TULSIRAMJI GAIKWAD-PATIL College of Engineering and Technology
Wardha Road, Nagpur - 441108
Accredited with NAAC A+ Grade
Approved by AICTE, New Delhi, Govt. of Maharashtra
(**An Autonomous Institution Affiliated to RTM Nagpur University**)
Department of Biotechnology

Teaching Scheme and Syllabus

of

6th Semester B.Tech Biotechnology

(From Academic Year 2023-24)

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Department of Biotechnology

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.

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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Scheme of Instructions: Third Year B. Tech in Biotechnology

Semester VI

Sr. No.	Course Category	Course Code	Course Title	L	T	P	Contact Hrs./Wk	Course Credits	EXAM SCHEME				
									CT1	CT2	CA	ESE	TOTAL
1	PCC	BBT3601	Mass Transfer in Biotechnology	3	-	-	3	3	15	15	10	60	100
2	PCC	BBT3602	Bioseparation Engineering	3		-	3	3	15	15	10	60	100
3	PCC	BBT3603	Animal and Plant Biotechnology	3	-	-	3	3	15	15	10	60	100
4	PEC	BBT3604-06	Professional Elective -III	3	-	-	3	3	15	15	10	60	100
5	PEC	BBT3607-09	Professional Elective -IV	3	-	-	3	3	15	15	10	60	100
6	OEC	B$$XX01-14	Open Elective – II	3	-	-	3	3	15	15	10	60	100
7	PCC	BBT3610	Mass Transfer in Biotechnology Lab	-	-	2	2	1	-	-	25	25	50
8	PCC	BBT3611	Animal and Plant Biotechnology Lab	-	-	2	2	1	-	-	25	25	50
9	PCC	BBT3612	Bioseparation Engineering Lab	-	-	2	2	1	-	-	25	25	50
10	PROJECT	BBT3613	Mini Project	-	-	2	2	1+1@	-	-	50	50	100
11	MCC	BAU3606	Social Awareness	2	-	-	2	Audit	-	-	-	-	-
			Total	20	0	8	28	23	90	90	185	485	850

L- Lecture T-Tutorial P-Practical CT1- Class Test 1 CT2- Class Test 2 CA- Continuous Assessment

ESE- End Semester Examination (For Laboratory: End Semester Performance)

Course Category	HSMC (Hum., Soc. Sc, Mgmt.)	BSC (Basic Sc.)	ESC (Engg. Sc.)	BS (Biological Sc.)	PCC (Professional Core courses)	PEC (Professional Elective Courses)	OEC (Biological Sc.)	Project (Project /Seminar/ Industrial Training)	MCC (Mandatory Courses)
Credits	3	-	-	--	8	6	3	2	Yes
Cumulative Sum	12	18	14	16	29	6	3	3	--

Progressive Total Credits: 101+23=124

BOS Chairman

Head
Department Of Biotechnology
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Dean Academics

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

Vice-Principal

Vice Principal
Tulsiramji Gaikwad-Patil
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Electives for Semester VI B.Tech Biotechnology

Professional Elective - III: Semester-VI		Professional Elective - IV: Semester-VI	
BBT3604	Big Data Analytic	BBT3607	Precision Medicine & Wellness
BBT3605	Biosimilars Technology	BBT3608	Nano Biotechnology
BBT3606	State of Art Imaging	BBT3609	Tissue Engineering

List of Open Elective

Sr. No.	Course Code	Course Title	Sr. No.	Course Code	Course Title
1	BCSXX01	Cyber Law and Ethics	9	BMEXX09	Nanotechnology and Surface Engineering
2	BCSXX02	Block chain Technology	10	BMEXX10	Automobile Engineering
3	BITXX03	Cyber Security	11	BEEXX11	Power Plant System
4	BITXX04	Artificial Intelligence	12	BEEXX12	Electrical Materials
5	BECXX05	Internet of Things	13	BAEXX13	Avionics
6	BECXX06	Embedded Systems	14	BAEXX14	Unmanned Aerial Vehicles
7	BCEXX07	Introduction to Art and Aesthetics	15	BBTXX15	Biomaterials
8	BCEXX08	Metro Systems and Engineering	16	BBTXX16	Food and Nutrition Technology

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Third Year B.Tech (Sixth Semester)				
BBT3601: Mass Transfer in Biotechnology				
Teaching Scheme			**Examination Scheme**	
Lectures	3 Hr / 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:	
1.	To comprehend the principles of molecular diffusion in fluids and solids, and apply interphase mass transfer coefficients to analyze diffusion through membranes for various applications such as oxygen transfer in fermenters.
2.	To master the techniques of distillation, including vapor-liquid equilibrium interpretation and estimation of VLE using vapor pressure data, for effective differential distillation, equilibrium distillation, and rectification.
3.	To understand gas absorption processes, including equilibrium relationships and mass transfer theories, and apply analytical and graphical methods to design plate columns for absorption and analyze mass transfer in packed and fluidized beds.

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 ka. 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 cocurrent and counter current contacting
Unit V	Drying: Characteristics of the biological materials. Theory and mechanism of drying. Evaluation of drying rates. Equipment for dehydration of biological materials, Crystallization, Theory of crystallization.

Text Books	
T.1	"Unit Operations of Chemical Engineering" by K. A. Gavhane
T.2	"Mass Transfer: Principles and Applications" by H. Panda
Reference Books	
R.1	"Separation Process Principles" by J. D. Seader, Ernest J. Henley, and D. Keith Roper
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

Course Outcomes		**CL**	**Hours**
BBT3601.1	Understand principles & applications of molecular diffusion, including its relevance in oxygen transfer methodology.	2	9
BBT3601.2	Analyze vapor-liquid equilibrium data, estimate VLE, and perform differential distillation, equilibrium distillation, and rectification processes effectively.	4	8
BBT3601.3	Comprehend gas absorption processes, design plate columns, and analyze mass transfer in packed and fluidized beds for industrial applications.	4	8
BBT3601.4	Apply liquid-liquid extraction principles, understand supercritical fluid extraction, and determine stages for contacting processes.	3	9
BBT3601.5	Understand drying characteristics, evaluate rates, select dehydration equipment, and grasp crystallization theory and applications.	2	8

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Third Year B.Tech (Sixth Semester)					
BBT3602: Bioseparation Engineering					
Teaching Scheme			**Examination Scheme**		
Lectures	3 Hr / 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:	
1.	To introduce the importance of bioseparation in biotechnology, covering the range and characteristics of bioproducts and the economic significance of downstream processing stages.
2.	To explore various methods of cell disruption and removal of insoluble solutes from fermentation broths, including physical, chemical, enzymatic, and mechanical techniques, along with microfiltration and centrifugation.
3.	To understand concentration techniques for bioproducts, including extraction methods like liquid-liquid and supercritical fluid extraction, as well as precipitation techniques, and to comprehend purification processes such as membrane separation and chromatography.

Course Contents	
Unit I	Introduction to Bioseparation: Introduction to separation of biomolecules and its importance in Biotechnology, Range and characteristics of bioproducts, Economic importance of Bioseparation, Characteristics of Fermentation Broths, Stages of Downstream Processing.
Unit II	Cell Disruption and Withdrawal of insoluble: Different methods of cell disruption for the release of cellular products: Physical, chemical, enzymes and mechanical methods. Removal of insoluble solutes: Pre-treatments of fermentation broths. Microfiltration and Centrifugation.
Unit III	Concentration of Bioproducts: Extraction of low molecular weight and high molecular weight bioproducts. Extraction of biomolecules by liquid-liquid, aqueous two-phase, reverse micellar, and supercritical fluid extraction. Precipitation techniques using salt and solvent.
Unit IV	Purification process: Membrane separation: Basic principles and advantages, Modes of operation, Pressure-driven processes (MF, UF, NF & RO), Concentration-driven by Pervaporation. Chromatographic separation: lon exchange, affinity, size exclusion chromatography.
Unit V	Finishing process Lyophilization and product formulation: Freeze drying, spray drying. Excipients: thickeners, surface agents, preservatives, colourings and flavourings. Dosage forms.

Text Books	
T.1	"Bioseparations Science" by Paul A. Belter and Wei-Shou Hu
T.2	"Downstream Processing of Proteins: Methods and Protocols" edited by Mohamed A. Desai and Nicolai L. Noppe
Reference Books	
R.1	"Principles of Downstream Techniques in Biological and Chemical Processes" by Mukesh Doble and Anil Kumar Kruthiventi
R.2	"Separation Processes in Biotechnology" by J. Sivasankar

Useful Links	
1	https://www.researchgate.net/publication/371875460_Industrial_Biotechnology_Downstream_processing
2	https://www.sciencedirect.com/topics/immunology-and-microbiology/downstream-processing
3	https://www.wiley.com/en-us/Downstream+Industrial+Biotechnology:+Recovery+and+Purification-p-9781118131244

Course Outcomes		**CL**	**Hours**
BBT3602.1	Analyze fermentation broths to identify downstream processing stages effectively.	3	9
BBT3602.2	Select appropriate cell disruption methods and evaluate their efficacy for removing insoluble solutes from fermentation broths.	5	7
BBT3602.3	Apply extraction and precipitation techniques to concentrate bioproducts efficiently.	5	8
BBT3602.4	Design purification protocols integrating membrane separation and chromatography techniques for bioproduct purification.	4	7
BBT3602.5	Formulate bioproducts using lyophilization and spray drying techniques, considering the role of excipients in dosage form formulations.	3	8

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Third Year B.Tech (Sixth Semester)				
BBT3603: Animal and Plant Biotechnology				
Teaching Scheme			**Examination Scheme**	
Lectures	3 Hr / 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:	
1.	To gain a thorough Knowledge about basic of Animal and plant Biotechnology.
2.	To study different techniques related to animal and plant biotechnology.
3.	To apply principles biotechnology for culturing, propagation and maintenance of animal and plant cells.

Course Outcomes
At the end of the unit, students will be able to :

Course Contents	
Unit I	Plant Tissue culture: Historical perspective of plant tissue culture, tissue culture lab and organization, sterilization techniques, types of nutrient media and media composition, plant regeneration pathways, role of phytohormones, cell culture techniques – cell tissue, organ cultures, callus cultures, suspension culture and protoplast culture
Unit II	Plant Propagation Technology: Basics of plant propagation, Green house cultivation technology, Poly-house farming techniques Hydroponic plant cultivation and its techniques, Aeroponic plant cultivation and techniques, Soil-less plant cultivation techniques and its advantages
Unit III	Animal Cell Culture: Cell culture substrates, cultural media, natural and artificial media, initiation and maintenance of cell cultures, cell culture products, cryopreservation techniques, immobilized cultures, organ culture- culture techniques, organ engineering
Unit IV	Transgenic Animal Technology: Transgenic animals with new traits, transgenic animals as bioreactors for producing pharmaceutically important compounds and therapeutics, tissue engineering
Unit V	Animal and Plant Biotechnology Applications: Herbicide-resistant crops, Drought-tolerant crops, Disease-resistant crops, Phytoremediation, Transgenic animals for research, Organ donation, Pharmaceutical production

Text Books	
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

Course Outcomes		**CL**	**Hours**
BBT3603.1	Understand the basic principles of animal and plant Biotechnology.	6	7
BBT3603.2	Describe basic techniques for preparation of different media for plant and animal cell culture.	4	8
BBT3603.3	Develop different techniques for propagation and maintenance of animal and plant cells.	5	9
BBT3603.4	Develop different techniques for production of transgenic plants and animals.	5	8
BBT3603.5	Select proper culture techniques for propagation of transgenic plants and animals.	4	7

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Third Year B.Tech (Sixth Semester)				
BBT3604: PE3: Big Data Analytics				
Teaching Scheme			**Examination Scheme**	
Lectures	3 Hr / 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:	
1.	To comprehend the fundamentals of Big Data, including its types, characteristics, and evolution, and to analyze the challenges associated with Big Data, focusing on the 5 Vs (Volume, Velocity, Variety, Veracity, and Value), and to evaluate the importance and application of Big Data in various domains.
2.	To understand the history and architecture of Hadoop, including its distributed file system (HDFS), components, data formats, and scalability, and to develop proficiency in application development and database integration within the Hadoop ecosystem.
3.	To master the MapReduce framework, including its basics, working principles, development of MapReduce applications, and testing procedures, and to analyze real-world scenarios for implementing MapReduce solutions effectively.

Course Contents	
Unit I	Introduction to Big Data: Types of Digital Data-Characteristics of Data - Evolution of Big Data - Definition of Big Data - Challenges with Big Data - 5 Vs of Big Data, Big data Technology Components, Big data importance and its application, Big data features- security, compliance, auditing and protection, Big data privacy and ethics, Big data analytics, analytics processes and tools, modern analytics tools
Unit II	Hadoop: History of Hadoop, Apache Hadoop, the Hadoop distributed file system, Components of Hadoop, data format, analyzing data with Hadoop, scaling out, Hadoop streaming, Hadoop pipes, Hadoop Echo System, Application development in Hadoop, Getting your database in Hadoop
Unit III	MapReduce: MapReduce framework and basics, how map reduce works, developing a map reduce application, unit test with MR unit, test data and local test, MapReduce types, input format, output formats, MapReduce features, Real world map reduce.
Unit IV	HDFS (Hadoop Distributed file system): Design of HDFS, HDFS Concepts, benefits and challenges, files sizes, block sizes and block abstraction in HDFS, data replication, how does HDFS store, read and write files, java interfaces to

	HDFS, command line interface, Hadoop file system interface, data flow, data ingest with flame and scoop, Hadoop archives.
Unit V	Hadoop Environment: Setting up a Hadoop cluster, Cluster specification, cluster setup and installation, Hadoop configuration, security in, Hadoop, administering Hadoop, HDFS monitoring and maintenance, Hadoop benchmarks, Hadoop in the cloud. Hadoop Ecosystem and YARN: Hadoop ecosystem components, scheduler fair and capacity, Hadoop 2.0 new features- Name Node high availability, HDFS federation, MRy2, YARN, Running MRv1 in YARN

Text Books	
T.1	"Big Data: Principles and Best Practices of Scalable Realtime Data Systems" by Nathan Marz and James Warren
T.2	"Hadoop: The Definitive Guide" by Tom White
Reference Books	
R.1	"MapReduce Design Patterns: Building Effective Algorithms and Analytics for Hadoop and Other Systems" by Donald Miner and Adam Shook
R.2	"Hadoop Operations: A Guide for Developers and Administrators" by Eric Sammer

Useful Links	
1	https://www.geeksforgeeks.org/hadoop-tutorial/
2	https://www.guru99.com/bigdata-tutorials.html
3	https://intellipaat.com/blog/tutorial/hadoop-tutorial/

Course Outcomes		**CL**	**Hours**
BBT3604.1	Apply knowledge of Big Data fundamentals to analyze challenges and opportunities associated with Big Data, including its characteristics and importance in various domains.	3	6
BBT3604.2	Develop proficiency in Hadoop architecture and application development, including understanding Hadoop components, analyzing data with Hadoop, and integrating databases into Hadoop environment.	5	6
BBT3604.3	Apply MapReduce framework to develop and test MapReduce applications, and analyze real-world scenarios for implementing MapReduce solutions effectively.	3	6
BBT3604.4	Demonstrate understanding of HDFS design and functionality, including data replication, storage, and data ingest processes, and utilize Java interfaces and command-line tools for HDFS management.	2	5
BBT3604.5	Apply knowledge of Hadoop cluster setup and administration, including configuring security, monitoring, and maintenance of HDFS, and analyze Hadoop benchmarks and new features in Hadoop 2.0, such as YARN.	3	6

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Third Year B.Tech (Sixth Semester)				
BBT3605: PE3: Biosimilar Technology				
Teaching Scheme			**Examination Scheme**	
Lectures	3 Hr / 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:	
1.	To understand the concept and evolution of biosimilars, including the comparison between biosimilars and small molecule drugs.
2.	To explore different types of biotherapeutics and their applications in various diseases, while also examining the limitations and challenges in biotherapeutic development.
3.	To comprehend the key steps and regulatory aspects of biosimilar development, including characterization, optimization, manufacturing, clinical trials, and comparison with small molecule drug development.
Course Outcomes	
At the end of the unit, students will be able to:	

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 biosimilar development
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 healthcare and sustainability of the biopharmaceutical industry

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

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

Course Outcomes		**CL**	**Hours**
BBT3605.1	Understand biosimilars, their evolution, and comparison with small molecule drugs.	2	9
BBT3605.2	Identify biotherapeutics types, their applications, and recognize development challenges.	2	8
BBT3605.3	Comprehend biosimilar development steps, regulatory aspects, and compare with small molecule drugs.	3	7
BBT3605.4	Analyze biosimilar development challenges, including market competition and regulatory hurdles.	3	8
BBT3605.5	Evaluate biosimilar case studies, future prospects, and their role in healthcare accessibility.	4	9

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Third Year B.Tech (Sixth Semester)				
BBT3606: PE3: State of Art Imaging				
Teaching Scheme			**Examination Scheme**	
Lectures	3 Hr / 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:	
1.	To understand various microscopy techniques, including X-ray diffraction, computed tomography, electron microscopy, and fluorescence imaging.
2.	To explore magnetic resonance techniques, such as nuclear magnetic resonance and magnetic resonance imaging, in biotechnology.
3.	To comprehend stereo microscopy and its applications in mycology, insect biology, and rhizosphere biology.

Course Contents	
Unit I	Optical and Electron microscopy: Introduction to X-rays, Production of X-Rays, X-Ray diffraction and its application, Computed Tomography (CT Scan) Transmission electron microscopy (TEM), scanning electron microscopy (SEM), Raman scattering and Infrared (IR), Fluorescence imaging methods, Surface enhanced Raman Scattering (SERS)
Unit II	Magnetic Resonance: Nuclear Magnetic Resonance (NMR) and its applications, Magnetic Resonance imaging (MRI) and its applications in biotechnology
Unit III	Stereo Microscopy: Stereo microscopy and its application in mycology, insect biology and rhizo-sphere biology
Unit IV	Ultra sound imaging or sonography: Endoscopic ultrasound, color Doppler, Duplex ultra-sound, Ecocardiogram, Angiography
Unit V	Bioluminescence and mass spectrometry imaging: Biological Luminescence Imaging (BLI), In Vivo BLI, Molecular BLI, mass spectrometry imaging, Calcium imaging

Text Books	
T.1	"Principles of Optics: Electromagnetic Theory of Propagation, Interference and Diffraction of Light" by Max Born and Emil Wolf (for Optical microscopy)
T.2	"Introduction to X-Ray Powder Diffractometry" by Ron Jenkins (for X-Ray diffraction)
Reference Books	
R.1	"Fluorescence Imaging Spectroscopy and Microscopy" by Xavier Intes (for Fluorescence imaging methods)

R.2	"Nuclear Magnetic Resonance Spectroscopy: An Introduction to Principles, Applications, and Experimental Methods" by Joseph B. Lambert (for Nuclear Magnetic Resonance)
R.3	"MRI: Basic Principles and Applications" by Mark A. Brown and Richard C. Semelka (for Magnetic Resonance Imaging)
R.4	"Principles and Applications of Stereomicroscopy" by Gillian Pocock (for Stereo microscopy)
R.5	"Diagnostic Ultrasound: Imaging and Blood Flow Measurements" by K. Kirk Shung and J. A. Thieme (for Ultrasound imaging)
R.6	"Mass Spectrometry: Principles and Applications" by Edmond de Hoffmann and Vincent Stroobant (for Mass spectrometry imaging)

Useful Links	
1	https://www.cell.com/trends/biotechnology/fulltext/S0167-7799(02)02024-3
2	https://bmcsystbiol.biomedcentral.com/articles/10.1186/1752-0509-2-74
3	https://www.biotechjournal.in/images/paper_pdffiles/Bio-60fd9da08e614.pdf

Course Outcomes		CL	Hours
BBT3606.1	Choose appropriate microscopy techniques, including X-ray diffraction, computed tomography, electron microscopy, and fluorescence imaging.	5	9
BBT3606.2	Infer magnetic resonance techniques, such as nuclear magnetic resonance and magnetic resonance imaging, in biotechnology.	4	8
BBT3606.3	Comprehend stereo microscopy and its applications in mycology, insect biology, and rhizosphere biology.	4	9
BBT3606.4	Recommend appropriate ultrasound imaging techniques, including endoscopic ultrasound and color Doppler, for medical diagnostics.	5	9
BBT3606.5	Examine bioluminescence imaging and mass spectrometry imaging techniques for biological research and analysis.	3	8

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Third Year B.Tech (Sixth Semester)				
BBT3607: PE4: Precision Medicine & Wellness				
Teaching Scheme			**Examination Scheme**	
Lectures	3 Hr / 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:	
1.	To analyze omics technologies for understanding disease mechanisms and biomarker identification.
2.	To assess major genome projects and types of genetic variations.
3.	To evaluate genetic screening for Mendelian diseases and pharmacogenomic testing.

Course Contents	
Unit I	Use of genomics, transcriptomics, proteomics and metabolomics in understanding disease condition. Biomarker identification and validation of a disease state.
Unit II	Human Genome project. Cancer genome project. Different types of genetic and nongenetic variations.
Unit III	Genetic screening and diagnosis: prenatal carrier testing and newborn screening for Mendelian diseases. Pharmacogenomic testing for drug selection, dosingand predicting adverse effects of commonly prescribed drugs,
Unit IV	Tumor profiling, Patient data and clinical decisions. Risk assessment through omics approach.
Unit V	Ethical, legal, and social implications of health privacy and policy laws for precision medicine. Ayurveda system of *Prakriti* and *Agni*.

Text Books	
T.1	"Introduction to Genomics" by Arthur M. Lesk
T.2	"The Human Genome Project: What Does Decoding DNA Mean for Us?" by Tanya Lewis
Reference Books	
R.1	"Transcriptomics: Methods and Protocols" edited by Michael J. Dyer
R.2	"Principles of Proteomics" by Richard Twyman
R.3	"Metabolomics: From Fundamentals to Clinical Applications" edited by Alessandra Sacco
R.4	"Ethical, Legal, and Social Issues in Medicine" by Marcia Angell and Donald W. Light

R.5	"The Ayurveda Encyclopedia: Natural Secrets to Healing, Prevention, and Longevity" by Swami Sadashiva Tirtha

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/

Course Outcomes		**CL**	**Hours**
BBT3607.1	Analyze omics technologies to understand disease mechanisms and identify biomarkers.	4	8
BBT3607.2	Understand major genome projects and different types of genetic variations.	2	8
BBT3607.3	Evaluate genetic screening for Mendelian diseases and pharmacogenomic testing.	5	8
BBT3607.4	Assess tumor profiling and patient data for clinical decisions using omics approaches.	5	8
BBT3607.5	Examine ethical, legal, and social implications of health privacy laws and Ayurvedic principles in precision medicine.	3	8

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Third Year B.Tech (Sixth Semester)				
BBT3608: PE4: Nano Biotechnology				
Teaching Scheme			**Examination Scheme**	
Lectures	3 Hr / 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:	
1.	To introduce the fundamentals of nanotechnology and nanobiotechnology, focusing on key nanomaterials such as carbon nanomaterials, fullerenes, nanotubes, and nanowires.
2.	To explore nanobiotechnological devices including nanoparticles, dendrimers, nanorobots, and nanoshells, along with biosensors such as DNA, protein-based, and antibody-based biosensors, emphasizing detection techniques and microfabrication methods.
3.	To understand the synthesis and biomedical applications of biopolymers and polymer nanocomposites, analyzing different types and their respective applications in various fields.

Course Contents	
Unit I	Introduction to nanotechnology and nanobiotechnology. Nanomaterial: Carbon nanomaterial, Fullerenes, Nanotube, Nanowire.
Unit II	Nanobiotechnological devices: Nanoparticles, Dendrimers, Nanorobots, Nubot, Nanoshell. Biosensors: DNA, Protein-based, Antibodies and its application. Detection in Biosensors: fluorescence, absorption, electrochemical methods. Techniques used for microfabrication. Future direction in biosensor research.
Unit III	Biopolymer: synthesis of polymer nanofibers and their biomedical applications. Polymer nanocomposite: Types and application.
Unit IV	Nanomedicine as a drug delivery system. Implications of nanotechnology in the society. Positive and negative aspects of nanotechnology.
Unit V	Application of Nanotechnology: Nanotechnology for waste reduction and Improved energy efficiency, nanotechnology-based water treatment strategies and Environmental remediation. Case studies and Regulatory needs.

Text Books	
T.1	"Nanobiotechnology: Concepts, Applications and Perspectives" by Christof M. Niemeyer and Chad A. Mirkin
T.2	"Nanobiotechnology: Bioinspired Devices and Materials of the Future" by Oded Shoseyov and Ilan Levy
Reference Books	

R.1	"Biosensors: An Introduction" by Ajit Sadana and Neeti Sadana
R.2	"Biopolymers: New Materials for Sustainable Films and Coatings" edited by David Plackett
R.3	"Polymer Nanocomposites: Processing, Characterization, and Applications" edited by Joseph H. Koo and Jin Kuk Kim
R.4	"Nanomedicine: Principles and Perspectives" by Raj Bawa, Gerald F. Audette, and Israel Rubinstein

Useful Links	
1	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4862100/
2	https://www.sciencedirect.com/topics/chemistry/biopolymer
3	https://www.sciencedirect.com/topics/medicine-and-dentistry/nanomedicine

Course Outcomes		**CL**	**Hours**
BBT3608.1	Understand nanotechnology basics and key nanomaterials.	2	6
BBT3608.2	Explore nanobiotechnological devices and biosensors, emphasizing detection techniques.	2	5
BBT3608.3	Comprehend biopolymer synthesis and applications in various fields.	3	6
BBT3608.4	Evaluate nanomedicine's role in drug delivery and societal implications of nanotechnology.	5	6
BBT3608.5	Examine nanotechnology applications in waste reduction, energy efficiency, water treatment, and environmental remediation, including regulatory needs.	5	6

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Third Year B.Tech (Sixth Semester)				
BBT3609: PE4: Tissue Engineering				
Teaching Scheme			**Examination Scheme**	
Lectures	3 Hr / 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:	
1.	To analyze the fundamentals of tissue engineering, including stem cell tissue engineering, growth factors, extracellular matrix, mechanical forces on cells, cell adhesion, and migration.
2.	To explore tissue engineering enabling technologies such as polymer scaffolds, biomimetic materials, nanocomposite scaffolds, bioreactors, and regulatory issues.
3.	To examine tissue engineering applications in various fields including skin, nerve, musculoskeletal, bone, cartilage, temporomandibular, smooth muscle, esophagus, vascular grafts, cardiac, heart valves, urologic organs, hepatic, renal, dental, and tracheal tissue engineering.

Course Contents	
Unit I	Unit-1 Fundamental Of Tissue Engineering Fundamentals Of Stem Cell Tissue Engineering; Growth Factors; Extracellular Matrix: Structure, Function And Tissue Engineering Application; Mechanical Forces On Cells; Cell Adhesion; Cell Migration.
Unit II	Unit-2 Tissue Engineering Enabling Technologies Polymer Scaffold For Tissue Engineering Applications; Biomimetic Materials; Nanocomposite Scaffolds Tissue Engineering; Bioreactors; Regulatory Issues In Tissue Engineering.
Unit III	Unit-3 Tissue Engineering Application I Bioengineering Of Human Skin Substitute; Nerve Tissue Engineering; Musculoskeletal Tissue Engineering; Bone Tissue Engineering; Cartilage Tissue Engineering; Temporomandibular Tissue Engineering; Smooth Muscle Tissue Engineering; Esophagus Tissue Engineering.
Unit IV	Unit-4 Tissue Engineering Application II Vascular Graft Tissue Engineering Cardiac Tissue Engineering; Heart Valve Tissue Engineering; Urologic Organ Tissue Engineering; Hepatic Tissue Engineering; Renal Tissue Engineering; Dental Tissue Engineering; Tracheal Tissue Engineering.
Unit V	Unit-5: Emerging Trends in Tissue Engineering: novel biomaterials, 3D bioprinting, organ-on-a-chip technologies, and the application of tissue

	engineering in regenerative medicine, ethical considerations associated with the translation of tissue engineering technologies from the lab to clinical practice.

Text Books	
T.1	"Principles of Tissue Engineering" by Robert Lanza, Robert Langer, and Joseph P. Vacanti
T.2	"Tissue Engineering: Principles and Practices" by John P. Fisher, Antonios G. Mikos, and Joseph D. Bronzino
Reference Books	
R.1	"Tissue Engineering: From Lab to Clinic" by Miguel Alaminos, Antonio Campos, and Miguel Ángel Martín-Piedra
R.2	"Biomaterials Science: An Introduction to Materials in Medicine" by Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, and Jack E. Lemons
R.3	"Nanotechnology in Tissue Engineering and Regenerative Medicine" edited by Ketul C. Popat
R.4	"Regenerative Medicine: From Protocol to Patient" edited by Gustav Steinhoff

Useful Links	
1	https://www.sciencedirect.com/topics/engineering/tissue-engineering
2	https://www.aabb.org/news-resources/resources/cellular-therapies/facts-about-cellular-therapies/regenerative-medicine
3	https://wyss.harvard.edu/technology/3d-bioprinting/

Course Outcomes		**CL**	**Hours**
BBT3609.1	Understand the fundamentals of tissue engineering, including stem cell tissue engineering, growth factors, extracellular matrix, mechanical forces on cells, cell adhesion, and migration.	2	9
BBT3609.2	Explore tissue engineering enabling technologies such as polymer scaffolds, biomimetic materials, nanocomposite scaffolds, bioreactors, and regulatory issues.	2	9
BBT3609.3	Examine tissue engineering applications in various fields including skin, nerve, musculoskeletal, bone, cartilage, temporomandibular, smooth muscle, esophagus, vascular grafts, cardiac, heart valves, urologic organs, hepatic, renal, dental, and tracheal tissue engineering.	5	9

BBT3609.4	Evaluate advanced tissue engineering applications in areas such as vascular grafts, cardiac, heart valves, urologic organs, hepatic, renal, dental, and tracheal tissue engineering.	5	9
BBT3609.5	Analyze emerging trends in tissue engineering including novel biomaterials, 3D bioprinting, organ-on-a-chip technologies, and ethical considerations in regenerative medicine.	3	9

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Third Year B.Tech (Sixth Semester)				
BBT3610: Mass Transfer in Biotechnology Lab				
Teaching Scheme			**Examination Scheme**	
Lectures	2 Hr / Week		**ESE**	25 Marks
Tutorial	-		**CIE**	25 Marks
Practical	-		**Total**	50 Marks
Practical Credit: 1			**Duration of Exam:** 2 Hours	

Course Objectives	
The Objectives of this course is:	
1.	Determine the diffusion coefficient of acetone in air through experimental measurements and analysis.
2.	Investigate the drying characteristics of a given material under constant drying conditions to determine equilibrium and critical moisture content.
3.	Determine the mass transfer coefficient for the absorption of water vapor on silica gel using experimental techniques.

Sr. No.	**Experiments**
1	Determination of diffusion coefficient of an organic vapor (acetone) in air.
2	Examination of the drying characteristics of a given material under constant drying conditions and to report equilibrium and critical moisture content.
3	Determination of the mass transfer coefficient for the absorption of water vapor on silica gel.
4	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.
5	Estimation of the rate constant for the physical dissolution of benzoic acid in a liquid.
6	Determination of the diffusion coefficient for the given liquid-liquid system as a function of concentration.
7	Estimation of KLa for air/oxygen absorption in nature.
8	Examination of crystallization phenomena in Batch Crystallization
9	To find the mass transfer coefficient in a wetted wall Column
10	To verify Rayleigh's Equation for Simple Distillation

Text Books	
T.1	"Unit Operations of Chemical Engineering" by K. A. Gavhane
T.2	"Mass Transfer: Principles and Applications" by H. Panda
Reference Books	
R.1	"Separation Process Principles" by J. D. Seader, Ernest J. Henley, and D. Keith Roper
R.2	"Introduction to Chemical Engineering" by S. K. Ghosal and A. K. Biswas

Useful Links	
1	https://www.sciencedirect.com/topics/engineering/tissue-engineering
2	https://www.aabb.org/news-resources/resources/cellular-therapies/facts-about-cellular-therapies/regenerative-medicine
3	https://wyss.harvard.edu/technology/3d-bioprinting/

Course Outcomes		CL	Hours
BBT3610.1	Understand principles & applications of molecular diffusion, including its relevance in oxygen transfer methodology.	2	9
BBT3610.2	Analyze vapor-liquid equilibrium data, estimate VLE, and perform differential distillation, equilibrium distillation, and rectification processes effectively.	4	8
BBT3610.3	Comprehend gas absorption processes, design plate columns, and analyze mass transfer in packed and fluidized beds for industrial applications.	4	8
BBT3610.4	Apply liquid-liquid extraction principles, understand supercritical fluid extraction, and determine stages for contacting processes.	3	9
BBT3610.5	Understand drying characteristics, evaluate rates, select dehydration equipment, and grasp crystallization theory and applications.	2	8

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Third Year B.Tech (Sixth Semester)				
BBT3611: Animal and Plant Biotechnology Lab				
Teaching Scheme			**Examination Scheme**	
Lectures	2 Hr / Week		**ESE**	25 Marks
Tutorial	-		**CIE**	25 Marks
Practical	-		**Total**	50 Marks
Practical Credit: 1			**Duration of Exam:** 2 Hours	

Course Objectives	
The Objectives of this course is:	
1.	To gain a thorough Knowledge about basic of Animal and plant Biotechnology.
2.	To study different techniques related to animal and plant biotechnology.
3.	To apply principles biotechnology for culturing, propagation and maintenance of animal and plant cells.

Sr. No.	**Experiments**
1	To Assess Cell Disruption Techniques for Enhanced Biomolecule Release
2	To Investigate Microfiltration and Centrifugation for Insoluble Solute Withdrawal
3	To Demonstrate Liquid-Liquid Extraction of Low Molecular Weight Bioproducts
4	To Explore Membrane Separation Techniques: Microfiltration to Reverse Osmosis
5	To Perform Chromatographic Separation: Ion Exchange, Affinity, Size Exclusion
6	To Evaluate the Efficiency of Various Membrane Separation Processes
7	To Optimize Liquid-Liquid Extraction Parameters for Biomolecule Extraction
8	To Analyze the Impact of Excipients on Lyophilization and Product Formulation
9	To Investigate the Role of Pervaporation in Concentration-Driven Processes
10	To Characterize Freeze-Dried Products Through Lyophilization Techniques

Text Books	
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

Course Outcomes		**CL**	**Hours**
BBT3611.1	Understand the basic principles of animal and plant Biotechnology.	6	7
BBT3611.2	Describe basic techniques for preparation of different media for plant and animal cell culture.	4	8
BBT3611.3	Develop different techniques for propagation and maintenance of animal and plant cells.	5	9
BBT3611.4	Develop different techniques for production of transgenic plants and animals.	5	8
BBT3611.5	Select proper culture techniques for propagation of transgenic plants and animals.	4	7

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Third Year B.Tech (Sixth Semester)				
BBT3612: Bioseparation Engineering				
Teaching Scheme			**Examination Scheme**	
Lectures	2 Hr / Week		**ESE**	25 Marks
Tutorial	-		**CIE**	25 Marks
Practical	-		**Total**	50 Marks
Practical Credit: 1			**Duration of Exam:** 2 Hours	

Course Objectives	
The Objectives of this course is:	
1.	Demonstrate proper sterilization techniques for glassware and equipment used in plant tissue culture, ensuring contamination-free experimental conditions.
2.	Prepare standard tissue culture media and sterilize it effectively to provide a suitable environment for tissue culture experiments.
3.	Perform sterilization of various explants and demonstrate proper inoculation techniques onto culture media to initiate plant tissue growth.

Sr. No.	**Experiments**
1	To Assess Cell Disruption Techniques for Enhanced Biomolecule Release
2	To Investigate Microfiltration and Centrifugation for Insoluble Solute Withdrawal
3	To Demonstrate Liquid-Liquid Extraction of Low Molecular Weight Bioproducts
4	To Explore Membrane Separation Techniques: Microfiltration to Reverse Osmosis
5	To Perform Chromatographic Separation: Ion Exchange, Affinity, Size Exclusion
6	To Evaluate the Efficiency of Various Membrane Separation Processes
7	To Optimize Liquid-Liquid Extraction Parameters for Biomolecule Extraction
8	To Analyze the Impact of Excipients on Lyophilization and Product Formulation
9	To Investigate the Role of Pervaporation in Concentration-Driven Processes
10	To Characterize Freeze-Dried Products Through Lyophilization Techniques

Text Books	
T.1	"Bioseparations Science" by Paul A. Belter and Wei-Shou Hu
T.2	"Downstream Processing of Proteins: Methods and Protocols" edited by Mohamed A. Desai and Nicolai L. Noppe
Reference Books	
R.1	"Principles of Downstream Techniques in Biological and Chemical Processes" by Mukesh Doble and Anil Kumar Kruthiventi
R.2	"Separation Processes in Biotechnology" by J. Sivasankar

Useful Links	
1	https://www.researchgate.net/publication/371875460_Industrial_Biotechnology_Downstream_processing
2	https://www.sciencedirect.com/topics/immunology-and-microbiology/downstream-processing
3	https://www.wiley.com/en-us/Downstream+Industrial+Biotechnology:+Recovery+and+Purification-p-9781118131244

Course Outcomes		**CL**	**Hours**
BBT3612.1	Analyze fermentation broths to identify downstream processing stages effectively.	3	9
BBT3612.2	Select appropriate cell disruption methods and evaluate their efficacy for removing insoluble solutes from fermentation broths.	5	7
BBT3612.3	Apply extraction and precipitation techniques to concentrate bioproducts efficiently.	5	8
BBT3612.4	Design purification protocols integrating membrane separation and chromatography techniques for bioproduct purification.	4	7
BBT3612.5	Formulate bioproducts using lyophilization and spray drying techniques, considering the role of excipients in dosage form formulations.	3	8

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Third Year B.Tech (Sixth Semester)				
BBTXX15: OE: Biomaterials				
Teaching Scheme			**Examination Scheme**	
Lectures	3 Hr / 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:	
1.	To understand the classification and properties of biomaterials, including their interaction with physiological fluids and biological responses.
2.	To explore the characteristics, corrosion behavior, and host tissue reactions of metallic implant materials, along with their applications in hard and soft tissue replacements.
3.	To investigate the fabrication techniques, mechanical improvements, and biocompatibility considerations of ceramic, glass, and composite implant materials, emphasizing their suitability for biomedical applications.

Course Contents	
Unit I	**Introduction:** Definition of biomaterials, requirements & classification of biomaterials, Comparison of properties of some common biomaterials. Effects of physiological fluid on the properties of biomaterials. Biological responses (extra and intra-vascular system). Surface properties of materials, physical properties of materials, mechanical properties.
Unit II	**Metallic implant materials**: Stainless steel, Co-based alloys, Ti and Ti-based alloys. Importance of stress-corrosion cracking. Host tissue reaction with bio metal, corrosion behavior and the importance of passive films for tissue adhesion. Hard tissue replacement implant, Soft tissue replacement implants.
Unit III	**Ceramics and glasses-bio ceramics:** Type of Ceramics and their classification, Calcinations, Annealing. Sintering, nearly inert ceramics, bio-reactive glasses and glass ceramics, Calcium phosphate ceramics. Composite implant materials: Mechanics of improvement of properties by incorporating different elements. Composite theory of fiber reinforcement (short and long fibres, fibres pull out)
Unit IV	**Surface properties and modification of surface properties**: Basic principles of engineering manufacturing, methods and applications of common manufacturing processes, milling, grinding, finishing, rolling, forging, Concept of biomimetic synthesis
Unit V	**Biocompatibility & Toxicological screening of biomaterials**: Definition of biocompatibility, blood compatibility and tissue compatibility. Toxicity tests: acute

	and chronic toxicity studies (in situ implantation, tissue culture, haemolysis, thrombogenic potential test, systemic toxicity, intracutaneous irritation test).

Text Books	
T.1	Computational methods in drug design Fred E. Cohen, Walter Hamilton Moos. Publisher: ESCOM Science, 1993
T.2	Molecular Modelling for Beginners - Alan Hinchliffe Publisher: John Wiley & Sons Inc, 2008. ISBN: 978-0470513149
Reference Books	
R.1	Materials Science and Engineering- Callister.
R.2	Materials for Medical Engineering- Euromat 99 vol-2

Useful Links	
1	https://nptel.ac.in/courses/113104009
2	https://nptel.ac.in/courses/102106057
3	https://nptel.ac.in/courses/113108071

Course Outcomes		**CL**	**Hours**
BBTXX15.1	**Demonstrate** the fundamental concepts of properties, requirements & classification of biomaterials.	2	6
BBTXX15.2	**Acquire** the knowledge about various types of Metallic implant materials.	2	5
BBTXX15.3	**Summarize** the types and classification on Ceramics and glasses-bio ceramics.	3	6
BBTXX15.4	**Demonstrate** the Surface properties and modification of surface properties.	5	6
BBTXX15.5	**Comprehend** the principles of biocompatibility, interactions between biomaterials and biological systems	5	6

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Third Year B.Tech (Sixth Semester)				
BBTXX16: OE: Food and Nutrition Technology				
Teaching Scheme			**Examination Scheme**	
Lectures	3 Hr / 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:	
1.	To understand the microorganisms associated with food, their growth factors, and spoilage mechanisms.
2.	To learn principles and techniques of food preservation emphasizing inactivation, inhibition, and recontamination prevention.
3.	To explore the production processes of commercially important organic acids and understand their significance in food technology.

Course Contents	
Unit I	**Food Microbiology:** Micro-organisms associated with food, factors affecting growth of micro-organisms in food, food spoilage. Enzymatic and nonenzymatic changes in food spoilage.
Unit II	**Food Preservation Techniques:** Principles of different modes of food preservation; Preservation methods with emphasis on inactivation, inhibition, and avoiding recontamination.
Unit III	**Production of Primary and Secondary Metabolites:** The process of production of some commercially important organic acids: citric acid, lactic acid, acidic acid, gluconic acid, amino acids and alcohol.
Unit IV	**Food composition and nutrients present in foods:** Nutrition terminologies, Food pyramid, energy value of food, factors affecting and calorie needs for Basal Metabolic Energy, physical activity and diet induced thermogenesis; energy imbalance and body weight regulation.
Unit V	**Human Nutrition:** Role of carbohydrate, lipids and protein in human nutrition. Digestion and absorption of nutrients in human body, Fortification: chemical & biofortification.

Text Books	
T.1	Fundamental Food Microbiology (3rd Edition) – by Bibek Ray. CRC Press: ISBN - 0-8493-1610-3

T.2	Toledo, R.T. Fundamentals of Food Process Engineering, Chapman and Hall; 2000
Reference Books	
R.1	Shakuntala, N., & Many, O. Food: Facts and Principles, New Age International; 2001.
R.2	Food, Nutrition and Diet Therapy by Krause and Mahan 1996, Publisher- W.B.Saund

Useful Links	
1	https://nptel.ac.in/courses/103107088
2	https://nptel.ac.in/courses/126105013
3	https://nptel.ac.in/courses/126105027

Course Outcomes		**CL**	**Hours**
BBTXX16.1	**Discuss** the fundamentals of microbes associated with food and factors responsible for food spoilage.	2	7
BBTXX16.2	**Analyse** the different methods in food preservation technology	3	8
BBTXX16.3	**Explain** process of production of industrially important microbial metabolites.	2	7
BBTXX16.4	**Analyse** the effects of food in various factors like BMR and physical activity.	3	7
BBTXX16.5	**Summarize** the role of different food components in the human nutrition	5	8

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Third Year B.Tech (Sixth Semester)				
BAU3606: Social Awareness				
Teaching Scheme			**Examination Scheme**	
Lectures	2 Hr / Week		**ESE**	-
Tutorial	-		**CIE**	-
Practical	-		**Total**	-
Theory Credits: Audit			**Duration of Exam:** -	
Course Activity:				
1.	Social awareness (Artisans-relates to engg., visit to hospitals, orphanages, police station, courts, trauma centers, consumer forums)			
2.	Social Service (teach in neighborhood, adopt an underprivileged school, village stay / visit (NSS), cleanliness drive, and skill transfer)			

Course Contents

Human beings live in relationship with their family members and with others in the society. As a society, mankind strives to achieve ordered and organized life through which an environment of cooperation and coexistence is expected. A healthy society creating an environment of fearlessness is a key for the mankind to achieve higher goals because it is society which makes us most human, most complete as people.

Although as a society, our expectation is fearlessness, but due to lack of understanding of our role in a society, we fail to fulfill the expectation. The social awareness activity shall promote an understanding and sharing of issues of societal problem through exposure to variety of artisans and different kind of organizations. It is expected that this exposure will enable the learners to appreciate social issues, problems and challenges.

Each institution will offer a range of introductory activity based courses focusing on local artisans related to engineering so that students are sensitized to appreciate their problems and can take up some of the problems to solve while they do their regular studies. This course shall also include visits to visit to hospitals, orphanages, police station, courts, trauma centers, consumer forums so that they get exposed to different facets of societal problems. Care should be taken to give adequate representation to local and regional organizations and artisans. For example, Banaras has local traditions in Banarasi Saari, Toy making, etc and has almost all types of organizations. An institution in Banaras area can offer courses on these artisans. This will, in turn, also ensure wider community involvement/interaction with the institution. At the end of the course/semester, a student should be able to identify a social issue, prepare project report and give presentation on the selected issues. Contact hours per week should be 3-4 hours. Towards the end of the course, the institution can organize an exhibition in which all the students publicly demonstrate findings of their reports and their future plan of actions.

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