 lecture) **Microbial leaching** of ore-direct and indirect mechanisms. Mining and metal. Use of microorganisms in the augmentation of petroleum recovery. Biotechnology with special reference to Copper and Iron. (2 lectures) Government policies on bioremediation and challenges in execution. (1 lecture)	**1**	**15**
References	1. Environmental Biotechnology by S. K. Agarwal 2. Biodegradation & Bioremediation (1999), Martin Alexander, Academic press. 3. Stanier R. Y., Ingram J.L., Wheelis M.L., Painter R.R., General Microbiology, McMillan Publications, 1989. 4. Foster C.F., John Ware D.A., Environmental Biotechnology, Ellis Horwood Ltd., 1987. 5. Karrely D., Chakrabarty K., Omen G.S., Biotechnology and Biodegradation, Advances in Applied Biotechnology Series, Vol.4, Gulf Publications Co. London, 1989. 6. Bioremediation engineering; design and application 1995 John. T. cookson, Jr. McGraw Hill, Inc. 7. Environmental Biotechnology by A.K. Chatterjee 8. Environmental Biotechnology by S.N.Jogdand Himalaya Publishing		

Course Code	Course Title	Credits	No. of Lectures
UMNBTS6-316	**Minor - Biochemistry**	**2**	**30**

Course Objectives:

CO1: To understand the metabolic pathways involved in the breakdown of amino acids and lipids, including key reactions like deamination, transamination, oxidation pathways, and the urea cycle.

CO2: To explore the biochemical mechanisms of photosynthesis, including light and dark reactions, pigment function, and carbon assimilation processes like starch and sucrose synthesis.

CO3: To study the biosynthesis and regulation of key biomolecules such as glycogen and cholesterol, and their role in cellular energy and metabolic balance.

Learning Outcomes: Students will be able to: LO1: Describe and differentiate the steps in amino acid and fatty acid metabolism, including key enzymes involved. LO2: Explain and illustrate the fundamental reactions of photosynthesis and the synthesis and regulation of carbohydrates like starch and sucrose. LO3: Analyze and summarize the pathways for glycogen and cholesterol synthesis and explain their regulation under various physiological conditions.			
Unit I **Amino Acid and Lipid Catabolism**	**Amino Acid Breakdown :** Deamination, Transamination, Urea Cycle, Breakdown of Glucogenic and Ketogenic Amino Acids (names only) (5 Lectures) **Lipid Metabolism :**Mobilization, Transport of Fatty Acids. (3 Lectures) Beta, Alpha and Omega Oxidation of Saturated Fatty Acids; Oxidation of Unsaturated Fatty Acids; Oxidation of Odd Chain Fatty Acids. Energy Yield, (4 Lectures) Ketone Body Breakdown to Yield Energy. (Sequence of Reactions only)(3 Lectures)	**1**	**15**
Unit II **Carbohydrate Synthesis**	Photosynthesis, Fundamental Reactions of Photosynthesis, Photosynthetic Pigments, Light Reactions, Cyclic and Non-Cyclic Photo Induced Electron Flow, Dark Phase of Photosynthesis, (5 Lectures) Starch Synthesis (3 Lectures) Sucrose Synthesis (1 Lecture) Regulation of Starch and sucrose synthesis (2 Lecture) Glycogen - Synthesis and Regulation (2 Lectures) Cholesterol - Synthesis and Regulation (2 Lectures)	**1**	**15**
References	Lehninger Principles of Biochemistry, 6th Edition		

Course Code	Course Title	Credits
UMNBTS6-317	**Minor - Practicals of Instrumentation and Biochemistry**	**2**

1. Differential Centrifugation
2. Preparation of density gradient
3. Density Gradient Centrifugation
4. Problems based on autoradiography
5. Hill's Reaction
6. SGOT
7. SGPT
8. Iodine Value

MODALITY OF ASSESSMENT

The performance of the learners for those papers having Semester End Examinations and Internal Assessment shall be evaluated in two parts as per the following ratio:

Semester End Examination: Internal Assessment [60:40]

The learner's performance shall be assessed by conducting the **Semester-end Examination with 60% marks** and **Continuous Internal Assessment (CIA) with 40% mark**s. Practical papers will consist of semester-end examination only.

Students will have to score 40% marks INDIVIDUALLY in Internal assessment as well as Semester-end examination to pass the course.

Internal Assessment: It is defined as the assessment of the learners based on internal evaluation by way of participation of learners in various academic and correlated activities in the given semester of the programme.

Semester End Assessment: It is defined as the assessment of the learners based on performance in the Semester-end Theory/ Practical examination.

Table-1- Mode of Assessment under NEP 2020

Name of the course	Credits	Nature of Evaluation & Mode of Assessment	Duration	Marks
Major/ Minor Subject (Theory)	**2 Credit**	**1. Internal (40%)** (Table 2)		20
		2. Semester-end Theory Examination (60%) (Table 3)	**90 mins**	30
Major (Practical) **(2 subjects)**	**2 Credit**	**Semester-end Practical Examination (Table-4)**	**3 hours**	50
Open Electives(OE) OR Value Education Course (**VEC**) OR Indian Knowledge system (**IKS**)	**2 Credit**	Continuous Internal Evaluation - Assignments/ Presentations/ Group Discussion/ Case Studies etc. **Any two modes of assessment with evaluation at Department level (25 M Each)**	-	50
Vocation Skill Course (**VSC**)(Practical)	**2 Credit**	Practicals (Table-4)	**3 hours**	50
Skill Enhancement Course (**SEC**)(Theory) OR Ability Enhancement Course (**AEC**)	**2 Credit**	**1. Internal (40%)** (Table 2)		20
		2. Semester-end Theory Examination (60%) (Table 3)	**90 mins**	30
On Job training (**OJT**)/NSS/ NCC/ Co-curricular Course (**CC**)/ Field project (**FP**)/ Internship	**2 Credit**	Continuous Internal Evaluation --Tests, Essays, Articles, Group assignments/ Reports/ Journals/ Diaries/ Reviews/ Dissertations/ Observations of Students/Presentation etc (As per the nature of the course)	-	

Note: **CC-Co-curricular Courses** include involvement/participation in various areas such as Cultural Activities, Departmental activities, Fine/Applied/Visual/Performing Arts, Sports,

and fitness, NSS/ NCC, DLLE, The Sunday School (TSS), Health & Wellness, Yoga education etc. Record of involvement
/Participation by students must be documented with signatures of staff concerned in students' CC Cards.

Table - 2

Theory - Mode of assessment-Continuous Internal Assessment [40%]

Evaluation type
• Assignments • Project based learning activities (Group Discussion/Research/ Case studies/ Reports / Assignments / Presentations / Skit / Poster / etc.). • Class Test (Objective - Multiple Choice Questions/ Subjective). • Active participation in class activities. • Overall conduct as a responsible student with respect to good behavior, leadership qualities, interpersonal skills etc.

Table-3

Paper Pattern for Semester-End Theory Examination
• Each unit should have equal weightage. • Minimum one question per unit • No MCQ/True-False type of questions should be asked, only descriptive questions are allowed. • Each question should have extra sub-questions (max 100% option)

Table-4

Semester End Examination for Practical Assessment -50 marks (2-Credit)-Major

[To be conducted at departmental level]

	For 1 subject		**For 2 subjects**	
A	Any one/ more experiment/s	35	Min two experiments per subject	40
B	Viva	10	Viva	05
C	Journal	05	Journal	05
	Total	**50 M**	Total	**50 M**