TULSIRAMJI GAIKWAD-PATIL COLLEGE OF ENGINEERING & TECHNOLOGY
Wardha Road, Nagpur - 441108
Accredited with NAAC A+ Grade
Approved by AICTE, New Delhi, Govt. of Maharashtra
(An Autonomous Institution Affiliated to Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur)
Department of Biotechnology

Teaching Scheme and Syllabus

of

6th Semester B.Tech Biotechnology

(From Academic Year 2025-26)

Vision of Institute

To emerge as a learning Centre of Excellence in the National Ethos in domains of Science, Technology and Management.

Mission of Institute

1. To strive for rearing standard and stature of the students by practicing high standards of professional ethics, transparency and accountability.
2. To provide facilities and services to meet the challenges of Industry and Society.
3. To facilitate socially responsive research, innovation and entrepreneurship.
4. To ascertain holistic development of the students and staff members by inculcating knowledge and profession as work practices.

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Department of Biotechnology

Vision of the Department

To produce competent Entrepreneurs, Researchers and industry ready Professionals in Biotechnology through quality education

Mission of the Department

1. To impart quality technical education and unique interdisciplinary research by merging science and technology
2. To make students aware about techniques of modern biotechnology and industrial advancements
3. To Inculcate Social and Ethical values in the students and empower them through imparting of knowledge and skills in biotechnology

Program Education Objectives (PEO)

1. Develop Biotechnology graduates as human resource with technical competencies and strong foundation of science and engineering.
2. Acquire fundamental knowledge of mathematics, Biosciences and engineering to analyze, design and implement solutions to the Biotechnological problems.
3. Understand emerging concepts and trends in Biotechnology and allied fields.
4. Apply various tools to develop innovative systems for the bioprocesses.

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Program Outcomes (PO)

1. **Engineering Knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem Analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and software tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Lifelong learning:** Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

Program Specific Outcomes (PSO)

PSO-1: Ability to apply the acquired knowledge and recent techniques to come up with ideas in the domains of Bioprocess Engineering, Bioinformatics and Biopharmaceuticals.
PSO-2: Ability to utilize their proficiency and skills in solving real life problems in Diagnostics Genetic Engineering and Fermentation Technology using recent technologies.
PSO-3: Analyzing the impact of Biotechnology Engineering solutions in the societal and human context to create productive human resource for the country.

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SCHEMEOFINSTRUCTION& SYLLABI

Programme: B.Tech Biotechnology

Scheme of Instructions: Third Year B.Tech. in Biotechnology (As Per NEP 2020) Semester– VI

SN	Sem	Type	BoS/ Dept	Sub Code	Subject	T/P	Contact Hours			Credits	% Weightage			ESE Duration	Total Marks
							L	P	Hrs		CT/IA	CA	ESE		
1	**VI**	PCC	**BT**	BBT33601	Mass Transfer in Biotechnology	T	3	0	5	3	30	10	60	3hrs	100
2	**VI**	PCC	**BT**	BBT33602	Bioreaction Engineering	T	3	0	5	3	30	10	60	3hrs	100
3	**VI**	PCC	**BT**	BBT33603	Mass Transfer in Biotechnology Lab	P	0	2	4	1	25	-	25	-	50
4	**VI**	PCC	**BT**	BBT33604	Animal and Plant Biotechnology Lab	P	0	2	4	1	25	-	25	-	50
5	**VI**	PEC	**BT**	BBT33605-7	Program Elective II	T	4	0	6	4	30	10	60	3hrs	100
6	**VI**	PEC	**BT**	BBT33608-10	Program Elective III	T	4	0	6	4	30	10	60	3hrs	100
7	**VI**	MDM	**CE**	BCE33615	Environmental Engineering	T	2	0	4	2	14	6	30	2hrs	50
8	**VI**	VSEC	**BT**	BBT33612	Microbial Identification Studies	P	0	4	4	2	25		25	-	50
Total							**16**	**8**	**38**	**20**					**600**

Course Category	BSC/ ESC (Basic Science Course/ Engineering Science Course.)	PCC (Programme Core courses	(MDM) Multidisciplinary Minor/ (O C) Open Elective Course	VSEC (Skill Course)	Humanities Social Science & Management		Experiential Learning Courses	CC (Co-Curricular Courses)
					AEC(Ability Enhancement Course)	IKS(Indian Knowledge System)		
Credits	00	32	6	2	0	0	0	0
Cumulative Sum	29	50	10	6	8	2	2	4

PROGRESSIVE TOTAL CREDITS: 105+20=125

Chairperson	Dean Academics	Vice Principal	Principal	Date of Release	Version	Applicable for
				Nov.2025	1.00	AY 2025-26 Onwards

HEAD
Department Of Biotechnology
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Dean Academics
Tulsiramji Gaikwad-Patil College Of Engineering and Technology, Nagpur

Vice Principal
(Academics)
TGPCET, NAGPUR

Dr. Premanand Naktode
Principal
TGPCET, Nagpur

Programme: B.Tech Biotechnology

List of **Program Electives** offered by The **Biotechnology** Department

Program Elective- I	Program Elective-II	Program Elective-III	Program Elective- IV	Program Elective- V
Semester V	**Semester VI**	**Semester VI**	**Semester VII**	**Semester VIII**
BBT33507- Biopharmaceutical Technology	**BBT33605-** Enzyme Technology	**BBT33608-** Biosimilars Technology	**BBT34703-** Nanotechnology	**BBT34706-** Good Manufacturing and Laboratory Practices
BBT33508- Introduction to Bioinformatics	**BBT33606-** Precision Medicine Technology	**BBT33609-** Stem cell Technology	**BBT34704-** Tissue Engineering and organ Printing	**BBT34707-** Biosensors
BBT33509- Bioremediation and Biodegradation	**BBT33607-** Biofertilizer and Biopesticide technology	**BBT33610-** Bioenergy and Biofules	**BBT34705-** Industrial Microbiology and its Application	**BBT34708-** Pollution control and Remediation

Program:B.Tech Biotechnology

List of **Open Electives** offered by **Biotechnology** Department

Open Elective-I	Open Elective-II	Open Elective-III
Semester-III	**Semester-IV**	**Semester-V**
BBT32309: Food and Nutrition	**BBT32408:** Waste Management	**BBT35310:**Bioterrorism and National Security

Course Category	BSC (Basic Science Course)	ESC (Engineering Science Course.)	PCC (Programme Core courses	PEC (Programme Elective courses)	Multi-disciplinary courses	VSEC (Skill Course)	Humanities Social Science & Management	Experiential Learning Courses	CC (Liberal Learning Courses	Semester Wise Credits
Sem -I	8	5	2	--	--	2	--	--	2	**22**
Sem -II	8	8	--	--	--	2		-	2	**21**
Sem -III	--	--	8	--	-	-	4	-	--	**20**
Sem -IV	--	--	8	--	-	2	6	--	--	**20**
Sem -V	--	--	11	4	4	--	--	--	--	**22**
Sem -VI	--	--	8	4	4	2	--	2	--	**20**
Sem -VII	--	--	4	2	4	--	--	12	--	**18**
Sem -VIII	--	--	4	6	-	--	--	8	--	**22**
Cumulative Sum	**16**	**13**	**66**	**16**	**12**	**8**	**10**	**22**	**4**	**165**

Chairperson	Dean Academics	Vice Principal	Principal	Date of Release	Version	Applicable for
				Nov,2025	1.00	AY 2025-26 Onwards

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(Academics)
TGPCET, NAGPUR

Dr. Premanand Naktode
Principal
TGPCET, Nagpur

Third Year (Semester-VI) B.Tech. Biotechnology				
BBT33601:Mass Transfer in Biotechnology				
Teaching Scheme			**Examination Scheme**	
Lectures	3Hr/Week		**ESE**	60 Marks
Tutorial	-		**CIE**	40 Marks
Practical	-		**Total**	100 Marks
TheoryCredits:3			**Duration of Exam:** 3 Hours	

Course Objectives

The Objectives of this courses:

To develop a fundamental understanding of mass transfer operations—including diffusion, distillation, absorption, extraction, drying, and crystallization—with emphasis on equilibrium, rate processes, and stage-wise/continuous contacting.

Course Contents

Unit I	Molecular diffusion in fluids, Diffusion in solids. Interphase Mass Transfer, coefficient and their correlations. Concept of effective diffusivity, Diffusion through membranes and applications. Measurement of kLa. Oxygen transfer Methodology in fermenters.
Unit II	Distillation: Vapor liquid equilibrium, T-x,y and P-x,y diagrams, estimation of VLE using vapor pressure data and relative volatility. Differential distillation, Equilibrium distillation, Rectification.
Unit III	Gas Absorption: Equilibrium relationship, Mass transfer theories. Plate column for absorption, analytical and graphical calculation of number of plates. Mass transfer in packed and fluidized beds.
Unit IV	Liquid-Liquid Extraction: Equilibrium for immiscible and partially miscible systems. Supercritical fluid extraction. Concept of number of stages for co current and counter current contacting
Unit V	Drying: Characteristics of biological materials. Theory and mechanism of drying. Evaluation of drying rates. Equipment for dehydration of biological materials, Crystallization, Theory of crystallization.

Textbooks	
T.1	—MassTransferOperations‖RobertE.Treybal,McGraw-Hill,3rdEdition,1981
T.2	"UnitOperationofChemicalEngineering‖McCabe,WarrenL.,JulianC.Smith, McGraw Hill Publication, New York 2004, 7th Edition.
Reference Books	
R.1	"SeparationProcessPrinciples"byJ.D.Seader,ErnestJ.Henley,andD.KeithRoper
R.2	"Introduction to Chemical Engineering" by S.K. Ghosal and A.K. Biswas

Useful Links	
1	https://www.sciencedirect.com/topics/physics-and-astronomy/molecular-diffusion
2	https://www.sciencedirect.com/topics/engineering/interphase-mass-transfer
3	https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Introduction_to_Solid_State_Chemistry/01:_Lectures/1.09:_Diffusion

After completion of this course students will able to:

Course Code	Course Outcomes	CL	Hours
BBT33601.1	**Apply** mass transfer principles to determine diffusivity and transfer coefficients in chemical and biological systems.	**3**	**9**
BBT33601.2	**Analyze** VLE data and distillation methods to estimate stages and separation efficiency.	**4**	**9**
BBT33601.3	**Analyze** gas absorption operations using mass transfer theories and design concepts.	**4**	**9**
BBT33601.4	**Evaluate** liquid–liquid extraction processes to select suitable stage arrangements.	**5**	**9**
BBT33601.5	**Evaluate** drying and crystallization operations to recommend appropriate process conditions and equipment.	**5**	**9**

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Third Year (Semester-VI) B. Tech Biotechnology

BBT33602 : Bio Reaction Engineering

Teaching Scheme			Examination Scheme	
Lectures	3 Hrs/Week		**ESE**	60 Marks
Tutorial	-		**CIE**	40 Marks
Practical	-		**Total**	100 Marks
Theory Credits : 3			**Duration of Exam :** 3 Hours	

Course Objectives

The Objectives of this course is:

To develop a comprehensive understanding of reactor design principles, including material and energy balances, performance parameters, and the analysis and evaluation of ideal and non-ideal reactors for single and multiple reactions under varying kinetic and operating conditions.

Course Contents

Unit I	Introduction To Reactor Design: Types of reactors, PFR, CSTR etc., Material & energy balances, single ideal reactor, Space-time and space-velocity, Holding Time, Introduction of non-ideal flow, Problems
Unit II	Ideal Reactors for a Single Reaction: Ideal Batch Reactor, Steady State Mixed Flow Reactor, Steady State Plug Flow Reactor, Problems Design for Single Reactions: Size comparison of single reactors, General graphical comparison, Multiple reactor system, Recycle reactor, Autocatalytic reactions, Problems.
Unit III	Design for Parallel Reactions: Introduction to design of parallel reactions, Qualitative and Quantitative discussion on product distribution, Contacting patterns, Reactor Size and arrangement, Selectivity, Yield, and Problems.
Unit IV	Potpourri of Multiple Reactions: Reversible first order reaction, First order Followed by zero order reaction, Zero order followed by first order reaction, Successive reversible reactions of different orders, reversible reactions, Irreversible series-parallel reactions, Graphical representation, Denbigh reactions and their special cases, Problems.
Unit V	Temperature and Pressure Effects: Single and multiple reactions, Heats of reaction from thermodynamics, Equilibrium constant, Temperature, Graphical design procedure, Optimum Temperature Progression, Heat Effects, Adiabatic And non-adiabatic operations, Problems.

Textbooks	
T.1	Chemical Reaction Engineering, Octave Levenspiel, John Wiley & Sons, Singapore, 3rd edition, 1998.
T.2	Elements of Chemical Reaction Engineering, Fogler H.S., Prentice-Hall, NJ, 4th Edition, 2006.
Reference Books	
R.1	Chemical Reactor Analysis, G.F. Froment and K.B. Bischoff, JohnWiley& Sons, Singapore, 2nd edition, 1990.
R.2	Chemical Engineering Kinetics, Smith J.M., McGraw-Hill, NY, 3rd edition, 1981

Useful Links	
1	http://digimat.in/nptel/courses/video/103106117/L02.html
2	https://enine.digimat.in/nptel/courses/video/103101001/L03.html

After completion of this course students will able to:

Course Code	Course Outcomes	CL	Hours
BBT33602.1	**Explain** reactor types and perform material/energy balances in Ideal reactors	**3**	**9**
BBT33602.2	**Analyze** the performance of ideal reactors (Batch, CSTR,PFR) for a single reaction	4	**9**
BBT33602.3	**Evaluate** parallel reaction systems in terms of selectivity,yield, and product distribution	**5**	**9**
BBT33602.4	**Analyze** and classify multiple complex reactions andgraphical representation	**4**	**9**
BBT33602.5	**Apply** heat and pressure effects on reaction kinetics andreactor design	3	**9**

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Third Year (Semester-VI)B.Tech. Biotechnology

BBT33603:Mass Transfer in Biotechnology Lab

Teaching Scheme			Examination Scheme	
Lectures	2Hr/Week		**ESE**	25 Marks
Tutorial	-		**CIE**	25 Marks
Practical	-		**Total**	50 Marks
Practical Credits:1			**Duration of Exam:** 2Hours	

CourseObjectives

The Objective of this courses:

To provide students with hands-on experience in analyzing diffusion, mass transfer, and separation processes through experiments involving drying, absorption, extraction, distillation, crystallization, and related operations.

Sr.No.	Experiments (Minimum 8 experiments should be performed)
1	Determination of diffusion coefficient of an organic vapor (acetone) in air.
2	Determination of Effective Diffusivity in a Solid.
3	Examination of the drying characteristics of a given material under constant drying conditions and determination of equilibrium and critical moisture content.
4	Gas Absorption in a Packed Column: Determination of Height of Transfer Unit (HTU) and Height Equivalent to a Theoretical Plate (HETP).
5	Determination of Mass Transfer Coefficient in a Fluidized Bed Adsorption System.
6	Determination of the mass transfer coefficient for the absorption of water vapor on silica gel.
7	Analysis of the variation of mass transfer coefficient as a function of flow rate of air for the vaporization of naphthalene in a packed bed.
8	Diffusion Through a Membrane: Determination of Permeability of a Dialysis Membrane Using a Dye or Salt Solution.
9	Estimation of the rate constant for the physical dissolution of benzoic acid in a liquid.
10	Determination of the diffusion coefficient for the given liquid–liquid system as a function of concentration.
11	Liquid–Liquid Extraction: Determination of the Partition Coefficient (K_e) of Acetic Acid Between Water and Butanol.
12	Estimation of $kLa$for air/oxygen absorption in nature.
13	Examination of crystallization phenomena in batch crystallization.
14	To find the mass transfer coefficient in a wetted wall column.
15	To verify Rayleigh's Equation for Simple Distillation.

Textbooks	
T.1	Mass Transfer Operations by *Robert E. Treybal*
T.2	Mass Transfer: Theory and Applications by *K.V. Narayanan & B. Lakshmikutty*
Reference Books	
R.1	"SeparationProcessPrinciples"byJ.D.Seader,ErnestJ.Henley,andD.KeithRoper
R.2	"IntroductiontoChemicalEngineering"byS.K.GhosalandA.K.Biswas

UsefulLinks	
1	https://www.sciencedirect.com/topics/physics-and-astronomy/molecular-diffusion
2	https://www.sciencedirect.com/topics/engineering/interphase-mass-transfer
3	https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Introduction_to_Solid_State_Chemistry/01:_Lectures/1.09:_Diffusion

After completion of this course students will able to:

Course Code	CourseOutcomes	CL	Hours
BBT33603.1	**Apply** diffusion and mass transfer principles to estimate key transport parameters in gas, liquid, and solid systems.	**3**	**9**
BBT33603.2	**Apply** experimental methods to determine drying behavior, dissolution rates, and oxygen transfer characteristics.	**3**	**9**
BBT33603.3	**Analyze** mass transfer operations such as absorption, extraction, and distillation using experimental data.	**4**	**9**
BBT33603.4	**Evaluate** the performance of packed beds, fluidized beds, membranes, and wetted-wall columns.	**5**	**9**
BBT33603.5	**Assess** crystallization and phase-change experiments to derive critical process parameters.	**5**	**9**

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Third Year (Semester-VI) B.Tech. Biotechnology				
BBT33604:Animal and Plant Biotechnology Lab				
Teaching Scheme			**Examination Scheme**	
Lectures	2Hr/Week		**ESE**	25 Marks
Tutorial	-		**CIE**	25 Marks
Practical	-		**Total**	50 Marks
Practical Credits: 1			**Duration of Exam:** 2 Hours	

Course Objectives
The Objective of this course is:
To provide comprehensive knowledge of animal and plant biotechnology, including fundamental concepts, key techniques, and their application in culturing, propagating, and maintaining plant and animal cells.

Sr. No.	Experiments (Minimum 8 practical's should be performed)
1	Sterilization techniques, membrane filtration.
2	Preparation of media
3	Surface sterilization of explants.
4	Callus induction, initiation in suspension culture.
5	Role of hormones in plant morphogenesis.
6	Regeneration of shoot and roots from callus culture.
7	Hardening of plantlets.
8	Establishing a primary cell line.
9	Sub-culturing of cells
10	Trypan blue dye exclusion assay for cell viability in animals.
11	In Vitro Seed Germination on Sterile MS Medium
12	Leaf Disc Culture for Indirect Organogenesis
13	Effect of Different Sugar Concentrations on In Vitro Shoot Growth
14	Preparation and Sterilization of Animal Cell Culture Glassware &Plasticware
15	Calculation of Cell Count Using Hemocytometer (Without Viability Test)

Textbooks	
T.1	"Plant Tissue Culture: Techniques and Experiments" by Roberta H. Smith
T.2	"Animal Cell Culture: Essential Methods " by John M. Davis
Reference Books	
R.1	"Plant Propagation: Principles and Practices" by Hudson T. Hartmann and Dale E. Kester
R.2	"Transgenic Animal Technology: A Laboratory Handbook " by Carl A. Pinkert

Useful Links	
1	https://www.researchgate.net/publication/371875460_Industrial_Biotechnology_Downstream_processing
2	https://agsci.psu.edu/digital-education/academic/syllabi/abe-888
3	https://handbook.unimelb.edu.au/2024/subjects/chen90035

After completion of this course students will able to:

Course Outcomes		CL	Hours
BBT33604.1	**Explain** the basic principles of animal and plant Biotechnology.	**2**	**9**
BBT33604.2	**Illustrate** basic techniques for preparation of different media for plant and animal cell culture.	**3**	**9**
BBT33604.3	**Demonstrate** techniques for propagation and maintenance of animal and plant cells.	**3**	**9**
BBT33604.4	**Classify** different techniques used in production of transgenic plants and animals.	**4**	**9**
BBT33604.5	**Select** proper culture techniques for propagation of transgenic plants and animals.	**5**	**9**

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Third Year (Semester-VI) B.Tech. Biotechnology

BBT33605: PE-II: Enzyme Technology

Teaching Scheme			Examination Scheme	
Lectures	4Hr /Week		ESE	60 Marks
Tutorials	--		CIE	40 Marks
Practical	--		Total	100 Marks
Theory Credits: 4			Duration of Exam: 3 Hours	

Course Objectives

To provide a comprehensive understanding of enzymes, including their fundamental concepts, mechanisms and kinetics, and their industrial and clinical applications.

Course Contents

Unit1	**Introduction of Enzyme:** Brief history, nomenclature & classification, Coenzyme and Cofactors, Induced & Lock-Key hypothesis, Transition-state stabilization hypothesis, Zymogen, Ribozyme &Abzymes, Allosteric enzymes.
Unit2	**Enzyme Kinetics:** Single substrate steady state kinetics; MichaelisMenten equation, Linear plots, King-Altman's method; Inhibitors and activators; Multi substrate systems; ping-pong mechanism, Alberty equation, Sigmoidal kinetics and Allosteric enzymes
Unit3	**Enzyme immobilization:** Methods of immobilization of enzymes-physical & chemical techniques, Kinetics of immobilized enzyme, Effect of external mass transfer & intra-particle diffusion, limitation & applications of immobilized enzymes, Bioreactors using immobilized enzyme.
Unit4	**Extraction and Purification of Enzymes:** Methods of production of enzymes, Extraction of Enzymes –soluble enzymes – membrane bound enzymes – Nature of extraction medium – purification of enzyme –criteria of purity –Determination of molecular weight of enzymes.
Unit5	**Industrial and Clinical uses of Enzymes (Applied Enzymology):** Industrial Enzymes- Thermophilic enzymes, amylases, lipases, proteolytic enzymes in meat and leather industry, enzymes used in various fermentation processes. Clinical enzymes- Enzymes as thrombolytic agents, Anti-inflammatory agents, asparaginase, Isoenzymes etc.. Immobilization of enzymes, ELIZA. Enzyme Engineering and site directed mutagenesis, Designer enzymes

Textbooks	
T.1	—Enzyme Technology" by Martin F. Chaplin and Christopher Bucke Cambridge University Press
T.2	—Biotechnology: Enzymes and Bioprocessing" by H.J. Rehm and G. Reed (Vol. 7a & 7b of Biotechnology series)
Reference Books	
R.1	Biocatalysis and Enzyme Technology" by Klaus Buchholz, Volker Kasche, and Uwe Theo Bornscheuer.
R.2	Biocatalysis and Enzyme Technology" by Klaus Buchholz, Volker Kasche, and Uwe Theo Bornscheuer

Useful Links	
1	https://pubmed.ncbi.nlm.nih.gov/37945176/
2	https://www.ncbi.nlm.nih.gov/books/NBK554481/
3	https://pubs.acs.org/doi/10.1021/acsomega.2c07560
4	https://pmc.ncbi.nlm.nih.gov/articles/PMC4692135/

After completion of this course students will able to:

Course Code	Course Outcomes	CL	Class Sessions
BBT33605.1	**Explain** enzyme classification, components, and basic mechanisms of enzyme action.	**2**	**9**
BBT33605.2	**Illustrate** enzyme kinetic principles, including Michaelis–Menten behavior, inhibition, and allosteric regulation.	**3**	**9**
BBT33605.3	**Analyze** enzyme immobilization methods and mass-transfer effects in bioreactor applications.	**4**	**9**
BBT33605.4	**Classify** enzyme production, extraction, and purification techniques using biochemical analytical methods.	**4**	**9**
BBT33605.5	**Summarize**industrial and clinical applications of enzymes and basic enzyme engineering strategies.	**5**	**9**

Third Year (Semester-VI) B.Tech. Biotechnology				
BBT33606: PE-II: Precision Medicine &Wellness				
Teaching Scheme			**Examination Scheme**	
Lectures	4Hr/Week		**ESE**	60 Marks
Tutorial	-		**CIE**	40 Marks
Practical	-		**Total**	100 Marks
Theory Credits: 4			**Duration of Exam:** 3 Hours	

Course Objectives
The Objective of this course is:
To analyze omics technologies and genome-level variations for understanding disease mechanisms, biomarker identification, and the application of genetic screening and pharmacogenomics in healthcare.

Course Contents	
Unit I	Use of genomics, transcriptomics, proteomics and metabolomics in understanding disease conditions. Biomarker identification and validation of a disease state.
Unit II	Human Genome project. Cancer genome project. Different types of genetic and non-genetic variations.
Unit III	Genetic screening and diagnosis: prenatal carrier testing and newborn screening for Mendelian diseases. Pharmacogenomic testing for drug selection, dosing and Predicting adverse effects of commonly prescribed drugs,
Unit IV	Concept of rare and Orphan disorders, Importance of focus to rare diseases, Classification and types of rare disorders, representative cases rare disorders viz. EpidermolysisBullosa, Pompe, Fabry, Friedreich'sAtaxi. Modern approaches to target rare disorders, Globaland National Policy for research on rare diseases.
Unit V	Ethical, legal, and social implications of health privacy and policy laws for precision medicine. Ayurveda system of *Prakriti*and *Agni*.

Textbooks	
T.1	—Introduction to Genomics & quot; by Arthur M. Lesk , 4th Edition, 2025.
T.2	"The Human Genome Project: What Does Decoding DNA Mean for Us?" by Kevin A. Boon 1st edition, 2002.
Reference Books	
R.1	"Transcriptomics: Methods and Protocols " edited by Michael J. Dyer.
R.2	"Principles of Proteomics‖ by Richard Twyman 2nd Edition, 2014.
R.3	"Metabolomics: From Fundamentals to Clinical Applications" edited by Alessandra Sacco 1st Edition, 2017.

R.4	"Ethical, Legal, and Social Issues in Medicine" by Marcia Angell and Donald W. Light 2 nd Edition 2007.
R.5	"The Ayurveda Encyclopedia: Natural Secretsto Healing, Prevention, and Longevity" by Swami Sadashiva Tirtha , B. Jain Publishers, 2023.

Useful Links	
1	https://www.genome.gov/human-genome-project
2	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2860823/
3	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3221079/

After completion of this course students will able to:

Course Outcomes		CL	Hours
BBT33606.1	**Determine** the fundamental concepts of major genome projects and differentiate between the various types of genetic variations.	**3**	**9**
BBT33606.2	**Apply** omics technologies (genomics, proteomics, etc.) to investigate disease mechanisms and stratify patients based on biomarkers.	**3**	**9**
BBT33606.3	**Analyze** the concept, classification, and representative examples (e.g.,Pompe, Fabry) of rare and orphan disorders, including modern therapeutic approaches and global research policies**.**	**4**	**9**
BBT33606.4	**Evaluate** genetic screening and pharmacogenomic testing strategies for diagnosing and personalizing treatment for Mendelian diseases.	**5**	**9**
BBT33606.5	**Justify** the ethical, legal, and social implications (ELSI) of health privacy laws and compare them with Ayurvedic principles in precision medicine.	**5**	**9**

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Third Year (Semester-VI) B.Tech. Biotechnology				
BBT33607: PE-II: Biofertilizer and Biopesticide Technology				
Teaching Scheme			**Examination Scheme**	
Lectures	**4Hrs/Week**		**ESE**	**60 Marks**
Tutorials	**--**		**CIE**	**40 Marks**
Practical	**--**		**Total**	**100 Marks**
TotalCredits:4			**Duration of Exam: 3 hours**	

Course Objectives

The objectives of this course are-

To provide comprehensive knowledge of biofertilizers by understanding beneficial microbial groups—including Rhizobium, free-living and symbiotic nitrogen fixers, and mycorrhizal associations—their taxonomy, physiology, plant interactions, and the techniques for their cultivation, identification, isolation, and inoculum production.

Course Contents

Unit1	Biofertilizers – Definition, kinds, microbes as biofertilizers, Symbiotic associates – Rhizobium taxonomy, Physiology, Host cell – Rhizobium interactions, mass cultivation, inoculants and serology.
Unit2	Frankia woodland and Actinorhizal nitrogen fixing plants and its host plants, characteristics, identification, cultural method and maintenance of Azospirillum, Azotobacter, Azolla and anabaena.
Unit3	Mycorrhiza - VAM association, types, occurrence, Collection, isolation and inoculum production, Structural components of VAM fungi, Life cycle of VAM fungi, Host- fungus signaling pathway.
Unit4	Large scale production of biofertilizer, Organic farming Carrier materials, general outline of microbes as fertilizers, Rhizosphere effect microbial products influencing plant growth.
Unit5	Biopesticides–Definition, kinds and commerce of biopesticide, Bacillusthuringiensis, insect viruses and entomo pathogenic fungi – its characteristics, physiology, mechanism of action and application.

Textbooks	
T1	
T2	Mycorrhiza: Structure, Function, Molecular Biology and Biotechnology by Ajit Varma and Bertold Hock 1st Edition 1995.
Reference Books	
R1	Azospirillum / Plant Associations by Yaacov Okon CRC Press ISBN: 0849349257 / 9780849349256.
R2	The Mycota. IV Environmental and Microbial Relationships by D. T. Wicklow and Bengt Söderström 1st Edition 1997.
Useful Links	
1	http://www.digimat.in/nptel/courses/video/102105058/L55.html
2	https://archive.nptel.ac.in/courses/102/105/102105058/
3	https://ggsestc.digimat.in/nptel/courses/video/102103555/L25.html

After completion of this course students will able to:

Course Code	Course Outcomes	CL	Class Sessions
BBT33607.1	**Discuss** major biofertilizer microbes and explain their physiology and symbiotic interactions with host plants.	**2**	**9**
BBT33607.2	**Demonstrate** cultural and maintenance techniques for effective cultivation of Azotobacter, Azolla, and Anabaena.	**3**	**9**
BBT33607.3	**Apply** appropriate methods for isolation, inoculum production, and large-scale cultivation of mycorrhizae and other biofertilizer organisms	**3**	**9**
BBT33607.4	**Classify** the role of rhizosphere microbial products and carrier materials in organic farming and plant growth promotion..	**4**	**9**
BBT33607.5	**Evaluate** the characteristics, physiology, and mechanisms of action of biopesticides such as *Bacillus thuringiensis* and insect viruses used in pest management.	**5**	**9**

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Third Year (Semester-VI) B.Tech. Biotechnology				
BBT33608: PE-III: Biosimilar Technology				
Teaching Scheme			**Examination Scheme**	
Lectures	4Hr/Week		**ESE**	60Marks
Tutorial	-		**CIE**	40Marks
Practical	-		**Total**	100Marks
Theory Credits: 4			**Duration of Exam:**3Hours	

Course Objectives	
The Objective of this course is:	
To develop a comprehensive understanding of biosimilars, including their evolution, therapeutic applications, development challenges, and the key scientific and regulatory processes involved in their characterization, optimization, manufacturing, and comparison with small-molecule drugs.	
Course Contents	
Unit I	Introduction to Biosimilars: Definition and overview of biosimilars, History and evolution of biosimilars, The concept of biological equivalence, Comparison of Biologics and small molecule drugs.
Unit II	Biotherapeutics and Their Applications: Types of biotherapeutics(peptides, antibodies, enzymes etc.), Applications of biotherapeutics in various diseases, Limitations and challenges in biotherapeutic development.
Unit III	Biosimilar Development Process: Overview of the biosimilar development process, Key steps in biosimilar development (characterization, optimization, manufacturing, and clinical trials), Comparison of biosimilar development with small molecule drug development, Regulatory aspects of Biosimilardevelopment.
Unit IV	Challenges and Opportunities in Biosimilar Development: Market competition and competition for biosimilars, Regulatory challenges and approval processes, Manufacturing and analytical methods for biosimilars, Patent landscape and Intellectual property considerations.
Unit V	Case Studies and Future Prospects: Case studies of successful and failed biosimilar development programs, Emerging trends and future prospects in biosimilar technology, The role of biosimilars in access to affordable Health care and sustainability of the biopharmaceutical industry.

Textbooks	
T.1	"Biosimilars: A New Generation of Biologics" by Sarfaraz K. Niazi 1st Edition 2017.
T.2	"Biopharmaceuticals: Biochemistry and Biotechnology" by Gary Walsh 2 nd Edition 2003.
Reference Books	
R.1	"Biosimilars and Interchangeable Biologics: Tactical Elements" by Sarfaraz K. Niazi 2nd Edition 2025.
R.2	"Biosimilars and Follow-On Biologics: Regulatory, Clinical, and Biopharmaceutical Development" by Sarfaraz K. Niazi 1st Edition 2018.

Useful Links	
1	https://www.iqvia.com/solutions/therapeutics/biosimilars
2	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5423073/
3	https://www.nature.com/articles/d42473-019-00145-0

After completion of this course students will able to:

Course Code	Course Outcomes	CL	Hours
BBT33608.1	**Describe** the concept of biosimilars, their revolution, and comparison withsmall molecule drugs.	**2**	**9**
BBT33608.2	**Classify**biotherapeutics types, their applications, and recognizeDevelopment challenges.	**2**	**9**
BBT33608.3	**Comprehend** biosimilar development steps, regulatory aspects,and compare with small molecule drugs.	**3**	**9**
BBT33608.4	**Analyze**biosimilar development challenges, including marketCompetition and regulatory hurdles.	**4**	**9**
BBT33608.5	**Evaluate**biosimilar case studies, prospects, and their role inhealthcare accessibility.	**5**	**9**

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Third Year (Semester-VI) B.Tech. Biotechnology				
BBT33609: PE-III: Stem Cell Technology				
Teaching Scheme			**Examination Scheme**	
Lectures	4Hr/Week		**ESE**	60 Marks
Tutorial	-		**CIE**	40 Marks
Practical	-		**Total**	100 Marks
Theory Credits: 4			**Duration of Exam:** 3 Hours	

Course Objectives	
The Objective of this course is:	
To provide a comprehensive understanding of stem cell biology, including stem cell types and properties, their niche-specific functions, therapeutic applications in major diseases, and the associated ethical, legal, and societal considerations.	
Course Contents	
Unit I	Introduction to Stem Cells: Principles & Properties of Stem Cells, Types of Stem cells, Comparison of Embryonic & Adult stem cells.
Unit II	Stem cell niche: Introduction to stem cell niches in gut epithelium, bone marrow, epidermis, testis & neural tissues.
Unit III	Types of regeneration- Stem cells derived from amniotic fluid, extra embryonic membrane, germ cells, hematopoietic organs, neurons & kidney. Bone marrow & cord blood collection procedures, cryopreservation, & their applications. Cord blood transplantation, donor selection, HLA matching, Patient selection, peripheral & bone marrow transplantation.
Unit IV	Experimental Methods- isolation & differentiation of human adult stem cells, embryonic stem cells, mouse stem cells. Stem cell techniques- FACS, GFP tagging.
Unit V	Applications of stem cells: Stem cell applications in cancer, diabetes, heart disease, muscular dystrophy, stem cell regulations- debate, social & ethical concerns.

Textbooks	
T.1	Stem cells by C.S Potten., Elsevier, 2006.
T.2	Essentials of Stem Cell Biology by Robert Lanza., 4th edition. Elsevier 2014.
Reference Books	
R.1	AriffBongso, EngHin Lee, "Stem Cells: From Bench to Bedside," World Scientific, 2011.
R.2	Daniel R. Marshak, "Stem cell biology," Cold Spring Harbor Laboratory Press, 2001.

Useful Links	
1	https://nptel.ac.in/courses/102106068
2	https://nptel.ac.in/courses/102106035
3	https://nptel.ac.in/courses/102106083

After completion of this course students will able to:

Course Code	Course Outcomes	CL	Class Sessions
BBT33609.1	**Interpret** the basic concepts of stem cells.	**2**	**9**
BBT33609.2	**Comprehend** the microenvironments or niches that support stem cell maintenance and differentiation	**3**	**9**
BBT33609.3	**Acquire** the knowledge of the transformation and protein expression in chloroplasts	**2**	**9**
BBT33609.4	**Demonstrate** the experimental Methods, isolation& Differentiation of stem cells	**3**	**9**
BBT33609.5	**Interpret** the knowledge of stem cells in treating various diseases such as cancer, diabetes,	**3**	**9**

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Third Year (Semester-VI) B. Tech Biotechnology

BBT33610 : PE-III: Bioenergy and Biofuels

Teaching Scheme			Examination Scheme	
Lectures	4 Hrs/Week		**ESE**	60 Marks
Tutorial	-		**CIE**	40 Marks
Practical	-		**Total**	100 Marks
Theory Credits : 4			**Duration of Exam :** 3 Hours	

Course Objectives

The Objective of this course is:

To provide an understanding of bioenergy sources and biomass conversion technologies, including the production of major biofuels and their applications, sustainability aspects, and future trends.

Course Contents

Unit 1	**Introduction to Bioenergy** Overview of global energy demand and the role of renewable energy, Classification of bioenergy resources – solid, liquid, and gaseous fuels, Types of biomass – lignocellulosic biomass, algae, energy crops, and agricultural residues, Thermochemical and biochemical conversion technologies for bioenergy production, Advantages and limitations of bioenergy systems.
Unit 2	**Biomass Conversion Technologies** Thermochemical conversion – combustion, pyrolysis, and gasification processes, Biochemical conversion – anaerobic digestion and fermentation, Characteristics and preprocessing of biomass feed stocks, Comparison of conversion technologies in terms of efficiency and environmental impact, Recent advancements in integrated bio refineries.
Unit 3	**Biogas and Bio hydrogen Production** Principles of anaerobic digestion, Microbial consortia involved and stages of biogas production, Factors affecting biogas yield – temperature, pH, C:N ratio, substrates, Bio hydrogen production methods – bio-photolysis, photo-fermentation, and dark fermentation, Applications and challenges in scaling up gaseous biofuel technologies.
Unit 4	**BioEnergy, Sustainability & Future Prospective** Bioethanol production from sugar, starch, and lignocellulosic materials, Pretreatment, hydrolysis, fermentation and distillation techniques, Biodiesel production through transesterification of vegetable oils and waste cooking oil, Process parameters affecting biodiesel yield and quality, Fuel properties, blending, and standards for bioethanol and biodiesel. Biobutanol, and Biopropanol production
Unit 5	**Applications, Sustainability, and Future Perspectives** Applications of biofuels in transport, power generation, and rural energy systems, Environmental impact and life cycle assessment (LCA) of biofuels, Socio-economic and policy issues related to bioenergy adoption, Global bioenergy scenario and case studies, Recent trends and future scope of bioenergy technologies. Biorefineries and its future respective

Textbooks	
T.1	Anju Dahiya, *Bioenergy: Biomass to Biofuels and Waste to Energy*, 2nd Edition, Academic Press, 2020
T.2	Godfrey Boyle, *Renewable Energy: Power for a Sustainable Future*, 4th Edition, Oxford University Press, 2017
Reference Books	
R.1	Jay Cheng (Ed.), *Biomass to Renewable Energy Processes*, 2nd Edition, CRC Press, 2017
R.2	Ashok Pandey, Christian Larroche, Steven C. Ricke, Claude-Gilles Dussap, Edgard Gnansounou (Eds.), *Biofuels: Alternative Feedstocks and Conversion Processes for the Production of Liquid and Gaseous Biofuels*, 2nd Edition, Academic Press, 2019

Useful Links	
1	https://link.springer.com/article/10.1007/s10311-021-01273-2
2	https://pmc.ncbi.nlm.nih.gov/articles/PMC6045967/
3	https://link.springer.com/chapter/10.1007/978-3-319-11906-9_6

After completion of this course students will able to:

Course Outcomes		**CL**	**Class sessions**
BBT33610.1	**Explain** the types and significance of bioenergy and biomass resources.	**2**	**9**
BBT33610.2	**Explain** various biomass conversion technologies and their industrial relevance	**2**	**9**
BBT33610.3	**Analyze** the microbial processes involved in biogas and bio hydrogen production	**4**	**9**
BBT33610.4	**Compare** the production methods of bioethanol and biodiesel	**4**	**9**
BBT33610.5	**Evaluate** the sustainability and applications of biofuels in real- world scenarios	**5**	**9**

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Third Year (Semester-VI) B.Tech. Biotechnology				
BCE33615:Environmental Engineering				
Teaching Scheme			**Examination Scheme**	
Lectures	2Hr/Week		**ESE**	30 Marks
Tutorial	-		**CIE**	20 Marks
Practical	-		**Total**	50 Marks
TheoryCredits:2			**Duration of Exam:** 3Hours	

Course Objectives

To understand the importance and necessity of water and water supply scheme and treatment of water.

Course Contents

Unit I	**Introduction:** Importance and necessity of a water supply scheme. **Water Demand:** All types of water demand, empirical formulae, factors affecting per capita demand, variation in demand, design period, population forecasting methods and examples. **Sources of water:** Rainwater, Ground water-springs, infiltration galleries, dug wells, tube wells, Surface water stream, lake, river, impounding reservoirs, ponds & sea. **Intake structures:** Location, types-river, lake, canal, reservoir etc.
Unit 2	**Conveyance of water:** Types of pipes, joints , fittings, valves &appurtenances. Hydraulic design aspects: Friction, Manning's, Darcy-Weishbach& Hazen-William's equation and problem. **Rising main and pumps:** Concept of rising main, Classification, working, merits and demerits, selection of pumps.
Unit 3	**Water quality:** Physical, Chemical and bacteriological characteristics of water, Health effects of various water characteristics, Standards of drinking water.(WHO 2011, CPHEOO, IS 10500). Waterborne diseases **Water treatment:** Objective of treatment, unit operations and processes, household & community based rural water treatment, decentralized water treatment, flow sheet of conventional water treatment plant. **Aeration:** Purpose, types of aerators, design of cascade aerator. **Coagulation and Flocculation:** Definition, Principles, types of coagulants and reactions, coagulant doses, types of mixing and flocculation devices.
Unit 4	**Sedimentation:** Principles, types of setting basins, inlet and outlet arrangements, simple design of sedimentation tank. **Clariflocculators:** Principles and operation. **Filtration:** Mechanism of filtration, types of filters-RSF, SSF, Pressure filters, elements of filters and specification, operational problems In filtration, Design of SSF and RSF, Membrane filtration technique of water treatment.

Unit 5	**Disinfection:** Purpose, Mechanism, criteria for good disinfectants, various disinfectants, their characteristics, disinfection by chlorination using different forms of chlorine. Types of chlorination. Distribution systems: Requirements of a good distribution system, methods of distribution systems and layouts, Leakage and leak detector, Study of fire hydrants. Storage reservoirs for treated water: Types, capacity of reservoir, mass curve. Miscellaneous Methods of Water Treatment: Color, Odors & Taste removal, removal of iron & manganese - water softening processes, base exchange process, swimming pool water treatment.

Textbooks	
T.1	Water and Wastewater Engineering - G. M. Fair, J.C. Geyer & D.A. Okun, Wiley Publication , 1971 edition
T.2	Water supply and Sanitary Engineering - Birdie G.S., DhanpatRai Publication, 2010 edition
T.3	Environmental Engg. I-P.N.Modi, Standard BookHouse,5th edition,2018
Reference Books	
R.1	Water Supply and Sanitary Engineering–S.C. Rangwala, Charotar Publishing House, 2005 edition
R.2	Water supply and sewage-M.J.Mcghee,Mc.GrawHill,6th edition,1991
R.3	Environmental Pollution Control Engg. -C.S.Rao, New Age International Publishers,3rd edition, 2018

Useful Links	
1	https://nptel.ac.in/courses/105/105/105105201/
2	https://nptel.ac.in/courses/105/106/105106119/

After completion of this course students will able to:

Course Code	Course Outcomes	CL	Class sessions
BCE33615.1	**Describe** the importance of water supply systems, water demand types, sources, and intake structures.	**2**	**8**
BCE33615.2	**Apply** population forecasting, empirical formulas, and hydraulic equations to estimate water demand and design conveyance systems.	**3**	**9**
BCE33615.3	**Analyze** water quality parameters and interpret drinking water standards to assess potability.	**4**	**10**
BCE33615.4	**Analyze** water quality parameters and interpret drinking water standards to assess potability processes for different field conditions.	**5**	**8**
BCE33615.5	**Assess** an integrated water treatment and supply scheme including intake, conveyance, treatment, and distribution**.**	**5**	**10**

Third Year (Semester-VI) B.Tech. Biotechnology				
BBT33612: Microbial Identification studies Lab				
Teaching Scheme			**Examination Scheme**	
Lectures	2Hr/Week		**ESE**	25 Marks
Tutorial	-		**CIE**	25 Marks
Practical	-		**Total**	50 Marks
Practical Credits: 2			**Duration of Exam:** 2 Hours	

Course Objectives
The Objective of this course is:
To gain basic knowledge about different types of identification techniques used in microbiology

Sr. No.	Experiments (Minimum 8 practical's should be performed)
1	Endospore staining of given bacterial culture.
2	Catalase test for production of catalase enzymes.
3	Coagulase test for staphylococcus.
4	Acid fast staining for mycobacterium.(Ziehl- Neelson staining)
5	Oxidase test for detection of cytochrome c oxidase.
6	Capsule staining of given bacterial culture
7	Simple staining of given bacterial culture.
8	Dot ELISA test for detection of antigen.
9	Total viable count of bacteria in given sample.
10	antibiotic sensitivity assay.
11	Test of sterility of given pharmaceutical product using membran filtration.
12	Minimum inhibitory concentration (MIC) testing.
13	Bacterial endotoxin testing in given pharmaceutical product
14	To evaluate efficacy of preservatives in pharmaceutical product
15	Enumeration of microorganisms in water used in pharmaceutical industry.

Textbooks	
T.1	Microbiology: An Introduction – Tortora, Funke & Case, Gerard J. Tortora, Berdell Funke, Christine Case, 12th Edition, 2016
T.2	Bailey & Scott's Diagnostic Microbiology, Patricia Tille, 14th Edition, 2017
T.3	Block's Disinfection, Sterilization, and Preservation, Seymour Block, 5th Edition,2001

Reference Books	
R.1	Bergey's Manual of Systematic Bacteriology-George M. Garrityetal.
R.2	Manual of Clinical Microbiology-American Society for Microbiology(ASM)

Useful Links	
1	https://www.microbiologyresearch.org/content/journal/ijsem/10.1099/ijs.0.016949-0
2	https://journals.asm.org/doi/10.1128/jcm.40.6.1887-1891.2002

After completion of this course students will able to:

Course Code	Course Outcomes	CL	Class Sessions
BBT33612.1	**Explain** basic microbial staining and biochemical identification methods.	**2**	**10**
BBT33612.2	**Apply** standard microbiological assays such as ELISA, viable count, MIC, and antibiotic sensitivity tests.	**3**	**10**
BBT33612.3	**Evaluate** sterility, contamination, endotoxins, and preservative effectiveness in pharmaceutical products.	**4**	**10**

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