Vel Tech
Rangarajan Dr. Sagunthala
R&D Institute of Science and Technology
(Deemed to be University Estd. u/s 3 of UGC Act, 1956)

NAAC A++

Recognised as CATEGORY-1 DEEMED TO BE UNIVERSITY by the UGC University Grants Commission

SCHOOL OF ELECTRICAL AND COMMUNICATION

DEPARTMENT OF BIOTECHNOLOGY

CURRICULUM AND SYLLABI

VTR UGE Regulation 2021

VISION & MISSION OF THE INSTITUTE

Vision:

- To create, translate and disseminate frontiers of knowledge embedded with creativity and Innovation for a positive transformation of emerging society.

Mission:

To nurture excellence in teaching, learning, creativity and research; translate knowledge into practice; foster multidisciplinary research across science, medicine, engineering, technology and humanities; incubate entrepreneurship; instill integrity and honor; inculcate scholarly leadership towards global competence and growth beyond self in a serene, inclusive and free academic environment.

VISION & MISSION OF THE DEPARTMENT

Vision

- To adopt viable strategies to address global socioeconomic challenges in Biotechnology.

Mission

M1: To educate and nurture socially responsible Biotechnologists who can tackle global challenges.
M2: To build vital state-of-the-art research facilities that impart core skills to student and faculty.
M3: To Promote Entrepreneurship and startups.
M4: To collaborate with world class organizations to enhance the knowledge in Industrial and Research activities.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

1. Have a strong foundation in Biotechnology in order to gain competence towards active Research and Industrial career opportunities.
2. Have a thorough practical and problem-solving skills towards sustainable developmental goals.
3. Have confidence in technical communication skills with an extensive knowledge on sustained career advancement.

PROGRAM OUTCOMES (POs)

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 solution**s: 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 IT tools including prediction and modeling 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. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

1. Apply knowledge and analytical abilities in Biotechnology to solve the real world problems.
2. Develop and implement biotechnology and allied biological sciences to meet the industrial demands and social needs.
3. Impart sustainable practices in environmental and biosafety principles.

VTR UGE REGULATION 2021
SCHOOL OF ELECTRICAL AND COMMUNICATION
DEPARTMENT OF BIOTECHNOLOGY
LIST OF COURSES

B. Tech - BIOTECHNOLOGY

PROGRAM CORE COURSES						
		Course Name	L	T	P	C
	Course Code	BASIC SCIENCES				
1	10211BT101	Microbiology	3	0	0	3
2	10211BT102	Cell Biology	3	0	0	3
3	10211BT115	Analytical and Instrumentation Engineering	3	0	0	3
4	10211BT301	Microbiology Lab	0	0	2	1
5	10211BT302	Biochemistry Lab	0	0	2	1
6	10211BT303	Cell Biology Lab	0	0	2	1
7	10211BT118	Biochemistry	3	0	0	3
GENETIC ENGINEERING / MOLECULAR BIOLOGY						
8	10211BT104	Molecular Biology:Concepts and Techniques	3	0	0	3
9	10211BT105	Genetic Engineering	3	0	0	3
10	10211BT304	Molecular Biology & Genetic Engineering Lab	0	0	2	1
CHEMICAL ENGINEERING						
11	10211BT106	Chemical Reaction Engineering	3	0	0	3
12	10211BT107	Mass Transfer Operations in Biotechnology	3	0	0	3
13	10211BT108	Principles of Chemical Engineering	3	1	0	4
14	10211BT112	Unit Operations in Biotech Industry	3	0	0	3
INDUSTRIAL BIOTECHNOLOGY						
15	10211BT110	Bioprocess Engineering	3	0	0	3
16	10211BT111	Downstream Processing	3	0	0	3
17	10211BT113	Metabolic Engineering	3	0	0	3
18	10211BT114	Green Biotechnology & Pollution Abatement	2	0	0	2
19	10211BT117	Plant and Animal Biotechnology	3	0	0	3
20	10211BT305	Bioprocess Engineering Lab	0	0	2	1
21	10211BT306	Downstream Processing Lab	0	0	2	1
PHARMACEUTICAL & MEDICAL BIOTECHNOLOGY						
22	10211BT202	Bioinformatics	2	0	2	3
23	10211BT116	Immunology and Immunotechnology	3	0	0	3
24	10211BT307	Immunology Lab	0	0	2	1
		TOTAL				58

PROGRAM ELECTIVE COURSES						
INDUSTRIAL DOMAIN						
1	10212BT101	Fluid Mechanics and Transport phenomena	3	0	0	3
2	10212BT102	Bioenergy	3	0	0	3
3	10212BT103	Food Processing Technology	3	0	0	3
4	10212BT104	Agricultural Biotechnology	3	0	0	3
5	10212BT105	Algal Biotechnology	3	0	0	3
6	10212BT106	Nanobiotechnology and application	3	0	0	3
7	10212BT107	Fermentation Technology	3	0	0	3
8	10212BT108	Protein Engineering	3	0	0	3
9	10212BT109	Process Instrumentation and dynamic control	3	0	0	3

10	10212BT110	Bioreactor design and Instrumentation control	3	0	0	3
11	10212BT111	Valorisation	3	0	0	3
12	10212BT112	Environmental Biotechnology	3	0	0	3
13	10212BT113	Enzyme technology and Biotransformation	3	0	0	3
14	10212BT114	Synthetic Biology	3	0	0	3
MEDICAL DOMAIN						
15	10212BT115	Cancer Biology	3	0	0	3
16	10212BT116	Molecular Pathogenesis	3	0	0	3
17	10212BT117	Biopharmaceutical Technology	3	0	0	3
18	10212BT118	Stem cell Technology	3	0	0	3
19	10212BT119	Biosensor and Instrumentation	3	0	0	3
20	10212BT120	Biomaterials	3	0	0	3
21	10212BT121	Biochips and Microarray technologies	3	0	0	3
22	10212BT122	Plant Biotechnology	3	0	0	3
23	10212BT123	Animal Biotechnology	3	0	0	3
24	10212BT124	Tissue Engineering	3	0	0	3
25	10212BT125	Herbal and Phytochemical Engineering	3	0	0	3
26	10212BT126	Medical Genomics and Proteomics	3	0	0	3
27	10212BT127	Cellular Engineering	3	0	0	3
28	10212BT128	Bioprinting	3	0	0	3
29	10212BT129	Augmented Reality & Virtual Reality	3	0	0	3
30	10212BT130	Precision Agricultural Biotechnology	3	0	0	3
31	10212BT143	Computational Biology: Techniques and Application	2	0	2	3
32	10212BT144	Advanced Biochemistry	3	0	0	3
FOOD BIOTECHNOLOGY DOMAIN						
33	10212BT131	Principles of Functional Food and Applications	3	0	0	3
34	10212BT132	Nutraceuticals	3	0	0	3
35	10212BT133	Food Preservation and Packaging Technologies	3	0	0	3
36	10212BT134	Marine Biotechnology and Aquaculture	3	0	0	3
37	10212BT135	Food Safety, Quality and Regulation	3	0	0	3
38	10212BT136	Storage Engineering	3	0	0	3
INDEPENDENT LEARNING						
39	10214BT501	Community service project	0	0	2	1
40	10214BT601	Minor Project I	0	0	4	2
41	10214BT602	Minor Project II	0	0	4	2
42	10214BT701	Major Project	0	0	18	9

OPEN ELECTIVE COURSES						
S. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
1	10213BT101	Biochips	3	0	0	3
2	10213BT102	Biosensors	3	0	0	3
3	10213BT103	Biomaterials Engineering	3	0	0	3
4	10213BT104	Bio-Inspired Design: Principles and Practice	3	0	0	3
5	10213BT105	Engineering Advances i1n Food Preservation	3	0	0	3

Specializations:

a. Food and Precision Agriculture

S.No	Course Code	Course Name	L	T	P	C
1	10212BT131	Principles of Functional Food and Applications	3	0	0	3
2	10212BT135	Food Safety, Quality and Regulation	3	0	0	3
3	10212BT133	Food Preservation, Packaging Technologies	3	0	0	3
4	10212BT132	Nutraceuticals	3	0	0	3
5	10212BT130	Precision Agricultural Biotechnology	3	0	0	3
6	10212BT104	Agricultural Biotechnology	3	0	0	3

b. Regenerative Medicine, Health Diagnostics and Disease control

S.No	Course Code	Course Name	L	T	P	C
1	10212BT117	Biopharmaceutical Technology	3	0	0	3
2	10212BT125	Herbal and Phytochemical Engineering	3	0	0	3
3	10212BT115	Cancer Biology	3	0	0	3
4	10212BT118	Stem Cell Technology	3	0	0	3
5	10212BT126	Medical Genomics and Proteomics	3	0	0	3
6	10212BT116	Molecular Pathogenesis	3	0	0	3

Minor in Bioprocess control and devices

S.No	Course Code	Course Name	L	T	P	C
1	10213BT107	Bioprocess Control components	3	0	0	3
2	10213BT108	Advanced Analytical and Instrumentation bioprocess applications	3	0	0	3
3	10213BT109	Biosensors	3	0	0	3
4	10213BT110	Biochips	3	0	0	3
5	10213BT111	Biomaterials	3	0	0	3
6	10213BT112	Computational applications in Bioprocess	3	0	0	3

Honors in Bioengineering

S.No	Course Code	Course Name	L	T	P	C
1	10212BT137	Instrumentation and Process Control	3	0	0	3
2	10212BT138	Biomolecular Modelling	3	0	0	3
3	10212BT139	Biomechanics	3	0	0	3
4	10212BT140	Bionanotechnology	3	0	0	3
5	10212BT141	Biochemical Engineering	3	0	0	3
6	10212BT142	OMICS Technologies	3	0	0	3

PROGRAM CORE COURSES

BASIC SCIENCES

Course Code	Course Title	L	T	P	C
10211BT101	MICROBIOLOGY	3	0	0	3

Course Category	*Program Core*
Preamble	*This course introduces the Biotechnology student to the concepts and techniques used in Microbiology.*
Prerequisite Courses	*NIL*

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

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Understand the concepts of microbiology and the basic methods to identify micro organisms	K2
CO2	Explain the diversity of different micro-organisms with their life cycles	K2
CO3	Identify the appropriate culture techniques for growing different microbial species	K3
CO4	Illustrate and apply the principles of physical and chemical methods to control the growth of micro organisms	K3
CO5	Make use of Microbes on bio- products and bio mineralization	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand the concepts of micro biology and the basic methods to identify micro organisms	H	M	M	M								H	M	M	M
CO2	Explain the diversity of different micro-organisms with their life cycles	H	M	L									H	M	L	L
CO3	Identify the appropriate culture techniques for growing different microbial species	M	M	H	M								H		L	M

CO4	Illustrate and apply the principles of physical and chemical methods to control the growth of micro organisms	H	H	H	M		M		L				H	H	H	H
CO5	Make use of Microbes on bio- products and bio mineralization	M	M	H	M	H	M	H				M	H	H	H	H

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION**	**9 hours**

History of Microbiology, Basics of Microbial existence, Classification, Nomenclature and Identification of microorganisms, Microscopic examination of microorganisms, light and electron microscopy; principles of different staining methods such as Gram staining, acid fast staining, capsular staining, flagellar staining, fungal staining.

UNIT II	**MICROBIAL STRUCTURE AND MULTIPLICATION**	**9 hours**

Colony morphology and arrangement of bacterial cells; Structure and multiplication of bacteria, viruses, algae and fungi. Special mention of life history of Actinomycetes, Yeast, Mycoplasma, Bacteriophage (Lytic, Lysogenic cycle).

UNIT III	**MICROBIAL NUTRITION AND GROWTH**	**9 hours**

Nutritional classification of microorganisms based on carbon, energy and electron sources and different media used for bacterial culture (defined, complex, selective, differential, enriched); Definition of growth, balanced and unbalanced growth, growth curve and different methods to quantify bacterial growth:(counting chamber, viable count method, counting without equipment), pure culture techniques (spread plate, streak plate) and preservation methods.

UNIT IV	**CONTROL OF MICROORGANISMS**	**9 hours**

Host-microbe interactions, clinically important microorganisms; Methods of Sterilization and Disinfection – Physical and chemical control of microorganisms; anti-bacterial, anti-fungal and anti-viral agents, mode of action of antibiotics and its resistance.

UNIT V	**INDUSTRIAL AND ENVIRONMENTAL MICROBIOLOGY**	**9 hours**

Introduction to Industrial Microbiology - primary and secondary metabolites their applications, industrial use of microbes (production of penicillin, alcohol &vitamin B12; Microbial ecology, Microbial leaching of mineral ores, Biogas, Biofertilizers, Biopesticides and Bioremediation.

LEARNING RESOURCES	
Text Books	1. Pelczar M.J., "Microbiology", 5th Edition, Tata McGraw-Hill, 2001. 2. Prescott L.M., Harley J.P.and Klein D.A., "Microbiology", 4th Edition, Wm. Brown Publishers, 2010. 3. Ananthanarayanan R and Jayaram PanikerC.K., "Textbook Microbiology",10th Edition, Orient Longman, 2017. 4. Talaron K., Talaron A., Casita, Pelczar and Reid, "Foundations Microbiology", W.C. Brown Publishers, 1993.
Reference Books	1. Casida L.E., "Industrial Microbiology", New Age International, 1968. 2. Schlegel H.G., "General Microbiology", 7th Edition, Cambridge University Press, 1993. 3. Tortora J., Funke R. and Case L, "Microbiology an Introduction", 3rd Edition, Benjamin/Cummings publishing, 1989.
Reference videos	https://www.youtube.com/watch?v=cQuX8tfwlYA https://www.youtube.com/watch?v=gVf9D-fcbU4 https://www.youtube.com/watch?v=8AhDxAQaDOA https://www.youtube.com/watch?v=9sLN1tGRvyc https://www.youtube.com/watch?v=jQGXGWBmVsA
Reference NPTEL	https://nptel.ac.in/courses/102103015
Reference research/ review articles	1. Badar, R. A., Carmona, J. L., Collantes, J. G., Lojo, D. R., Ocampo, S. M., Ursua, R. L., & Bercede, D. H. (2022). Staining capability of plant extracts for the identification of gram-positive and gram-negative bacteria: A systematic review. Asian Journal of Biological and Life Sciences, 11(2), 277. 2. Kamiński, B., & Paczesny, J. (2024). Bacteriophage Challenges in Industrial Processes: A Historical Unveiling and Future Outlook. Pathogens, 13(2), 152. 3. Figueroa-Bossi, N., Balbontín, R., & Bossi, L. (2022). Basic bacteriological routines. Cold Spring Harbor Protocols, 2022(10), pdb-prot107849. 4. Mancuso, G., Midiri, A., Gerace, E., & Biondo, C. (2021). Bacterial antibiotic resistance: The most critical pathogens. Pathogens, 10(10), 1310. 5. De Simeis, D., & Serra, S. (2021). Actinomycetes: A never-ending source of bioactive compounds - An overview on antibiotics production. Antibiotics, 10(5), 483.

Course Code	Course Title	L	T	P	C
10211BT102	CELL BIOLOGY	3	0	0	3

Course Category	*Program Core*
Preamble	*This course enables comprehension of cellular structure and their interactions.*
Prerequisite Courses	10210BM101 – Biology for engineerings

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Understand basics of cell structure and organelle function	K2
CO2	Demonstrate the cellular transport mechanisms, signaling models and its functions	K2
CO3	Illustrate the significant of different hormones and its signaling models.	K2
CO4	Make use of signal transduction pathways in cells and their receptor kinase.	K3
CO5	Apply the cell culturing methods to maintain the cell lines for specific metabolite production.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand basics of cell structure and organelle function	H	H										H	M		
CO2	Demonstrate the cellular transport mechanisms in and out of the cell	H	H										H	M		
CO3	Illustrate the significant of receptors and its signaling models.	H	H										H	M		
CO4	Make use of signal transduction pathways in cells and their receptor kinase	H	H		H	H							H	H	H	

CO5	Apply the cell culturing methods to maintain the cell lines for specific metabolite production.	H	H		H	H							H	H	H	M

H – High; M- Medium; L- Low

Course Content:

UNIT I	**CELL STRUCTURE AND FUNCTION OF THE ORGANELLES**	**9 hours**

Structure of Prokaryotic and Eukaryotic cells and brief on their organelles, principles of membrane organization, membrane proteins, extra cellular matrix, cytoskeleton structures, cell junction and cell adhesions, types of cell division, mitosis & meiosis, cell cycle and molecules that control cell cycle.

UNIT II	**TRANSPORT ACROSS BIO MEMBRANES**	**9 hours**

Osmosis and reverse osmosis, Passive & active transport, permeases, sodium potassium pump,Ca2+ ATPase pumps, voltage and ligand gated channels, lysosomal and vacuolar membrane ATP dependent proton pumps, Principles of Patch-Clamp experiment to study ion-channels activity; Co- transport - symport, antiport, Transport vesicles involved in Endocytosis and exocytosis. Entry of virus and toxins into cells.

UNIT III	**RECEPTORS AND MODES OF CELL SIGNALLING**	**9 hours**

Cytosolic, nuclear and membrane bound receptors with examples, autocrine, paracrine and endocrine modes of action, quantification and characterization of receptors.

UNIT IV	**SIGNAL TRANSDUCTION**	**9 hours**

Signal amplification, role of secondary messengers- cyclic AMP, inositol tri phosphates and cyclic GMP; G proteins - role in signal transduction, calcium ion flux and its role in cell signaling, role of protein kinases - serine – threonine kinases, tumor necrosis factor receptor families.

UNIT V	**BASICS OF CELL CULTURE**	**9 hours**

Cell line, generation of cell lines, maintenance of stock cells, characterization of cells,morphological analysis techniques in cell culture, primary cultures, contamination, differentiation, three dimensional cultures, role of matrix in cell growth; Cell viability studies: using tetrazolium salts, LDH release, Tryphan blue exclusion, etc.

LEARNING RESOURCES

Text Books	1. Darnell J, Lodish H, Baltimore D, "Molecular Cell Biology", W.H.Freeman; 8th Edition,2016.

	2. Cooper G.M. and Hansman R.E., "The Cell: A Molecular Approach", 4th Edition, ASM Press, 2007. 3. Alberts Bruce *et al*., "Molecular Biology of the Cell", 4th Edition, Garland Science (Taylors Francis), 2002. 4. Sadava, D.E. "Cell Biology: Organelle Structure and Funtion", PanimaPublishing, 2004. 5. Rastogi, S.C. "Cell Biology" 2nd Edition, New Age International, 2002.
Reference Books	1. Becker W.M. *et al*., "The World of the Cell", Vth Edition, Pearson Education, 2003. 2. Campbell N.A., ReceeJ.B. and Simon E.J., "Essential Biology", IIIrd Edition, Pearson International, 2007. 3. Alberts Bruce *et al*., "Essential Cell Biology", IInd Edition, Garland Press (Taylor & Francis), 2004.
Reference videos	https://www.youtube.com/watch?v=RQ-SMCmWB1s https://www.youtube.com/watch?v=uIut0oVWCEg https://www.youtube.com/watch?v=vjFes5I07c0 https://www.youtube.com/watch?v=J7LGmFgW44c https://www.youtube.com/watch?v=RpDke-Sadzo
Reference NPTEL	https://archive.nptel.ac.in/courses/102/103/102103012/
Reference research/ review articles	1. Oh, M. H., Honey, S. H., & Tax, F. E. (2020). The control of cell expansion, cell division, and vascular development by brassinosteroids: a historical perspective. International Journal of Molecular Sciences, 21(5), 1743. 2. McGivern, J. G., & Ding, M. (2020). Ion channels and relevant drug screening approaches. SLAS DISCOVERY: Advancing the Science of Drug Discovery, 25(5), 413-419. 3. Zhao, Y. G., & Zhang, H. (2020). Phase separation in membrane biology: the interplay between membrane-bound organelles and membraneless condensates. Developmental Cell, 55(1), 30-44. 4. Kanneganti, T. D. (2020). Intracellular innate immune receptors: Life inside the cell. Immunological reviews, 297(1), 5. 5. Deng, B., Zhao, Z., Kong, W., Han, C., Shen, X., & Zhou, C. (2022). Biological role of matrix stiffness in tumor growth and treatment. Journal of translational medicine, 20(1), 540.

Course Code	Course Title	L	T	P	C
10211BT115	ANALYTICAL AND INSTRUMENTATION ENGINEERING	3	0	0	3

Course Category	*Program Core*
Preamble	*To study various analytical techniques and instrumentation involved in identifying the physical and chemical makeup or characteristics of a particular sample.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Comprehend the basic principles of general instrumentation and application	K2
CO2	Illustrate and interpret the molecular structural of biomolecules using molecular spectrometry	K2
CO3	Illustrate and interpret the structural properties using magnetic resonance spectroscopy and mass spectrometry	K2
CO4	Demonstrate the basic science and working principles of different chromatographic techniques (Normal phase and Reverse phase).	K2
CO5	Comprehend the basic principles and applications of electrophoresis method	K2

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Comprehend the basic principles of general instrumentation and application	H	M		M									H		
CO2	Illustrate and interpret the molecular structural of biomolecules using molecular spectrometry	H	H		M	H							H	H		L
CO3	Illustrate and interpret the structural properties using magnetic resonance spectroscopy and mass spectrometry	H	M	M	H	L							M	M	M	

CO4	Demonstrate the basic science and working principles of different chromatographic techniques (Normal phase and Reverse phase).	H	H	H	H	H	H	H					H	M	M	L
CO5	Comprehend the basic principles and applications of electro phoresis method	H	H		H	H	L	L					M	M	M	

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO SPECTROMETRY**	**9 hours**

Properties of electromagnetic radiation–wave properties–components of optical instruments– Sources of radiation wavelength selectors–sample containers – radiation transducers- Signal process and read outs – signal to noise ratio – sources of noise, Enhancement of signal to noise- types of optical instruments – Principle of Fourier Transform optical Measurements.

UNIT II	**MOLECULAR SPECTROSCOPY**	**9 hours**

Molecular absorption spectrometry – Measurement of Transmittance and Absorbance–Beer-lambert's law – Instrumentation –Applications ¬¬–Theory of fluorescence and Phosphorescence – Instrumentation – Applications – Theory of Infrared absorption spectrometry – IR instrumentation – Applications – Theory of Raman spectroscopy – Instrumentation – applications.

UNIT III	**MAGNETIC RESONANCE SPECTROSCOPY AND MASS SPECTROMETRY**	**9 hours**

Theory of NMR – environmental effects on NMR spectra – chemical shift- NMR spectrometers. Molecular mass spectra – Ion sources – Mass spectrometer – Electron paramagnetic resonance –g values – Types of Mass spectrometer- instrumentation and applications.

UNIT IV	**CHROMATOGRAPHY**	**9 hours**

General description of chromatography – Band broadening and optimization of column performance - Principles of TLC and Column chromatography –Partition chromatography – Adsorption chromatography – Ion exchange chromatography -size exclusion chromatography- Affinity chromatography- GC and HPLC.

UNIT V	**ELECTROPHORESIS**	**9 hours**

General principle of electrophoresis, support media (agarose and polyacrylamide gels), electrophoresis of proteins by SDS-PAGE, native PAGE, gradient gels, isoelectric focusing,

two dimensional PAGE, electrophoresis of nucleic acids using agarose gel, capillary electrophoresis.	
LEARNING RESOURCES	
Text Books	1. Skoog D.A. F., James Holler and StankyR.Crouch, "Instrumental Methods of Analysis", Cengage Learning, 2007. 2. Willard Hobart, et al., "Instrumental Methods of Analysis", 7th Edition, CBS, 1986. 3. Braun, Robert D, "Introduction to Instrumental Analysis", Pharma Book Syndicate, 1987. 4. Ewing G.W., "Instrumental Methods of Chemical Analysis", 5th Edition, McGraw- Hill, 1985.
Reference Books	1. Sharma B.K., "Instrumental Methods of Chemical Analysis: Analytical Chemistry", Goel Publishing House, 1972. 2. Haven Mary C., et.al., "Laboratory Instrumentation", 4thEdition, John Wiley, 1995.
Reference videos	https://youtu.be/spUNpyF58BY https://youtu.be/OiukFtC8E04 https://youtu.be/cJ9vweOnvbg https://youtu.be/8Q0VfIbhEmM https://youtu.be/dII05-g3LXY
Reference NPTEL	https://nptel.ac.in/courses/103108100
Reference research/ review articles	1. Hemath, M., Mavinkere Rangappa, S., Kushvaha, V., Dhakal, H. N., & Siengchin, S. (2020). A comprehensive review on mechanical, electromagnetic radiation shielding, and thermal conductivity of fibers/inorganic fillers reinforced hybrid polymer composites. Polymer Composites, 41(10), 3940-3965. 2. Pérez-Jiménez, A. I., Lyu, D., Lu, Z., Liu, G., & Ren, B. (2020). Surface-enhanced Raman spectroscopy: benefits, trade-offs and future developments. Chemical science, 11(18), 4563-4577. 3. Züllig, T., & Köfeler, H. C. (2021). High resolution mass spectrometry in lipidomics. Mass spectrometry reviews, 40(3), 162-176. 4. Murisier, A., Duivelshof, B. L., Fekete, S., Bourquin, J., Schmudlach, A., Lauber, M. A., ... & D'Atri, V. (2021). Towards a simple on-line coupling of ion exchange chromatography and native mass spectrometry for the detailed characterization of monoclonal antibodies. Journal of Chromatography A, 1655, 462499. 5. Dao, T. T., Truong, D. D., Duong, L. N., Nguyen, N. N., & Nguyen, H. D. (2023). Preparation of Bacillus subtilis cell samples and generation of an SDS-PAGE. BioTechniques, 74(3), 123-129.

Course Code	Course Title	L	T	P	C
10211BT301	MICROBIOLOGY LABORATORY	0	0	2	1

Course Category	*Program Core*
Preamble	*To learn and understand the principles behind the qualitative and quantitative estimation of biomolecules.*
Prerequisite Courses	*NIL*

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

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Demonstrate the safety regulations followed in the laboratory, handling of equipment and sterilization techniques.	K2, S3
CO2	Demonstrate the types of nutrient broth medium and identify techniques used for isolation and preservation of microorganisms.	K3, S3
CO3	Illustrate the working principles of microscopy and distinguish the morphology and type of microbes.	K4, S3
CO4	Examine the effect of disinfectants and antimicrobial activity.	K4, S4
CO5	Estimate the specific growth rate of bacterial species in various physiochemical conditions.	K5, S4

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Demonstrate the safety regulations followed in the laboratory, handling of equipment and sterilization techniques.	H	L	M	L	H	H	M	H	M	M	-	M	H	H	H
CO2	Demonstrate the types of nutrient broth medium and identify techniques used for isolation and preservation of microorganisms.	M	M	H	L	M	M	M	L	M	M	-	M	H	H	H

CO3	Illustrate the working principles of micro scopy and distinguish the morphology and type of microbes.	H	M	M	M	H	M	L	M	M	H	-	M	M	M	M
CO4	Examine the effect of disinfectants and antimicrobial activity.	M	H	M	H	H	M	H	M	M	H	-	M	M	H	M
CO5	Estimate the specific growth rate of bacterial species in various physiochemical conditions.	H	H	H	H	M	M	M	L	M	M	-	M	M	H	H

H – High; M- Medium; L- Low

LIST OF EXPERIMENTS:

1. Laboratory safety and sterilization techniques.
2. Culture Media-Types and Use; Preparation of Nutrient broth and agar
3. Culture Techniques, Isolation and Preservation of Cultures- Broth: flask, test tubes; Solid: Pour plates, streak plates, slants, stabs.
4. Quantification of Microbes: Sampling and Serial Dilution; Bacterial count in Soil – TVC.
5. Staining techniques – Simple and Gram's staining.
6. Effect of Disinfectants- Phenol Coefficient.
7. Antibiotic Sensitivity Assay.
8. Growth Curve in Bacteria and Yeast.
9. Effect of pH, Temperature, UV radiation on Growth Bacteria.
10. Biochemical test for identification of *E.coli*, *Bacillus*.

LEARNING RESOURCES

Reference Books	1. Cappuccino J.G. and Sherman N., "Microbiology: A Laboratory Manual", 4th Edition, Addison-Wesley, 1999. 2. Collee J.G.,*et al*, "Mackie & McCartney Practical Medical Microbiology" 4th Edition,Churchill Livingstone, 1996.
Virtual Lab	https://bio.libretexts.org/Courses/North_Carolina_State_University/MB352_General_Microbiology_Laboratory_2021_(Lee)/01%3A_Laboratory_Safety/1.01%3A_Safety_Procedures_for_the_Microbiology_Laboratory https://bio.libretexts.org/Courses/North_Carolina_State_University/MB352_General_Microbiology_Laboratory_2021_(Lee)/02%3A_Cultivation_of_Microbes/2.04%3A_Lab_Procedures-__Prepare_solid_media_Aseptic_Technique_T-streaking https://vlab.amrita.edu/?sub=3&brch=73~=213&cnt=2 https://bio.libretexts.org/Courses/North_Carolina_State_University/MB352_General_Microbiology_Laboratory_2021_(Lee)/05%3A_Enumeration_of_Bacteria/5.03%3A_Lab_Procedures-_Viable_Plate_count

	https://bio.libretexts.org/Learning_Objects/Laboratory_Experiments/Microbiology_Labs/Book%3A_General_Microbiology_Lab_Manual_(Pakpour_and_Horgan)/Lab_03%3A_Simple_Negat ive_and_Gram_Stain https://bio.libretexts.org/Bookshelves/Microbiology/Microbiology_(OpenStax)/13%3A_Control_of_Microbial_Growth/13.04%3A_Testing_the_Effectiveness_of_Antiseptics_and_Disinfectants https://medlineplus.gov/lab-tests/antibiotic-sensitivity-test/ https://bio.libretexts.org/Bookshelves/Microbiology/Microbiology_(Bruslind)/09%3A_Microbial_ Growth https://bio.libretexts.org/Courses/Manchester_Community_College_(MCC)/Remix_of_Openstax %3AMicrobiology_by_Parker_Schneegurt_et_al/08%3A_Microbial_Growth/8.03%3A_The_Eff ects_of_pH_on_Microbial_Growth https://bio.libretexts.org/Courses/North_Carolina_State_University/MB352_General_Microbiology_Laboratory_2021_(Lee)/07%3A_Microbial_Metabolism/7.01%3A_Introduction_to_Biochemi cal_Tests_Part_

Course Code	Course Title	L	T	P	C
10211BT302	BIOCHEMISTRY LABORATORY	0	0	2	1

Course Category	*Program Core*
Preamble	*To learn and understand the principles behind the qualitative and quantitative estimation of biomolecules.*
Prerequisite Courses	*10210CH102 – Biochemistry*

Course Outcomes	***Upon successful completion of the course, students will be able to:***	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Comprehend the protocol for preparation of weak buffers.	K2, S3
CO2	Illustrate the concentration of carbohydrates and amino acids by qualitative and quantitative method	K2, S3
CO3	Analyse protein concentration in aqueous solution by using spectroscopic methods.	K4, S4
CO4	Analyse and identify the biomolecules using chromatographic methods.	K4, S4
CO5	Evaluate the activity of enzymes for different substrates	K5, S5

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Comprehend the protocol for preparation of weak buffers.	H	M	M	M	H	-	-	H	M	M	-	M	H	M	M
CO2	Illustrate the concentration of carbo hydrates and amino acids by qualitative and quantitative method	M	H	H	M	H	M	-	M	M	H	-	M	M	H	H
CO3	Analyse protein concentration in aqueous solution by using spectroscopic methods.	H	H	M	H	H	M	-	M	M	H	-	M	H	H	M
CO4	Analyse and identify the biomolecules using chromatographic methods.	H	H	M	H	H	M	-	M	M	H	-	M	H	H	M

CO5	Evaluate the activity of enzymes for different substrates	M	H	M	H	H	M	M	H	M	M	-	M	M	H	M

H – High; M- Medium; L- Low

Course Content:

LIST OF EXPERIMENTS:

1. pH measurements and buffer preparation.
2. Qualitative tests for carbohydrates – distinguishing reducing from non-reducing sugars and keto from aldo sugars.
3. Quantitative method for amino acid estimation using ninhydrin – distinguishing amino from imino acid.
4. Quantification of sugars (Anthrone method).
5. Protein estimation by Biuret and Lowry's methods.
6. Estimation of Lipids by Zak's method.
7. Determination of saponification number of lipids.
8. Separation of amino acids – Thin layer chromatography.
9. Quantification of nucleic acids using spectrophotometer.
10. Estimate enzyme activity of alpha-amylase.

LEARNING RESOURCES

Text Books	
Reference Books	1. Gupta R.C., and Bhargavan S., "Practical Biochemistry", 5th Edition, CBS Publishers and Distributors Pvt., Ltd., 2013. 2. David T. Plummer., "Introduction of Practical Biochemistry", 2nd Edition, Mc Graw Hill, 1978.
Virtual Lab	https://chem.libretexts.org/Ancillary_Materials/Laboratory_Experiments/Wet_Lab_Experiments/General_Chemistry_Labs/Online_Chemistry_Lab_Manual/Chem_12_Experiments/05%3A_pH_Measurement_and_Its_Applications_(Experiment) https://biotech01.vlabs.ac.in/exp/analysis-of-carbohydrates/pretest.html https://vlab.amrita.edu/?sub=3&brch=63&sim=156&cnt=1 https://www.studocu.com/in/document/k-l-deemed-to-be-university/biology/5-quantitative-analysis-of-carbohydrates-by-anthrone-method/75541219 https://vlab.amrita.edu/?sub=3&brch=64&sim=1087&cnt=1 https://biotech01.vlabs.ac.in/exp/saponification-value-fats-oils/theory.html https://biotech01.vlabs.ac.in/exp/saponification-value-fats-oils/procedure.html https://vlab.amrita.edu/?sub=3&brch=63&sim=154&cnt=1 https://biomodel.uah.es/en/lab/ https://vlab.amrita.edu/?sub=3&brch=64&sim=1342&cnt=1

Course Code	Course Title	L	T	P	C
10211BT303	CELL BIOLOGY LABORATORY	0	0	2	1

Course Category	*Program Core*
Preamble	*To understand and practice the different techniques used in Cell Biology.*
Prerequisite Courses	*NIL*

Course Outcomes — *Upon successful completion of the course, students will be able to:*

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Demonstrate the safety regulations followed in the laboratory, handling of equipment and sterilization techniques.	K2, S3
CO2	Illustrate the working principles of phase contrast and fluorescent microscopy to identify the cellular components.	K2, S3
CO3	Make use of staining methods to analyses the plant cells and blood cells	K2, S4
CO4	Identify and distinguish cellular components and biomolecules by separation process	K3, S4
CO5	Analyse and evaluate the number of live cells and dead cells in bacterial sample	K3, S5

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Demonstrate the safety regulations followed in the laboratory, handling of equipment and sterilization techniques.	M	L	-	-	H	H	M	H	M	M	L	H	H	HL	-
CO2	Illustrate the working principles of phase contrast and fluorescent microscopy to identify the cellular components.	H	H	M	M	H	M	-	M	M	H	-	M	H	H	M
CO3	Make use of staining methods to analyses the plant cells and blood cells	M	H	M	M	H	M	-	M	M	H	-	M	M	H	M

CO4	Identify and distinguish cellular components and biomolecules by separation process	H	H	M	H	H	M	M	H	M	M	-	M	H	H	M
CO5	Analyse and evaluate the number of live cells and dead cells in bacterial sample	H	H	M	M	H	M	M	H	M	M	-	M	H	H	M

H – High; M- Medium; L- Low

Course Content:

LIST OF EXPERIMENTS:

1. Principles of microscopy, phase contrast and fluorescent microscopy.
2. Identification of given plant, animal and bacterial cells and theirs components bymicroscopy.
3. Identification of cells in a blood smear using Leishman stain.
4. Giemsa staining.
5. Haemotoxylin Eosin Staining.
6. Osmosis and Tonicity.
7. Tryphan Blue Assay
8. Separation and identification of peripheral Blood mononuclear cells from blood.
9. Isolation of chloroplasts from spinach leaves
10. Staining for different stages of mitosis in *Allium cepa* (Onion).

LEARNING RESOURCES

Reference Books	1. Rickwood D. and Harris J.R., "Cell Biology: Essential Techniques", John Wiley, 1996
Virtual Lab	https://openstax.org/books/microbiology/pages/2-3-instruments-of-microscopy https://www.labster.com/simulations/cell-structure https://myhematology.com/red-blood-cells/leishman-stain/ https://www.merckmillipore.com/IN/en/ivd-oem-materials-and-reagents/learning-center/giemsa-solution/r2ab.qB.aBwAAAFOqm81lSAJ,nav https://www.learnsci.com/resources/haematoxylin-eosin-h-e-stain-lab-simulation https://www.studocu.com/en-us/document/anne-arundel-community-college/fundamentals-of-biology-lab/lab-5-virtual-lab-tonicity-in-red-blood-cells/20723329 https://vlab.amrita.edu/?sub=3&brch=188&sim=336&cnt=5 https://www.stemcell.com/cell-separation/isolate-cells-from-blood https://vlab.amrita.edu/?sub=3&brch=187&sim=878&cnt=2 https://www.vlab.andcollege.du.ac.in/bioSc/zoology/mitosis/mitosis.html

Course Code	Course Title	L	T	P	C
10211BT118	BIOCHEMISTRY	3	0	0	3

Course Category	*Program Core*
Preamble	*To understand the chemistry behind the biomolecules and its production pathways.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Identification of metabolic pathways and its thermodynamic principles	K2
CO2	Describe the structure and metabolism of nucleic acids and amino acids	K3
CO3	Outline the different aspects of nucleic acid and lipids metabolism	K3
CO4	Utilize the other biomolecules such as vitamins and coenzymes and its importance.	K3
CO5	Develop drugs for hormone deficiencies related various diseases and disorders.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO2	Identification of metabolic pathways and its thermodynamic principles	M	H		M	M							M	M	L	L
CO3	Describe the structure and metabolism of nucleic acids and amino acids	M	H		M	M							M	M	L	L
CO4	Outline the different aspects of nucleic acid and lipids metabolism	M	H		M	M							M	M	L	L
CO4	Utilize the other biomolecules such as vitamins and coenzymes and its importance.	H	M	M									L	H	M	

CO5	Develop drugs for hormone deficiencies related various diseases and disorders.	M	H	H	M	H		M					M	M	H	L

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO BIOCHEMISTRY**	**9 hours**

Introduction and scope of biochemistry, basic principles of organic chemistry, chemistry of nucleic acids, Introduction to physiological buffers, role of biological buffers, pH, Weak acids and bases, water as universal solvent. Principle of viscosity, surface tension, diffusion, osmosis in biological system

UNIT II	**INTRODUCTION TO BIOMOLECULES**	**9 hours**

Structure, function and properties of carbohydrates - mono, di and polysaccharides - homopolysaccharides (starch and glycogen); heteropolysaccharides, Carbohydrates, Lipids: classification, structure, properties and functions, Amino acids: classification and general properties, Proteins: Primary, Secondary, Tertiary and Quaternary. Nucleic acid: structure of purine and pyrimidine

UNIT III	**METABOLIC PATHWAYS OF CARBOHYDRATES AND FATTY ACIDS**	**9 hours**

Metabolic pathways of Carbohydrates - Glycolysis, Glucogenesis, Glucogenolysis, TCA and ETC; Metabolism of fatty acids, synthesis and degradation of fatty acids.

UNIT IV	**METABOLIC PATHWAYS OF NUCLEIC ACIDS AND LIPIDS**	**9 hours**

Biosynthesis of nucleotides, de novo and salvage pathways for purines and pyrimidines, regulatory mechanisms: Degradation of nucleic acid by exo and endo nucleases. Triacylglycerol and phospholipid biosynthesis and degradation; Cholesterol biosynthesis and regulation and targets and action of cholesterol lowering drugs, statins.

UNIT V	**BIOENERGETICS**	**9 hours**

Bioenergetics - High energy compounds, electronegative potential of compounds, respiratory chain, ATP cycle, calculation of ATP yield during oxidation of glucose and fatty acids.

LEARNING RESOURCES

Text Books	1. Nelson D.L., Cox M.M., & Lehninger A.L., "Principles of Biochemistry", McMillan Learning, New York, USA, 2014 2. Voet D.J., Voet J.G. and Pratt C.W., "Principles of Biochemistry", 3rd Edition, John Wiley & Sons Inc., 2008. 3. Murray R.K., et al., "Harper's Illustrated Biochemistry". XXVIIth Edition, McGraw-Hill, 2006.

Reference Books	1. Berg J.M., Tymoczko, J.L. and Stryer, L., "Biochemistry",6th Edition, WH Freeman, 2006. 2. Salway J.G., "Metabolism at a Glance", 2nd Edition, Blackwell Science Ltd., 2000.
Reference videos	https://youtu.be/SeOrvA9ikW8 https://youtu.be/NIvhyULL3s0 https://youtu.be/WuQS_LpNMzo https://www.youtube.com/watch?v=zpk1p1l97u4 https://www.youtube.com/watch?v=1cxXwoyyOk4
Reference NPTEL	https://onlinecourses.nptel.ac.in/noc24_bt12/preview
Reference research/ review articles	1. Shao, X., Fredericks, S. A., Saylor, J. R., & Bostwick, J. B. (2020). A method for determining surface tension, viscosity, and elasticity of gels via ultrasonic levitation of gel drops. The Journal of the Acoustical Society of America, 147(4), 2488-2498. 2. Van Eker, D., Samanta, S. K., & Davis, A. P. (2020). Aqueous recognition of purine and pyrimidine bases by an anthracene-based macrocyclic receptor. Chemical Communications, 56(65), 9268-9271. 3. Paredes-Flores, M. A., Rahimi, N., & Mohiuddin, S. S. (2024). Biochemistry, glycogenolysis. In StatPearls [Internet]. StatPearls Publishing. 4. Long, T., Debler, E. W., & Li, X. (2022). Structural enzymology of cholesterol biosynthesis and storage. Current opinion in structural biology, 74, 102369. 5. Seyfried, T. N., Arismendi-Morillo, G., Mukherjee, P., & Chinopoulos, C. (2020). On the origin of ATP synthesis in cancer. Iscience, 23(11).

GENETIC ENGINEERING / MOLECULAR BIOLOGY

Course Code	Course Title	L	T	P	C
10211BT104	MOLECULAR BIOLOGY: CONCEPTS AND TECHNIQUES	3	0	0	3

Course Category	*Program Core*
Preamble	*To have familiarize the student with nucleic acids structure and functions*
Prerequisite Courses	*10211BT102 – Microbiology* *10211BT103 – Cell Biology*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Understand the physiochemical and, structural properties of nucleic acids	K2
CO2	Elucidate the concepts of DNA replication and repair mechanism.	K2
CO3	Demonstrate the role of promoters and enhancers in prokaryotic and eukaryotic Transcription.	K2
CO4	Illustrate the process of translation and post translational modifictions.	K2
CO5	Explain the key mechanism of gene regulation in prokaryotic and eukaryotic cells.	K2

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand the physio chemical and, structural properties of nucleic acids	H	H										H		M	
CO2	Elucidate the concepts of DNA replication and repair mechanism.	H	H										H		M	
CO3	Demonstrate the role of promoters and enhancers in prokaryotic and eukaryotic Transcription.	H	H	H									H		M	L

CO4	Illustrate the process of translation and post translational modifictions.	H	H										H		M	L
CO5	Explain the key mechanism of gene regulation in prokaryotic and eukaryotic cells.	M	M		H	H							H		H	

H – High; M- Medium; L- Low

Course Content:

UNIT I	**CHEMISTRY OF NUCLEIC ACIDS**	**9 hours**

Introduction to nucleic acids: Nucleic acids as genetic material, Structure and physicochemical properties of elements in DNA and RNA, Biological significance of differences in DNA and RNA. Primary structure of DNA: Chemical and structural qualities of 3', 5'-Phosphodiester bond. Secondary Structure of DNA: Watson & Crick model, Chargaff's rule, X–ray diffraction analysis of DNA, Forms of DNA, Conformational variants of double helical DNA, Hogsteen base pairing, Triple helix, Quadruple helix, Reversible denaturation and hyperchromic effect. Tertiary structure of DNA: DNA supercoiling. Structure and function of mRNA, r-RNA, t-RNA. Secondary structures in RNA.

UNIT II	**DNA REPLICATION**	**9 hours**

Organization of prokaryotic and eukaryotic chromosomes; DNA replication: Meselson & Stahl experiment, bi-directional DNA replication, Okazaki fragments, Proteomics of DNA replication, Fidelity of DNA replication, Inhibitors of DNA replication, Overview of differences in prokaryotic and eukaryotic DNA replication, Telomere replication in eukaryotes; D-loop and rolling circle mode of replication.

UNIT III	**TRANSCRIPTION**	**9 hours**

Characteristics of promoter and enhancer sequences. RNA synthesis: Initiation, elongation and termination of RNA synthesis, Proteins of RNA synthesis, Fidelity of RNA synthesis, Inhibitors of transcription, Differences in prokaryotic and eukaryotic transcription. Basic concepts in RNA world: Ribozymes, RNA processing: 5'-Capping, Splicing-Alternative splicing, Poly 'A' tail addition and base modification.

UNIT IV	**TRANSLATION**	**9 hours**

Introduction to Genetic code: Elucidation of genetic code, Codon degeneracy, Wobble hypothesis and its importance, Prokaryotic and eukaryotic ribosomes. Steps in translation: Initiation, Elongation and termination of protein synthesis; Inhibitors of protein synthesis; Post-translational modifications and its importance.

UNIT V	REGULATION OF GENE EXPRESSION AND DNA REPAIR	9 hours
Regulation of genes – replication- transcription & translation factors; Lac and trp operon; Mutation – transition- transversion- artificial & natural mutation; suppressor mutation; Repair of DNA.		
LEARNING RESOURCES		
Text Books	1. Friefelder David, "Molecular Biology",Narosa Publications, 1999 2. Weaver, Robert F., "Molecular Biology", 2nd Edition, Tata McGraw-Hill, 2003. 3. Friefelder David and George M. Malacinski, "Essentials of Molecular Biology", 2nd Edition, Panima Publishing, 1993.	
Reference Books	1. Tropp Burton E., "Molecular Biology: Genes to Proteins", 3rd Edition, Jones and Bartlett, 2008. 2. Glick B.R. and Pasternak J.J., "Molecular Biotechnology: Principles and Applications of Recombinant DNA", 4th Edition, ASM, 2010.	
Reference videos	https://www.youtube.com/watch?v=GGW4ufsvQWo https://www.youtube.com/watch?v=EO2DBj3D71k https://www.youtube.com/watch?v=JhP3kHVmicw https://www.youtube.com/watch?v=nX18E81nmFs https://www.youtube.com/watch?v=yrJn-7k_5Fc	
Reference NPTEL	https://onlinecourses.nptel.ac.in/noc24_bt07/preview	
Reference research/ review articles	1. Fariselli, P., Taccioli, C., Pagani, L., & Maritan, A. (2021). DNA sequence symmetries from randomness: the origin of the Chargaff's second parity rule. Briefings in bioinformatics, 22(2), 2172-2181. 2. Sánchez, H., McCluskey, K., van Laar, T., van Veen, E., Asscher, F. M., Solano, B., ... & Dekker, N. H. (2021). DNA replication origins retain mobile licensing proteins. Nature communications, 12(1), 1908. 3. Georgakopoulos-Soares, I., Parada, G. E., & Hemberg, M. (2022). Secondary structures in RNA synthesis, splicing and translation. Computational and structural biotechnology journal, 20, 2871-2884. 4. Nieuwkoop, T., Finger-Bou, M., van der Oost, J., & Claassens, N. J. (2020). The ongoing quest to crack the genetic code for protein production. Molecular cell, 80(2), 193-209. 5. Crowther, A., Bergan-Roller, H. E., Galt, N. J., Booth, C. S., Dauer, J. T., & Helikar, T. (2021). Discovering prokaryotic gene regulation with simulations of the trp operon.	

Course Code	Course Title	L	T	P	C
10211BT105	GENETIC ENGINEERING	3	0	0	3

Course Category	*Program Core*
Preamble	*The course is designed to familiarize the student with use of tools and techniques for the manipulation and analysis of genetic material.*
Prerequisite Courses	*10211BT102 – Cell Biology* *10211BT104 – Molecular biology: concepts and techniques*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Select the various manipulating tools used in genetic engineering	K3
CO2	Apply the vectors for cloning and expression of gene of interest	K3
CO3	Make use of cloning methods to construct DNA library for gene mapping	K3
CO4	Elucidate the use of modern tools and techniques to identify the DNA finger printing and sequencing	K3
CO5	Apply the genetic modification and biosafety regulations in the domain of food, medicine and agriculture	K4

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Select the various manipulating tools used in genetic engineering.	H	H										H		M	
CO2	Apply the vectors for cloning and expression of gene of interest.	H	H	H	H	H			H				H	M	H	H
CO3	Make use of cloning methods to construct DNA library for gene mapping.	H	H	H	H			H					M	H	H	
CO4	Elucidate the use of modern tools and techniques to identify the DNA finger printing and sequencing.	H	M	M		H	H	H	H				H	H	L	
CO5	Apply the genetic modification and biosafety regulations in the domain of food, Medicine and agriculture.	H	H	H	H			H	H			H	M	H	H	H

H – High; M- Medium; L- Low

Course Content:		
UNIT I	**BASICS OF GENETIC ENGINEERING**	**9 hours**
Overview of recombinant DNA technology and its applications. Recombinant DNA technology tools - Restriction and Modifying systems: Biological importance, Classification, Nomenclature, Applications in recombinant DNA technology - Cohesive ends, blunt ends, Isoschizomers, Neoschizomers, Star activity, Compatible cohesive ends, DNA polymerase, DNA ligase, Alkaline phosphatase – Inter and intra molecular ligation, Polynucleotide kinase, Terminal transferase and Exonuclease, Linkers and adpators; Safety guideline of recombinant DNA research.		
UNIT II	**CLONING VECTORS**	**9 hours**
Plasmid vector: Cloning site, Selection, Screening, Host range – shuttle vectors, Plasmid compatibility, copy number regulation and TA cloning. Bacteriophage vector: λDNA vectors – Insertional and replacement vectors, in vitro packaging, Size based selection and Spi^{-} selection. Single strand DNA vectors: M13 phage vector and its applications. Combinatorial vectors: Cosmid and Phagemid. Artificial chromosomes: Bacterial and yeast artificial chromosomes.		
UNIT III	**CONSTRUCTION OF LIBRARIES**	**9 hours**
Construction of genomic and cDNA library: Methods, Chromosomal walking, Limitations in cDNA library construction and full-length cDNA library construction; Screening of libraries with DNA probes and antisera; Characterization of recombinant clones by Southern, Northern, Western - PCR analysis.		
UNIT IV	**TECHNIQUES USED IN GENETIC ENGINEERING**	**9 hours**
Polymerase Chain reaction: Principle and Steps in PCR, Types of PCR - Inverse PCR, Nested PCR, AFLP-PCR, Hot start PCR, Colony PCR, Methylation specific PCR and single cell PCR. Real-time PCR/qPCR and its advantages – SYBR green assay, Taqman assay, Molecular beacons. DNA sequencing: Maxam Gilbert's and Sanger's methods of DNA sequencing, Pyrosequencing, Nanopore DNA sequencing, Next generation sequencing.		
UNIT V	**APPLICATIONS OF GENETIC ENGINEERING**	**9 hours**
Site directed mutagenesis: Primer extension method, Kunkel's method and PCR based site-directed mutagenesis. Applications of genetic engineering in medicine, agriculture, creation of knockout animals, transgenic animals; gene silencing and gene therapy.		

LEARNING RESOURCES	
Text Books	1. Old R.W., Primrose S.B., "Principles of Gene Manipulation, An Introduction to Genetic Engineering", Blackwell Science Publications, 1993.
Reference Books	1. Ansubel F.M., Brent R., Kingston R.E., and Moore D.D., "Current Protocols In Molecular Biology", Greene Publishing Associates, NY, 1988. **2.** Berger S.L., Kimmer A.R., "Methods in Enzymology", Vol. 152, Academic Press, 1987.
Reference videos	https://www.youtube.com/watch?v=i48eAyBPi2c https://www.youtube.com/watch?v=S8Z1_JwIRHM https://www.youtube.com/watch?v=a5jmdh9AnS4 https://www.youtube.com/watch?v=ONGdehkB8jU https://www.youtube.com/watch?v=J2Y_S4EkLy8
Reference NPTEL	https://onlinecourses.nptel.ac.in/noc22_bt59/preview
Reference research/ review articles	1. Akram, M., Jabeen, F., Daniyal, M., Zainab, R., ul Haq, U., Adetunji, C. O., & Ogbo, A. B. (2020). Genetic engineering of novel products of health significance: Recombinant DNA technology. Functional Foods and Nutraceuticals: Bioactive Components, Formulations and Innovations, 595-611. 2. Cronan, J. E. (2023). Two neglected but valuable genetic tools for Escherichia coli and other bacteria: In vivo cosmid packaging and inducible plasmid replication. Molecular Microbiology, 120(6), 783-790. 3. Ying, S. Y., Lui, H. M., Lin, S. L., & Chuong, C. M. (2024). Generation of full-length cDNA library from single human prostate cancer cells. Biotechniques, 27(3). 4. Shirmohammadi, A., Babaloo, A., Maleki Dizaj, S., Lotfipour, F., Sharifi, S., Ghavimi, M. A., & Khezri, K. (2021). A view on polymerase chain reaction as an outstanding molecular diagnostic technique in periodontology. BioMed Research International, 2021(1), 9979948. 5. Bezie, Y., Tilahun, T., Atnaf, M., & Taye, M. (2021). The potential applications of site-directed mutagenesis for crop improvement: A review. Journal of Crop Science and Biotechnology, 24, 229-244.

Course Code	Course Title	L	T	P	C
10211BT304	MOLECULAR BIOLOGY AND GENETIC ENGINEERING LABORATORY	0	0	2	1

Course Category	*Program Core*
Preamble	*To understand and have the hands on experience of techniques utilized in molecular biology and genetic engineering*
Prerequisite Courses	*10211BT104 - Molecular Biology: Concepts and Techniques*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Identify the cellular and genomic DNA by precipitation method.	K3, S3
CO2	Distinguish and analyse the fragments of DNA based on its molecular weight (Gel electrophoresis)	K3, S4
CO3	Apply and analyse DNA fragmentations using restriction enzymes.	K3, S4
CO4	Identify and examine DNA transformation for the development of recombinant cells.	K3, S5
CO5	Analyse the transformation efficiency by SDS PAGE and PCR studies.	K4, S5

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Identify the cellular and genomic DNA by precipitation method.	H	M	-	L	M	-	-	H	M	L	-	H	H	H	H
CO2	Distinguish and analyse the fragments of DNA based on its molecular weight (Gel electrophoresis)	H	H	M	H	H	M	-	M	M	H	-	M	H	H	H
CO3	Apply and analyse DNA fragmentations using restriction enzymes.	H	H	M	H	H	M	-	H	M	M	-	M	H	H	H

CO4	Identify and examine DNA transformation for the development of recombinant cells.	H	H	H	M	H	M	-	H	M	H	-	M	H	H	H
CO5	Analyse the transformation efficiency by SDS PAGE and PCR studies.	H	H	M	H	H	M	-	M	M	H	-	H	H	H	H

H – High; M- Medium; L- Low

Course Content:

LIST OF EXPERIMENTS:

1. Isolation of Genomic DNA (Bacterial cell, Animal cell and Plant cell).
2. Isolation of plasmid DNA.
3. Agarose gel electrophoresis.
4. Purification of DNA from agarose gel.
5. Restriction enzyme digestion and ligation.
6. Competent cell preparation (Calcium chloride method).
7. Transformation and screening of recombinants (Blue white selection method).
8. Induction and Analysis of Gene expression.
9. SDS PAGE analysis.
10. Polymerase Chain reaction (PCR).

LEARNING RESOURCES

Reference Books	1. Sambrook, J and Russell D.W., "The Condensed Protocols: From Molecular Cloning: A Laboratory Manual", Cold Spring Harbor, 2006. 2. Ansubel F.M., Brent. R., Kingston R.E. and Moore D.D., "Current Protocols in Molecular Biology", Greene Publishing Associates, 2003.
Virtual Lab	https://www.stemcell.com/protocol-for-genomic-dna-isolation-from-mouse-tail-animal-tissue-or-cultured-cells.html https://vlab.amrita.edu/?sub=3&brch=77&sim=314&cnt=1 https://vlab.amrita.edu/?sub=3&brch=77&sim=1375&cnt=2 https://vlab.amrita.edu/?sub=3&brch=77&sim=1365&cnt=2 https://vlab.amrita.edu/?sub=3&brch=77&sim=694&cnt=1 https://vlab.amrita.edu/?sub=3&brch=77&sim=702&cnt=2#:~:text=Pick%20a%20single%20bacterial%20colony,the%20growth%20of%20the%20culture. https://vlab.amrita.edu/?sub=3&brch=77&sim=1107&cnt=1 https://learn.genetics.utah.edu/content/labs/ https://vlab.amrita.edu/?sub=3&brch=237&sim=1249&cnt=1 https://vlab.amrita.edu/?sub=3&brch=186&sim=321&cnt=1

CHEMICAL ENGINEERING

Course Code	Course Title	L	T	P	C
10211BT106	CHEMICAL REACTION ENGINEERING	3	0	0	3

Course Category	*Program Core*
Preamble	*To study the fundamental concepts and designing of reactors used in biotechnological and chemical processing industries.*
Prerequisite Courses	*10211BT108 - Principles of Chemical Engineering* *10211BT110 - Bioprocess Engineering* *10211BT107 - Mass transfer operations in Biotechnology*

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

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Illustrate and infer the basics of reaction kinetics and development of rate equations.	K2
CO2	Develop rate equations for different types of ideal reactions (Batch, CSTR and PFR).	K3
CO3	Construct the mathematical models to represent rate equations for single and multiple reactions.	K3
CO4	Make use of dispersion and tank in series model to test the performance of non-ideal reaction.	K3
CO5	Apply the knowledge on development of novel bioreactors.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Illustrate and infer the basics of reaction kinetics and development of rate equations.	H	H		H	H							H	H	H	
CO2	Develop rate equations for different types of ideal reactions (Batch, CSTR and PFR).	H	H		H	H	H						H	H	H	
CO3	Construct the mathematical models to represent rate equations for multiple reactions.	H	H		H	H	H						H	H	H	

CO4	Make use of dispersion and tank in series model to test the performance of non-ideal reaction.	H	H		H	H							H	H	H	
CO5	Apply the knowledge on development of novel bioreactors.	H	H		H	H							H	H	H	

H – High; M- Medium; L- Low

Course Content:

UNIT I	**SCOPE OF CHEMICAL KINETICS & CHEMICAL REACTION ENGINEERING**	**9 hours**

Broad outline of chemical reactors; reaction system, chemical kinetics, rate equation, Elementary and non- elementary reactions. Molecularity and order, dependence of rate on concentration, temperature dependent term of a rate equation, concept of activation energy - Arrhenius theory, collision theory, transition state theory. Methods to determine order of a reaction- Integral & differential method of analysis of data, Half-life method.

UNIT II	**IDEAL REACTORS**	**9 hours**

Isothermal batch, flow, semi-batch reactors; Concept of ideal flow, space time and velocity, performance equations for single reactors: Batch reactors, Continuous stirred tank reactors (CSTR), Plug flow reactors (PFR).

UNIT III	**DESIGN OF MULTIPLE REACTOR SYSTEM**	**9 hours**

Design for single reaction: size comparison of single reactors; multiple reactor systems (Mixed flow reactors in series and parallel connection, Plug flow reactors in series and parallel connection); multiple reactions, and qualitative analysis of product distribution.

UNIT IV	**IDEAL FLOW AND NON-IDEAL FLOW**	**9 hours**

Reason for non-ideality, Residence time distribution, E curve, F curve, relationship between E and F curve, relationship between mean residence time and space time, State of aggregation- micro and macro fluid, Earliness or lateness of mixing, basic models for non-ideal reactor like tanks in series model and dispersion model.

UNIT V	**GAS-SOLID, GAS-LIQUID REACTORS**	**9 hours**

G/L reactions on solid catalysis; trickle bed, slurry reactors; three phase-fluidized beds; reactors for fluid-fluid reactions; tank reactors.

LEARNING RESOURCES

Text Books	1. Levenspiel O., "Chemical Reaction Engineering", 3rd Edition, John Wiley, 1999. **2.** Fogler H.S., "Elements of Chemical Reaction Engineering", Prentice Hall India, 2002.

Reference Books	1. Missen R.W., Mims C.A., and Saville B.A., "Introduction to Chemical Reaction Engineering and Kinetics", John Wiley, 1999. 2. Dawande, S.D., "Principles of Reaction Engineering", Ist Edition, Central Techno Publications, 2001.
Reference videos	https://www.youtube.com/watch?v=rCeSCjC4BjU https://www.youtube.com/watch?v=fQOzHC828aM https://www.youtube.com/watch?v=pIsGeffJGgo https://www.youtube.com/watch?v=MRe07mhFaJs https://www.youtube.com/watch?v=DLbhAS2Ww6U
Reference NPTEL	https://archive.nptel.ac.in/courses/103/106/103106116/
Reference research/ review articles	1. Taylor, C. J., Pomberger, A., Felton, K. C., Grainger, R., Barecka, M., Chamberlain, T. W., ... & Lapkin, A. A. (2023). A brief introduction to chemical reaction optimization. Chemical Reviews, 123(6), 3089-3126. 2. Cherkasov, N., Adams, S. J., Bainbridge, E. G., & Thornton, J. A. (2023). Continuous stirred tank reactors in fine chemical synthesis for efficient mixing, solids-handling, and rapid scale-up. Reaction Chemistry & Engineering, 8(2), 266-277. 3. Dong, Z., Wen, Z., Zhao, F., Kuhn, S., & Noël, T. (2021). Scale-up of micro- and milli-reactors: An overview of strategies, design principles and applications. Chemical Engineering Science: X, 10, 100097. 4. Lele, A. D., & Ju, Y. (2023). Assessment of the impact of reactor residence time distribution on non-equilibrium product selectivity of polypropylene pyrolysis using reactive molecular dynamics simulations. Fuel, 338, 127328. 5. Alwared, A. I., & Jaber, W. S. (2020). Spiral path three phase fluidized bed reactor for treating wastewater contaminated with engine oil. Applied Water Science, 10(9), 1-11.

Course Code	Course Title	L	T	P	C
10211BT107	MASS TRANSFER OPERATIONS IN BIOTECHNOLOGY	3	0	0	3

Course Category	*Program Core*
Preamble	*To understand the essential concepts and various applications of mass transfer in biotechnological industries.*
Prerequisite Courses	*10211BT104 – Principles of Chemical Engineering* *10211BT112– Unit Operations in Biotech Industry*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Demonstrate and infer the concepts of molecular diffusion in solids, fluids and interphase between two phases.	K2
CO2	Analyse the efficiency of distillation process on separation of volatile compounds.	K4
CO3	Analyse the efficiency of absorption process in gas-liquid mass transfer operations	K4
CO4	Analyse the efficiency of absorption process in Liquid-liquid mass transfer operations.	K4
CO5	Dissect the performance of adsorption process in solid-liquid systems	K4

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Demonstrate and infer the concepts of molecular diffusion in solids, fluids and interphase between two phases.	H	M	M	M								M	H	H	
CO2	Analyse the efficiency of distillation process on separation of volatile compounds.	L	M	H	H		H						M	H	H	H
CO3	Analyse the efficiency of absorption process in gas-liquid mass transfer operations	L	M	H	H		H						M	H	H	H

CO4	Analyse the efficiency of absorption process in Liquid-liquid mass transfer operations.	L	M	H	H		H						M	H	H	H
CO5	Dissect the performance of adsorption process in solid-liquid systems	L	M	H	H		H						M	H	H	H

H – High; M- Medium; L- Low

Course Content:

UNIT I	**DIFFUSION AND MASS TRANSFER**	**9 hours**

Molecular diffusion in solids, liquids and gases; Inter-phase mass transfer; theories to determine mass transfer coefficients; Analogies in Transport phenomenon.

UNIT II	**GAS - LIQUID OPERATIONS**	**9 hours**

Principles of gas absorption; Single and Multi component absorption; Absorption with chemical reaction; Design principles of absorbers; Industrial absorption equipment; HTU, NTU concepts.

UNIT III	**VAPOUR - LIQUID OPERATIONS**	**9 hours**

Vapour-Liquid equilibria; Simple, Steam and Flash Distillation; Continuous distillation; McCabe - Thiele & enthalpy concentration method; Industrial distillation equipments, HETP, HTU and NTU concepts.

UNIT IV	**EXTRACTION OPERATIONS**	**9 hours**

Liquid-Liquid equilibria, Staged and continuous extraction, Solid-liquid equilibria, Leaching principles, Equipment for extraction and leaching.

UNIT V	**SOLID - FLUID OPERATIONS**	**9 hours**

Adsorption equilibria – Types - Batch and fixed bed adsorption; Drying – Mechanism – Drying curves - Time of drying; Equipment for drying - Batch and continuous dryers.

LEARNING RESOURCES

Text Books	1. Treybal R.E., "Mass Transfer Operations", 3rd Edition, Mc Graw Hill, 1981. 2. Geankoplis C.J., "Transport Processes and Unit Operations", 3rd Edition, Prentice Hall of India, 2002. 3. Warren. L, Mc Cabe, Julian .C. Smith and Peter Harriott, "Unit Operations of Chemical Engineering", 6th Edition, McGraw Hill International Edition, New York, 2001.
Reference Books	1. Coulson J.M., Richardson J.F., Backhurst J.R. and Harker J.M., "Coulson & Richardson's Chemical Engineering", Vol. I, 6th Edition, Butter worth Heinemann, Oxford, 1999. 2. Perry's, "Handbook of Chemical Engineering", 7th Edition, McGraw Hill, 1997.

Reference videos	https://www.youtube.com/watch?v=XJSRZhY92i4 https://www.youtube.com/watch?v=dzWsPPyig1Q https://www.youtube.com/watch?v=P7PB31BQ5-s https://www.youtube.com/watch?v=o7iYOd1uWL4 https://www.youtube.com/watch?v=CRlsh2XqOI4
Reference NPTEL	https://nptel.ac.in/courses/103103145
Reference research/ review articles	1. Marinos-Kouris, D., & Maroulis, Z. B. (2020). Transport properties in the drying of solids. In Handbook of industrial drying (pp. 113-159). CRC Press. 2. Wang, C., Liu, Y., Jia, Z., Zhao, W., & Wu, G. (2023). Multicomponent nanoparticles synergistic one-dimensional nanofibers as heterostructure absorbers for tunable and efficient microwave absorption. Nano-Micro Letters, 15(1), 13. 3. Mehtari, N., Kahani, M., & Zamen, M. (2023). Energy, environmental, and economic analysis of a new configuration multi-stage flash distillation unit coupled with steam power plant. Case Studies in Thermal Engineering, 50, 103456. 4. Bu, X., Danstan, J. K., Hassanzadeh, A., Behrad Vakylabad, A., & Chelgani, S. C. (2024). Metal extraction from ores and waste materials by ultrasound-assisted leaching-an overview. Mineral Processing and Extractive Metallurgy Review, 45(1), 28-45. 5. Sharma, A., Khamar, D., Cullen, S., Hayden, A., & Hughes, H. (2021). Innovative drying technologies for biopharmaceuticals. International Journal of Pharmaceutics, 609, 121115.

Course Code	Course Title	L	T	P	C
10211BT108	PRINCIPLES OF CHEMICAL ENGINEERING	3	1	0	4

Course Category	*Program Core*
Preamble	*To study and understand various emphases of basic concepts on process calculations, thermodynamics and fundamental principles in biochemical engineering.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Explain the theoretical concepts of stoichiometry and fundamentals of ideal gas law in technological applications.	K2
CO2	Demonstrate the capability to analyze the energy conversion performance in a variety of modern applications in systems.	K2
CO3	Apply the thermodynamic laws and properties of various fluids mechanic process involved in biotechnology.	K4
CO4	Analyze the partial molar properties of various extensive thermodynamic parameters in solutions.	K4
CO5	Examine the Gibb's free energy changes in solutions mixtures by phase change and chemical equilibria	K4

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Demonstrate and make use of thermodynamic principles to define the energy changes in pure components.	H	H										H	M		
CO2	Demonstrate and develop the mathematical models to analyze mass and energy balance in various systems	H	H										H	M		

CO3	Apply the thermodynamic laws and properties of various fluids mechanic process involved in biotechnology.	H	H										H	M		
CO4	Analyze the partial molar properties of various extensive thermodynamic parameters in solutions.	H	H		H	H							H	H	H	
CO5	Examine the Gibb's free energy changes in solutions mixtures by phase change and chemical equilibria	H	H		H	H							H	H	H	M

H – High; M- Medium; L- Low

Course Content:

UNIT I	**BASIC CHEMICAL CALCULATIONS**	**9 hours**

SI units, stoichiometry, basic chemical calculations: mole, atomic mass and molar mass, equivalent mass, conversion of mass function to mole fraction, molarity, normality, density, specific gravity. Ideal gas law- Ideal mixtures and solutions – Dalton's law of additive volumes, Henry's law, Raoult's law, Concepts of Simpson's rule and their applications to different systems.

UNIT II	**MATERIAL AND ENERGY BALANCE**	**9 hours**

Overall and component balances, material balances without and with chemical reactions, degrees of freedom, steady and unsteady state, unit operations, recycle and by pass humidity calculations. Energy balance with and without ch emical reactions.

UNIT III	**THERMODYNAMIC LAWS AND PROPERTIES**	**9 hours**

Review of laws of thermodynamics and their applications; thermodynamic analysis of processes. Thermodynamic properties of fluids and their interrelationship: PVT behavior of pure substances; Equation of state; generalized correlations and acentric factor; Thermodynamics charts; Estimation of thermodynamic properties.

UNIT IV	**SOLUTION THERMODYNAMICS**	**9 hours**

Partial molar properties; Chemical potential; Gibbs-Duhem equation; Ideal and non-ideal solutions; Fugacity and fugacity coefficient; Activity and activity coefficient; Excess properties of mixtures.

UNIT V	PHASE AND CHEMICAL REACTION EQUILIBRIA	9 hours
Gibbs phase rule and its derivation for reacting and non-reacting systems; Phase equilibria-criteria-VLE Calculations – Liquid-liquid Equilibria; Chemical equilibrium constants; Homogeneous and heterogeneous reactions; Effect of Temperature- Effect of pressure-Equilibrium conversion in single and multiple reactions.		
LEARNING RESOURCES		
Text Books	1. Bhatt, B.I. and S.M. Vora, "Stoichiometry (SI Units)", 3rd Edition, Tata McGraw- Hill, 1996. 2. Smith J.M., Van Ness H.C., and Abbot M.M., "Introduction to Chemical Engineering Thermodynamics", 6th Edition, Tata McGraw-Hill, 2003. 3. Narayanan K.V., "A Text Book of Chemical Engineering Thermodynamics", PHI, 2003.	
Reference Books	1. Himmelblau, D.M., "Basic principles and calculations in Chemical Engineering", 6th Edition, PHI, 2006. 2. Narayanan, K.V. and Lakshmi Kutty, "Stoichiometry and Process Calculations", PHI, 2006. 3. 3. Coulson J.M., Richardson J.F., Backhurst J.R. and Harker J.M., "Coulson & Richardson's Chemical Engineering", Vol. I, 6th Edition, Butter worth Heinemann, Oxford, 1999. 4. Sandler S.I., "Chemical and Engineering Thermodynamics", John Wiley,1989.	
Reference videos	https://www.youtube.com/watch?v=UL1jmJaUkaQ https://www.youtube.com/watch?v=QQGaLrbXGq0 https://www.youtube.com/watch?v=gKDCMtuVrDs https://www.youtube.com/watch?v=utfxPRImBgw https://www.youtube.com/watch?v=J4WJCYpTYj8	
Reference NPTEL	https://archive.nptel.ac.in/courses/103/103/103103165/	
Reference research/ review articles	1. White, C., Silva III, H., & Vorobieff, P. (2021). Investigation of mixing law efficacy for gaseous hydrodynamic simulations. Journal of Thermophysics and Heat Transfer, 35(1), 98-103. 2. Heinzle, E., Dunn, I. J., Ingham, J., & Přenosil, J. E. (2021). Biological Reaction Engineering: Dynamic Modeling Fundamentals with 80 Interactive Simulation Examples. John Wiley & Sons. 3. Xamroyevna, M. B. (2024). THERMODYNAMICS OF LIVING SYSTEMS. Multidisciplinary Journal of Science and Technology, 4(3), 303-308. 4. Vegh, A., Korozs, J., & Kaptay, G. (2022). Extension of the Gibbs–Duhem Equation to the Partial Molar Surface Thermodynamic Properties of Solutions. Langmuir, 38(16), 4906-4912. 5. Tran, H. N. (2022). Improper estimation of thermodynamic parameters in adsorption studies with distribution coefficient KD (qe/C e) or Freundlich constant (KF): Considerations from the derivation of dimensionless thermodynamic equilibrium constant and suggestions. Adsorption Science & Technology, 2022, 5553212.	

Course Code	Course Title	L	T	P	C
10211BT112	UNIT OPERATIONS IN BIOTECH INDUSTRY	3	0	0	3

Course Category	*Program Core*
Preamble	*To know the fundamental concepts of fluid mechanics and heat transfer.*
Prerequisite Courses	*NIL*

Course Outcomes	***Upon successful completion of the course, students will be able to:***	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Apply the knowledge of units and dimension for different analysis.	K3
CO2	Make use of learn about flow measurements & different mechanical operations involved in fluid mechanics.	K3
CO3	Apply the laws of Fluid mechanics to identify rheological behavior of fluids under static conditions.	K3
CO4	Build the fundamental concepts of heat transfer.	K3
CO5	Construct the heat exchange equipment.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Apply the knowledge of units and dimension for different analysis.	H	M	M	L								L	H	M	
CO2	Make use of learn about flow measurements & different mechanical operations involved in fluid mechanics.	H	H		H	H							H	H	H	
CO3	Apply the laws of Fluid mechanics to identify rheological behavior of fluids under static conditions.	H	H		H	H							H	H	H	

CO4	Construct the mathematical models to demonstrate mass and heat transfer in different phases.	H	M	M	M	H							M	H	M	M
CO5	Apply the knowledge of radiation and heat exchange process in industrial scale.	H	M	M	M	M							M	H	M	H

H – High; M- Medium; L- Low

Course Content:

UNIT I	**DIMENSIONAL ANALYSIS**	**9 hours**

Units and Dimensions: Fundamental and derived units, Conversion; Dimensional consistency of equations; Dimensionless groups and constants. Derived Units, Dimensionless numbers, and constants, Dimensional analysis: Rayleigh's method, Buckingham's π method.

UNIT II	**FLUID FLOW PHENOMENA AND MEASUREMENTS**	**9 hours**

Fluid definition and Classification (Newtonian and Non-Newtonian), Pressure measurement, Types of flow-laminar & turbulent, Reynolds Stress, Eddy Viscosity, Flow in Boundary Layers, Reynolds number, Boundary Layer Separation. Different types of flow measuring devices (Orifice meter, Venturimeter, Rotameter) with derivations, flow measurements –. Pumps – types of pumps (Centrifugal & Reciprocating pumps), Energy calculations and characteristics of pumps.

UNIT III	**MECHANICAL OPERATIONS**	**9 hours**

Properties and characterization of particulate, Size reduction, Analysis and technical methods for size determination of powders in biotech industries- Size reduction and Screening equipment; Sieve analysis, Screen effectiveness, capacity, theory of Settling and Sedimentation. Mixing – Types of mixers, power number, power consumption in mixing operation, Biomaterials Handling-Belt conveyor, Screw Conveyor, bucket elevator and pneumatic conveyor.

UNIT IV	**FUNDAMENTALS OF HEAT TRANSFER**	**9 hours**

Introduction – Conduction – Basic concepts of conduction in solids, liquids and gases – One- and two-dimensional heat conduction – Critical and optimum insulation thickness. Introduction to unsteady state heat transfer. Principles of convection – Equations of forced and free convection.

UNIT V	RADIATION AND HEATEXCHANGERS	9 hours
Basic laws of heat transfer by radiation – black body and gray body concepts – solar radiations – combined heat transfer coefficients by convection and radiation. Heat Transfer equipment Double pipe, Shell & tube and Plate type heat exchanger.		
LEARNING RESOURCES		
Text Books	1. Warren L. McCabe, Julian C. Smith and Peter Harriot, "Unit operations in Chemical Engineering", 7th Edition, McGraw-Hill Education, 2017. 2. Christie Geankoplis, "Transport Process Principles and Unit Operations", 4th Edition, Prentice Hall of India, 2015. 3. Kumar K.L., "Fluid Mechanics", S Chand & Company Ltd., 2008. 4. YunusCengel, "Heat and Mass Transfer – Fundamentals & Applications", 5th edition, McGraw-Hill, 2015.	
Reference videos	https://www.youtube.com/watch?v=Ch6Iqog9gm8 https://www.youtube.com/watch?v=0KIj-r6hp1g https://youtu.be/npiTNdapr7w https://youtu.be/tG-PmLzx6NA https://youtu.be/z-2b6cRMF8Q	
Reference NPTEL	https://onlinecourses.nptel.ac.in/noc21_ch34/preview	
Reference research/ review articles	1. Bakarji, J., Callaham, J., Brunton, S. L., & Kutz, J. N. (2022). Dimensionally consistent learning with Buckingham Pi. Nature Computational Science, 2(12), 834-844. 2. Wen, X., Wang, L. P., Guo, Z., & Zhakebayev, D. B. (2021). Laminar to turbulent flow transition inside the boundary layer adjacent to isothermal wall of natural convection flow in a cubical cavity. International Journal of Heat and Mass Transfer, 167, 120822. 3. Sharma, A., Mishra, M. K., & Trivedi, A. (2023). HAZARD ASSESSMENT AND ITS CONTROL IN BULK MATERIAL HANDLING PROCESS OF AN INTEGRATED STEEL PLANT. 4. Akan, A. E. (2021). Determination and modeling of optimum insulation thickness for thermal insulation of buildings in all city centers of Turkey. International Journal of Thermophysics, 42(4), 49. 5. Gabir, M. M., & Alkhafaji, D. (2021, August). Comprehensive review on double pipe heat exchanger techniques. In Journal of Physics: Conference Series (Vol. 1973, No. 1, p. 012013). IOP Publishing.	

INDUSTRIAL BIOTECHNOLOGY

Course Code	Course Title	L	T	P	C
10211BT110	BIOPROCESS ENGINEERING	3	0	0	3

Course Category	*Program Core*
Preamble	*To comprehend the expertise in developing the bio-products with the help of upstream applications.*
Prerequisite Courses	*10211BT101 – Microbiology* *10211BT108 – Principles of Chemical Engineering* *10211BT112 – Unit Operations in Biotech Industry*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Illustrate and gain knowledge on construction of fermenters and its ancillaries.	K2
CO2	Apply and identify the suitable statistical models (medium formulations) and sterilization techniques in industrial fermentation process.	K3
CO3	Make use of stoichiometric analysis to infer the product formation and substrate utilization in biological systems.	K3
CO4	Analyze the criteria for scale-up of bioreactor systems with respect to mechanical and mass transfer properties.	K4
CO5	Demonstrate selective models to analyze growth kinetic parameters and inhibition effects in batch system.	K4

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Illustrate and gain knowledge on construction of fermenters and its ancillaries.	H	H										H	H	M	M
CO2	Apply and identify the suitable statistical models (medium formulations) and sterilization techniques in industrial fermentation process.	H	H	H	H	H	L						H	H	M	M

CO3	Make use of stoichiometric analysis to infer the product formation and substrate utilization in biological systems.	M	H			M							M	M	M	L
CO4	Analyze the criteria for scale-up of bioreactor systems with respect to mechanical and mass transfer properties.	M	H	H	H	H			M				H	H	H	H
CO5	Demonstrate selective models to analyze growth kinetic parameters and inhibition effects in batch system.	M	M		H	H			L				H	H	M	M

H – High; M- Medium; L- Low

Course Content:

UNIT I	**FERMENTATION PROCESSES AND BASIC CONFIGURATION OF FERMETER**	**9 hours**

Introduction to bioprocess development; current scenario of fermentation industry, general requirements of fermentation processes, types of fermentation process: Batch, fed batch and continuous. Construction of fermenter and ancillaries, main parameters to be monitored and controlled in fermentation processes; properties of fermented products.

UNIT II	**MEDIA OPTIMIZATION AND STERILIZATION KINETICS**	**9 hours**

Media formulation and optimization-one factor at a time method, Plackett Burman and Response surface methodology; design of various commercial media for industrial fermentations; Thermal death kinetics of microorganisms, Sterilization: batch and continuous-air, heat and filter sterilization of liquid media.

UNIT III	**STOICHIOMETRIC ANALYSIS**	**9 hours**

Stoichiometry and kinetics of bioprocesses, Stoichiometry of microbial reactions, Stoichiometry- Mass-balance equations, elemental balance, degrees of reduction of substrate and biomass, available electron balances, yield coefficients of biomass and product formation, maintenance coefficients energetic analysis of microbial growth and product formation, oxygen consumption and heat evolution in aerobic cultures, thermodynamic efficiency of growth.

UNIT IV	**BIOREACTOR STRATEGIES**	**9 hours**

Types of bioreactors-Modes of operation of bioreactor - Kinetics of cell growth in batch culture - Kinetics of cell growth in fed-batch culture-Kinetics of cell growth in continuous culture -

Stability analysis of bioreactor Scale up criteria for bioreactors (Constant power per Unit volume, Constant KLa, Constant mixing quality, Constant impeller tip speed, Constant momentum factor, Constant mixing rate number, Similar drop size distribution).		
UNIT V	**KINETICS OF MICROBIAL GROWTH AND PRODUCT FORMATION**	**9 hours**
Phases of cell growth in batch cultures; simple unstructured kinetic models for microbial growth - Monod model, growth of filamentous organisms, product formation kinetics - Leudeking-Piret models, substrate and product inhibition on cell growth and product formation; homogeneous and heterogeneous reaction kinetics.		
LEARNING RESOURCES		
Text Books	1. Shuler M.L. and FikretKargi, "Bioprocess Engineering: Basic Concepts", 2nd Edition, Prentice Hall, 2001. 2. Doran P., "Bioprocess Engineering Principles", 2nd Edition, Elsevier, 2012.	
Reference Books	1. Lydersen, Bjorn K, "Bioprocess Engineering Systems, Equipment and Facilities", John Wiley, 1994. 2. Bailey, James E. and David F. Ollis, "Biochemical Engineering Fundamentals", 2nd Edition, McGraw Hill, 1986. 3. Peter F. Stanbury, Stephen J. Hall and Whitaker A., "Principles of Fermentation Technology", 3rd Edition, Elsevier, 2016. 4. Harvey W. Blanch, Douglas S. Clark, "Biochemical Engineering", Marcel DekkerInc., 2007.	
Reference videos	https://youtu.be/bKunpGA2r7U https://youtu.be/mUDXupn2Dhk https://youtu.be/psPAJDWzrb8 https://youtu.be/8xbYn5IatvM https://youtu.be/rab_BkiNuW0	
Reference NPTEL	**https://nptel.ac.in/courses/102106053**	
Reference research/ review articles	1. Hanifah, I. A., Primarista, N. P. V., Prasetyawan, S., Safitri, A., Adyati, T., & Srihadyastutie, A. (2022, May). The effect of variations in sugar types and fermentation time on enzyme activity and total titrated acid on eco-enzyme results of fermentation. In 7th International Conference on Biological Science (ICBS 2021) (pp. 585-589). Atlantis Press. 2. GÜRKÖK, S. (2021). Statistical Optimization of Extracellular Thermo-Alkaline Lipase Production from Aeromonas caviae LipT51 with Response Surface Methodology. Journal of the Institute of Science and Technology, 11(3), 1770-1780. 3. Saadat, N. P., Nies, T., Rousset, Y., & Ebenhöh, O. (2020). Thermodynamic limits and optimality of microbial growth. Entropy, 22(3), 277. 4. Roberto, I. C., Pessoa, A., & Tonso, A. (2021). Bioreactors: Modes of Operation. In Pharmaceutical Biotechnology (pp. 157-179). CRC Press. 5. Bohórquez, W. F., Osorio-Pascuas, O. M., Santaella, M. A., & Orjuela, A. (2020). Homogeneous and heterogeneous catalytic kinetics in the production of triethyl citrate. Industrial & Engineering Chemistry Research, 59(43), 19203-19211.	

Course Code	Course Title	L	T	P	C
10211BT111	DOWNSTREAM PROCESSING	3	0	0	3

Course Category	*Program Core*
Preamble	*To understand the process involved in the recovery and purification of bioproducts*
Prerequisite Courses	*10211BT115 – Analytical and Instrumentation Engineering* *10211BT110 - Bioprocess Engineering*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Illustrate the importance of downstream processing on separation technology and economic aspects in process design.	K3
CO2	Demonstrate the primary separation techniques using mechanical, enzymatic, chemical methods.	K3
CO3	Make use of various mass transfer operations on separation of biological products.	K3
CO4	Apply different purification techniques (chromatography and electrophoresis) for product recovery.	K3
CO5	Utilize the product formulation and polishing techniques to develop the product for industrial scale up	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Illustrate the importance of down stream processing on separation technology and economic aspects in process design.	H	H	H	M								H	H	H	
CO2	Demonstrate the primary separation techniques using mechanical, enzymatic, chemical methods.	H	H	H	M								H	H	H	

CO3	Make use of various mass transfer operations on separation of biological products.	H	H	H	M								H	H	H	
CO4	Apply different purification techniques (chromatography and electrophoresis) for product recovery.	H	H	H	M								H	H	H	
CO5	Utilize the product formulation and polishing techniques to develop the product for industrial scale up	H	H	H	M								H	H	H	

H – High; M- Medium; L- Low

Course Content:

UNIT I	**DOWNSTREAM PROCESSING**	**9 hours**

Role and importance of downstream processing in biotechnological processes; characteristics ofbiomolecules and bioprocesses, Physico-chemical basis of bio-separation processes. Economics of downstream processing in Biotechnology, cost-cutting strategies, characteristics of biological mixtures, process design criteria for various classes of bio-products.

UNIT II	**PRIMARY SEPARATION TECHNIQUES**	**9 hours**

Mechanical, enzymatic and chemical methods of cell disruption for product release; Immobilization, super critical fluid extraction evaporation, super liquid extraction, solid liquid separation - flocculation, sedimentation, filtration, centrifugation settling and foam based separation.

UNIT III	**ENRICHMENT OPERATIONS**	**9 hours**

Adsorption, liquid-liquid extraction, aqueous two-phase extraction, membrane separation – ultra filtration and reverse osmosis, dialysis, precipitation of proteins by different methods. Centrifugation, settling, sedimentation, decanting and microfiltration.

UNIT IV	**PRODUCT PURIFICATION**	**9 hours**

Chromatographic techniques –adsorption, TLC, reverse phase, ion-exchange, size exclusion, hydrophobic interaction, bioaffinity and pseudo affinity chromatographic techniques. Electrophoresis of proteins and nucleic acids, 1D and 2D Gels, Types of Electrophoresis techniques (Capillary and Pulse field). Requirements and problems faced in bio-product purification.

UNIT V	PRODUCT FORMULATION AND POLISHING	9 hours
Crystallization, drying and lyophilization for final product formulation. Case study with examples for processing of two Industrial products.		
LEARNING RESOURCES		
Text Books	1. Belter P.A., Cussler E.L. and Wei-Houhu, "Bioseparations – Downstream Processing For Biotechnology, Wiley Interscience, 1988. 2. Sivasankar B., "Bioseparations: Principles and Techniques", PHI, 2005.	
Reference Books	1. Jenkins R.O., "Product Recovery in Bioprocess Technology – Biotechnology", Open Learning Series, Butterworth-Heinemann, 1992. 2. Janson J.C., and Ryden L., "Protein Purification – Principles, High Resolution Methods and Applications", VCH Pub., 1989. 3. Scopes R.K., "Protein Purification – Principles and Practice", Narosa Pub., 1994.	
Reference videos	https://youtu.be/Uut1cUs6GpA https://youtu.be/9--f0hMYQe0 https://youtu.be/sywSp-E2Rjw https://youtu.be/qIW_VjVf3ZY https://youtu.be/qPDRS75CR2Q	
Reference NPTEL	https://archive.nptel.ac.in/courses/102/106/102106022/	
Reference research/ review articles	1. Rodríguez-Sifuentes, L., Marszalek, J. E., Hernández-Carbajal, G., & Chuck-Hernández, C. (2021). Importance of downstream processing of natural astaxanthin for pharmaceutical application. Frontiers in Chemical Engineering, 2, 601483. 2. Alisherovna, A. M. (2023). THE STUDY OF HETEROGENEOUS SYSTEMS AND METHODS FOR THEIR SEPARATION. International Journal of Advance Scientific Research, 3(04), 90-96. 3. Pérez-Rodriguez, S., Ramírez, O. T., Trujillo-Roldán, M. A., & Valdez-Cruz, N. A. (2020). Comparison of protein precipitation methods for sample preparation prior to proteomic analysis of Chinese hamster ovary cell homogenates. Electronic Journal of Biotechnology, 48, 86-94. 4. Rana, B., & Joshi, G. K. (2023). Electrophoresis: Basic principle, types, and applications. In Basic Biotechniques for Bioprocess and Bioentrepreneurship (pp. 183-193). Academic Press. 5. Butreddy, A., Dudhipala, N., Janga, K. Y., & Gaddam, R. P. (2020). Lyophilization of small-molecule injectables: an industry perspective on formulation development, process optimization, scale-up challenges, and drug product quality attributes. Aaps Pharmscitech, 21, 1-20.	

Course Code	Course Title	L	T	P	C
10211BT113	METABOLIC ENGINEERING	3	0	0	3

Course Category	*Program Core*
Preamble	*To infer the importance of modifying the biological pathways for the improved production of valuable bio-products.*
Prerequisite Courses	*10212BT144 – Advanced Biochemistry* *10211BT110 – Bioprocess Engineering* *10211BT105 – Genetic Engineering*

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

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Identify the need and scope of metabolic engineering.	K3
CO2	Construct the scheme of regulatory pathways.	K3
CO3	Develop the tools used in metabolic engineering.	K3
CO4	Evaluate the strategies used in metabolic pathway manipulation.	K4
CO5	Analyze the applications of metabolic engineering in various fields.	K4

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Identify the need and scope of metabolic engineering.	H											H	H	L	
CO2	Construct the scheme of regulatory pathways.	H	M	M									H	H	L	
CO3	Develop the tools used in metabolic engineering.	H	M	M		H							H	H	L	
CO4	Evaluate the strategies used in metabolic pathway manipulation.	H	M	H	H	M	L	L	L				H	H	L	
CO5	Analyze the applications of metabolic engineering in various fields.	H	M	H	H	H	L	L	L				H	H	L	

H – High; M- Medium; L- Low

Course Content:		
UNIT I	**INTRODUCTION TO METABOLIC ENGINEERING**	**9 hours**
Importance of metabolic engineering; Concept of metabolic pathway synthesis; Central Metabolism: Fueling metabolism, Supply of biomass precursors, Anabolism, Anaplerosis. Need for pathway synthesis, Paradigm shift; Information resources; Scope and future of metabolic engineering; Methods for metabolic characterization.		
UNIT II	**REGULATION OF METABOLIC PATHWAY**	**9 hours**
Regulation of Enzymatic Activity, Regulation of Enzyme concentration, Regulation at whole cell level, Regulation of Metabolic networks, Transport mechanisms and their models, Mechanisms and theirdynamic representation		
UNIT III	**TOOLS IN METABOLIC ENGINEERING**	**9 hours**
Metabolic flux analysis (MFA), Methods for MFA - Metabolite Balancing, Tracer Experiments, MS and NMR in labelling measurement, Metabolic control analysis (MCA), Determination of Flux control coefficients, MCA of Linear and Branched pathways.		
UNIT IV	**METABOLIC PATHWAY MANIPULATION**	**9 hours**
Enhancement of product yield and productivity, Extension of substrate range, Extension of product spectrum and novel products, Improved cellular properties, metabolic pathway synthesis - case study: lysine biosynthesis, Synthetic biology in metabolic engineering - heterologous pathway modification yeast, genome-wide analysis and engineering.		
UNIT V	**APPLICATIONS OF METABOLIC ENGINEERING**	**9 hours**
Application of metabolic engineering in pharmaceuticals, chemical bioprocess, food technology, agriculture, environmental bioremediation and biomass conversion. Case studies of Metabolic engineering: engineering of *Saccharomyces crevices* for production of secondary metabolites. Enhancement of product yield (amino acid); Extension of substrate range; Extension of product spectrum and novel products (biopolymer).		
LEARNING RESOURCES		
Text Books	1. Stephanopoulos G.N., Aristidou A.A., Nielsen J., "Metabolic Engineering: Principles and Methodologies", Academic Press, 1998. 2. Sang Yup Lee and Terry Papoutsakis E., "Metabolic Engineering", Marcel Dekker, New York, 1999. 3. Heinrich R., and Schuster S., "The Regulation of Cellular Systems", Chapman & Hall, 1996.	
Reference Books	1. Eberhard O. Voit,"Computational Analysis of Biochemical Systems: A Practical Guide for Biochemists andMolecular Biologists", Cambridge University Press, 2000.	

	2. David Fell, "Understanding the Control of Metabolism", Portland Press, London, 1997.
Reference videos	https://youtu.be/lqlu3Xps9PM https://youtu.be/IbvCtKlNz1I https://youtu.be/pNH3JbJohJk https://youtu.be/TY7NqeZz7pg https://youtu.be/M0upS8uc5lA
Reference NPTEL	https://archive.nptel.ac.in/courses/102/105/102105086/
Reference research/ review articles	1. Dasgupta, A., Chowdhury, N., & De, R. K. (2020). Metabolic pathway engineering: Perspectives and applications. Computer Methods and Programs in Biomedicine, 192, 105436. 2. Johnson, R., Vishwakarma, K., Hossen, M. S., Kumar, V., Shackira, A. M., Puthur, J. T., ... & Hasanuzzaman, M. (2022). Potassium in plants: Growth regulation, signaling, and environmental stress tolerance. Plant Physiology and Biochemistry, 172, 56-69. 3. Vupputuri, A., Gupta, A., & Ghosh, N. (2021). MCA-DN: Multi-path convolution leveraged attention deep network for salvageable tissue detection in ischemic stroke from multi-parametric MRI. Computers in Biology and Medicine, 136, 104724. 4. Liu, J., Wang, X., Dai, G., Zhang, Y., & Bian, X. (2022). Microbial chassis engineering drives heterologous production of complex secondary metabolites. Biotechnology Advances, 59, 107966. 5. Antoniewicz, M. R. (2021). A guide to metabolic flux analysis in metabolic engineering: Methods, tools and applications. Metabolic engineering, 63, 2-12.

Course Code	Course Title	L	T	P	C
10211BT114	GREEN BIOTECHNOLOGY & POLLUTION ABATEMENT	2	0	0	2

Course Category	*Program Core*
Preamble	*To have insight knowledge on applications of biotechnology in creating sustainable environment.*
Prerequisite Courses	*10211BT101 - Microbiology*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Illustrate the process involved in biological waste management.	K2
CO2	Demonstrate the mechanism of biotransformation and biocatalysts.	K2
CO3	Outline the different forms of treating the environmental waste with biological process.	K2
CO4	Develop the bio-products with eco-friendly nature.	K3
CO5	Apply the knowledge of biotechnology in protecting the environment.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Illustrate the process involved in biological waste management.	M	M	L				H						H		
CO2	Demonstrate the mechanism of biotransformation and biocatalysis.	M	M	L				H	L					H		
CO3	Outline the different forms of treating the environmental waste with biological process.	M	M	L				H	L					H	H	
CO4	Develop the bio-products with eco-friendly nature.	M	M	L				H	L					H	H	M

CO5	Apply the knowledge of biotechnology in protecting the environment.	M	M	L				H	L					H	M	H

H – High; M- Medium; L- Low

Course Content:

UNIT I	**BIOLOGICAL WASTE MANAGEMENT**	**6 hours**

Biological wastewater treatment: Principles and design aspects of various waste treatment methods with advanced bioreactor configuration; Solid waste management: landfills, recycling and processing of organic residues, minimal national standards for waste disposal; Biodegradation of Xenobiotic Compounds; Factors affecting biodegradation, microbial degradation of hydrocarbons.

UNIT II	**BIOTRANSFORMATIONS AND BIOCATALYSTS**	**6 hours**

Basic organic reaction mechanism- Common prejudices against enzymes, advantages & disadvantages of biocatalysts, isolated enzymes versus whole cell systems, biocatalytic application, catalytic antibodies; stoichiometry.

UNIT III	**BIOREMEDIATION AND BIORESTORATION**	**6 hours**

Introduction and types of bioremediation, bioremediation of surface soil and sludge, bioremediation of subsurface material, *In situ* and *Ex-situ* technologies, phytoremediation-restoration of coal mines a case study. biorestoration: reforestation through micropropagation, use of mycorrhizae in reforestation, use of microbes for improving soil fertility, reforestation of soils contaminated with heavy metals.

UNIT IV	**ECO-FRIENDLY BIOPRODUCTS**	**6 hours**

Fundamentals of composting process: scientific aspects and prospects of biofuel production: bioethanol, biohydrogen and biodiesel; biofertilizers and biopesticides.

UNIT V	**BIOTECHNOLOGY IN ENVIRONMENT PROTECTION**	**6 hours**

Current status of biotechnology in environment protection and its future, release of genetically engineered organisms in the environment.

LEARNING RESOURCES

Text Books	1. Winter J., "Environmental Processes I-III", 2nd Edition, Wiley Publications, 2008. 2. Ramalho R.S., "Introduction to Wastewater Treatment", Academic Press, 1977. 3. Bhattacharya B.C. and Ritu Banerjee, "Environmental Biotechnology", Oxford Press, 2007.

	4. Singh D.P. and Dwivedi S.K., "Environmental Microbiology & Biotechnology", New Age International Publishers, 2004. **5.** Martin Alexander, "Biodegradation and Bioremediation", 2nd Edition, Elsevier Science & Technology, 1999.
Reference Books	1. Bruce Rittmann and Perry McCarty, "Environmental Biotechnology: Principles and Applications", 2nd Edition, McGraw Hill, 2020. 2. Pradipta K.M., "Textbook of Environmental Biotechnology", I.K. International Pvt. Ltd., 2007. **3.** Gupta O.P., "Energy Technology", Khannabooks, 2018.
Reference videos	https://youtu.be/hUOTjVm9n1E https://youtu.be/Efh5GkVbhEc https://youtu.be/Qxqg3iHTxUE https://youtu.be/LvqMMfa8ysM https://youtu.be/Xz1gTOXxeDY
Reference NPTEL	https://archive.nptel.ac.in/courses/102/105/102105088/
Reference research/ review articles	1. Khan, S., Anjum, R., Raza, S. T., Bazai, N. A., & Ihtisham, M. (2022). Technologies for municipal solid waste management: Current status, challenges, and future perspectives. Chemosphere, 288, 132403. 2. Rodrigues, R. C., Berenguer-Murcia, Á., Carballares, D., Morellon-Sterling, R., & Fernandez-Lafuente, R. (2021). Stabilization of enzymes via immobilization: Multipoint covalent attachment and other stabilization strategies. Biotechnology advances, 52, 107821. 3. Wang, M., Chen, S., Jia, X., & Chen, L. (2021). Concept and types of bioremediation. In Handbook of bioremediation (pp. 3-8). Academic Press. 4. Jain, A., Sarsaiya, S., Awasthi, M. K., Singh, R., Rajput, R., Mishra, U. C., ... & Shi, J. (2022). Bioenergy and bio-products from bio-waste and its associated modern circular economy: Current research trends, challenges, and future outlooks. Fuel, 307, 121859. 5. Yong, J. J. J. Y., Chew, K. W., Khoo, K. S., Show, P. L., & Chang, J. S. (2021). Prospects and development of algal-bacterial biotechnology in environmental management and protection. Biotechnology advances, 47, 107684.

Course Code	Course Title	L	T	P	C
10211BT117	PLANT AND ANIMAL BIOTECHNOLOGY	3	0	0	3

Course Category	*Program Core*
Preamble	*To have insight knowledge on applications of biotechnology in creating sustainable environment.*
Prerequisite Courses	*Higher Secondary School knowledge*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Summarize the knowledge of isolation, maintenance and growth of cells.	K2
CO2	Illustrate the concepts of micromanipulation technology and transgenic animal technology	K3
CO3	Develop the transgenic plant by gene transfer method with the significant viral vectors.	K3
CO4	Utilize the transgenic plants and plant tissues to produce the therapeutically valuable products.	K3
CO5	Make use of plant tissue culture techniques for various cultures developments.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Summarize the knowledge of isolation, maintenance and growth of cells.	H	L	H	L				L	M			M	H	H	H
CO2	Illustrate the concepts of micromanipulation technology and transgenic animal technology	M	L	L					L				M	L	L	M
CO3	Develop the transgenic plant by gene transfer method with the significant viral vectors.	H	M	H	H	H		L					H	H	M	L

CO4	Utilize the transgenic plants and plant tissues to produce the therapeutically valuable products.	H	L	L	M	M	L	L	L				H	H	H	M
CO5	Make use of plant tissue culture techniques for various cultures developments.	H	L	L	M	M							H	H	H	L

H – High; M- Medium; L- Low

Course Content:

UNIT I	**ANIMAL CELL CULTURE**	**8 hours**

Animal cell culture; media composition and growth conditions; Animal cell and tissue preservation; Anchorage and non-anchorage dependent cell culture; Primary and secondary culture; Animal cell growth characteristics and kinetics; somatic cell fusion; cell cultures as a source of valuable products; organ cultures.

UNIT II	**ADVANCES IN ANIMAL CELL CULTURE**	**8 hours**

Micro & macro- carrier culture; Hybridoma technology; monoclonal antibodies and their use in diagnosis, Stem cell technology; Concepts of transgenic animal technology; strategies for the production of transgenic animals and their importance in biotechnology, Animal cloning, *In vitro* fertilization technology

UNIT III	**PLANT CELL CULTURE**	**10 hours**

Totipotency; Plant growth regulators; Regeneration and micropropagation of plants: clonal propagation, organogenesis, shoot-tip and meristem culture, haploid culture, triploid culture, protoplast culture; Somaclonal variation; Tissue culture and Cell suspension culture system: methodology, growth kinetics and nutrient optimization; Plant Transformation methods (emphasis on Agrobacterium mediated transformation); Hairy root culture; Production of transgenic plants - herbicide resistance, Insect resistance and stress tolerance.

UNIT IV	**SECONDARY METABOLITE PRODUCTION**	**10 hours**

Principles, design and operation of bioreactors: specific design criteria for mammalian and plant systems; Strategies for fermentation with recombinant organisms; Isolation, characterization and production of secondary metabolites from different plant cell types; Plant products of industrial importance, Production of secondary metabolites, Plant derived vaccines.

UNIT V	**PROCESSING OF CELL CULTURES**	**9 hours**

Bioprocess monitoring and control: current practices in the bioprocess industries, advanced methodologies; Overview of downstream processing: centrifugation, filtration and chromatographic techniques.

LEARNING RESOURCES	
Text Books & Reference Books	1. Butterworth Heinemann Ltd., (1994) Biotol Series, In vitro Cultivation of Plant cell. 2. Bhojwani S.S. and Razdan M.K. (1996) Plant Tissue Culture: Theory and Practice, a Revised Edition, Elsevier Science 3. T. A. Brown, (2001) Gene Cloning and DNA Analysis: an Introduction, Blackwell Science. 4. M. L Shuler and F. Kargi. (2002), Bioprocess Engineering, Prentice Hall Inc. 5. A. Slater, N. Scott and M. Fowler (2003), Plant Biotechnology: the Genetic Manipulation of Plants, Oxford University Press. 6. M. M. Ranga (2007), Animal Biotechnology, 3rd Revised Edition, Agrobios. 7. Freshney. (2016) Culture of Animal Cells. 8. Meyer, Handschel, Wiesmann (2009). Fundamentals of Tissue Engineering and Regenerative Medicine. 9. Chawla H.S., "Introduction to Plant Biotechnology", 3rd Edition, Science Publishers, 2009. **10.** Selected Papers from Scientific Journals, particularly Nature & Science.
Reference videos	https://youtu.be/6Wdyyu-vQsU https://youtu.be/U76Ll3OuBsU https://youtu.be/4EAjUK62og4 https://youtu.be/7rI-Lyftpd0 https://youtu.be/Pa2EUPz3vRE
Reference NPTEL	https://archive.nptel.ac.in/courses/102/103/102103016/
Reference research/ review articles	1. Nix, J., Marrella, M. A., Oliver, M. A., Rhoads, M., Ealy, A. D., & Biase, F. H. (2023). Cleavage kinetics is a better indicator of embryonic developmental competency than brilliant cresyl blue staining of oocytes. Animal Reproduction Science, 248, 107174. 2. Tsao, L. C., Force, J., & Hartman, Z. C. (2021). Mechanisms of therapeutic antitumor monoclonal antibodies. Cancer research, 81(18), 4641-4651. 3. Sutradhar, M., & Mandal, N. (2023). Reasons and riddance of Agrobacterium tumefaciens overgrowth in plant transformation. Transgenic Research, 32(1), 33-52. 4. Nasim, N., Sandeep, I. S., & Mohanty, S. (2022). Plant-derived natural products for drug discovery: current approaches and prospects. The Nucleus, 65(3), 399-411. 5. Armstrong, A., Horry, K., Cui, T., Hulley, M., Turner, R., Farid, S. S., ... & Bracewell, D. G. (2021). Advanced control strategies for bioprocess chromatography: Challenges and opportunities for intensified processes and next generation products. Journal of Chromatography A, 1639, 461914.

Course Code	Course Title	L	T	P	C
10211BT305	BIOPROCESS ENGINEERING LABORATORY	0	0	2	1

Course Category	*Program Core*
Preamble	*To comprehend the principles of upstream processing techniques used in Biotechnology*
Prerequisite Courses	*10211BT101 - Microbiology*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Examine the effect of different parameters on the activity of enzymes.	K3, S4
CO2	Infer about the mechanism of substrate- enzyme binding and inhibitor- enzyme binding	K3, S5
CO3	Determine the suitable parameters for higher product recovery by using different optimization methods.	K4, S5
CO4	Analyze the immobilized enzymes and specific growth rate.	K4, S5
CO5	Discover the mass transfer coefficient using different methods	K4, S6

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Examine the effect of different parameters on the activity of enzymes.	H	H	M	H	H	-	-	M	M	H	-	H	H	M	L
CO2	Infer about the mechanism of substrate- enzyme binding and inhibitor-enzyme binding	H	H	M	H	M	-	-	M	M	H	-	H	H	M	L
CO3	Determine the suitable parameters for higher product recovery by using different optimization methods.	H	H	H	H	H	M	M	M	M	H	H	H	H	M	L
CO4	Analyze the immobilized enzymes and specific growth rate.	H	H	M	H	M	-	M	M	M	H	-	M	H	M	L

CO5	Discover the mass transfer coefficient using different methods	H	H	M	H	M	M	H	M	M	H	-	H	H	M	L

H – High; M- Medium; L- Low

Course Content:

LIST OF EXPERIMENTS:

1. Enzyme kinetics – Determination of Michaelis Menten parameters.
2. Effect of temperature and pH on enzyme activity.
3. Enzyme inhibition kinetics.
4. Enzyme immobilization – Gel entrapment and its kinetics.
5. Design of nutritional parameters by Plackett Burman method.
6. Determination of specific growth rate by Monod model.
7. Estimation of batch sterilization kinetics.
8. Estimation of KL_a – Dynamic Gassing-out method.
9. Estimation of KL_a – Sulphite Oxidation Method.
10. Estimation of KL_a – Power Correlation Method.
11. Estimation of Overall Heat Transfer Coefficient.

LEARNING RESOURCES

Reference Books	1. Shuler and Kargi, "Bioprocess Engineering Basic concepts", 2nd Edition, Pearson, 2017. 2. Stanbury P.F., Hall. S.J. and Whitaker. A, "Principles of Fermentation Technology, 3rd Edition, Elsevier, 2017. 3. Bailey J.E. and Ollis D.F., "Biochemical Engineering Fundamentals", 2nd Edition, Tata McGraw-Hill, 2015. 4. Pauline M. Doran, "Bioprocess Engineering Principles", 2nd Edition, Elsevier, 2013. 5. Blanch H.W. and Clark D.S., "Biochemical Engineering", 2nd Edition, Marcel Dekker, 2012.
Virtual Lab	https://vlab.amrita.edu/?sub=3&brch=64&sim=1090&cnt=1 https://vlab.amrita.edu/?sub=3&brch=64&sim=1342&cnt=2 https://bio.libretexts.org/Bookshelves/Biochemistry/Supplemental_Modules_(Biochemistry)/6._Lab_Notes_Part_2/6.2%3A_Enzyme_kinetics https://vlab.amrita.edu/?sub=3&brch=177&sim=1347&cnt=1 https://www.scribd.com/document/90594201/DaveDurden-Using-Plackett-Burman-Partial-Factorial-Designs-for-Method https://www.studocu.com/in/document/dr-br-ambedkar-university/biotechnology/growth-kinetics-monod-model/67179221 https://vlab.amrita.edu/?sub=3&brch=177&sim=1348&cnt=1 https://vlab.amrita.edu/?sub=3&brch=177&sim=1195&cnt=1 https://www.studocu.com/in/document/dr-br-ambedkar-university/biotechnology/determination-of-kla-by-sulphate-oxidation-method/67179211 https://www.studocu.com/in/document/dr-br-ambedkar-university/biotechnology/determination-of-kla-by-power-correlation/67179204 https://vlab.amrita.edu/?sub=1&brch=194&sim=791&cnt=1

Course Code	Course Title	L	T	P	C
10211BT306	DOWNSTREAM PROCESSING LABORATORY	0	0	2	1

Course Category	*Program Core*
Preamble	*To understand and practice the different techniques used in Downstream Processing.*
Prerequisite Courses	*10211BT115 – Analytical and Instrumentation Engineering* *10211BT110 - Bioprocess Engineering* *10211BT305 - Bioprocess Engineering Laboratory*

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

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Analyze the separation efficiency of centrifugation and microfiltration methods to separate solid and liquid	K4, S4
CO2	Compare different cell disturb methods for product recovery	K4, S4
CO3	Examine the protein separation efficiency of different methods	K4, S5
CO4	Distinguish the proteins from other biomolecules by various chromatographic methods	K4, S5
CO5	Choose proper method of polishing (drying) to increase the value of the biological product	K5, S6

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Analyze the separation efficiency of centrifugation and microfiltration methods to separate solid and liquid	H	H	M	H	H	M	M	L	M	H	-	H	H	M	L
CO2	Compare different cell disturb methods for product recovery	H	H	M	H	H	M	-	L	M	H	-	H	H	M	L
CO3	Examine the protein separation efficiency of different methods	H	H	M	H	H	M	M	L	M	H	-	H	H	M	L

CO4	Distinguish the proteins from other bio molecules by various chromatographic methods	H	H	H	H	H	M	M	L	M	H	-	H	H	M	L
CO5	Choose proper method of polishing (drying) to increase the value of the biological product	H	H	M	H	M	M	H	L	M	H	-	H	H	M	L

H – High; M- Medium; L- Low

Course Content:

LIST OF EXPERIMENTS:

1. Solid liquid separation – centrifugation
2. Cell disruption techniques – ultrasonication
3. Precipitation – ammonium sulphate precipitation
4. Membrane separation – Dialysis
5. Batch sedimentation
6. Aqueous two-phase extraction
7. High resolution purification – ion exchange chromatography
8. High resolution purification – affinity chromatography
9. High resolution purification – gel filtration chromatography
10. Product polishing – spray drying, freeze drying (Lyophilization)

LEARNING RESOURCES

Reference Books	1. Belter P.A., Cussler E.L. and Wei-Houhu, "Bioseparations – Downstream Processing For Biotechnology, Wiley Interscience, 1988. 2. Jenkins R.O., "Product Recovery in Bioprocess Technology – Biotechnology", Open Learning Series, Butterworth-Heinemann, 1992. 3. Janson J.C., and Ryden L., "Protein Purification – Principles, High Resolution Methods and Applications", VCH Pub., 1989.
Virtual Lab	https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Organic_Chemistry_Lab_Techniques_(Nichols)/01%3A_General_Techniques/1.05%3A_Filtering_Methods/1.5G%3A_Centrifugation https://www.assaygenie.com/sonication-protocol-for-cell-lysis https://opsdiagnostics.com/applications/samplehomogenization/homogenizationguidepart5.html https://vlab.amrita.edu/?sub=3&brch=70&sim=722&cnt=1 https://www.thermofisher.com/in/en/home/life-science/protein-biology/protein-biology-learning-center/protein-biology-resource-library/protein-biology-application-notes/separation-characteristics-dialysis-membranes.html https://uorepc-nitk.vlabs.ac.in/exp/batch-reactor/theory.html https://openbiotechnologyjournal.com/VOLUME/13/PAGE/27/ https://bio.libretexts.org/Bookshelves/Biochemistry/Fundamentals_of_Biochemistry_(Jakubowski_and_Flatt)/01%3A_Unit_I

	Structure_and_Catalysis/03%3A_Amino_Acids_Peptides_and_Proteins/3.04%3A_Protein_Purification https://www.caframolabsolutions.com/application/homogenizing/protein-affinity-chromatography/ https://conductscience.com/gel-filtration-chromatography-protocol/ https://ajpsonline.com/HTMLPaper.aspx?Journal=Asian%20Journal%20of%20Research%20in%20Pharmaceutical%20Sciences;PID=2016-6-4-10

PHARMACEUTICAL & MEDICAL BIOTECHNOLOGY

Course Code	Course Title	L	T	P	C
10211BT202	BIOINFORMATICS	2	0	2	3

Course Category	*Program Core*
Preamble	*To have insight knowledge on applications of biotechnology in creating sustainable environment.*
Prerequisite Courses	*NIL*

Course Outcomes	***Upon successful completion of the course, students will be able to:***	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Interpret the basics of bioinformatics and different types of biological databases and their growth.	K2
CO2	Demonstrate the sequence alignment and programming algorithms	K2
CO3	Develop the concept and definition of sequence patterns, motifs and profiles.	K3
CO4	Analyze the protein prediction structure algorithms and microarray construction and Protein analysis using bio informatics tools.	K3
CO5	Discover the drug for various diseases by using bioinformatics tools	K4

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Interpret the basics of bioinformatics and different types of biological databases and their growth.	H	H	H	M	H							M		H	
CO2	Demonstrate the sequence alignment and programming algorithms	H	H	H	M	H							M	H	M	
CO3	Develop the concept and definition of sequence patterns, motifs and profiles.	H	H	H	M	H							H	H	M	

CO4	Analyze the protein prediction structure algorithms and microarray construction and Protein analysis using bio informatics tools.	H	H	H	M	H							H	H	L	H
CO5	Discover the drug for various diseases by using bioinformatics tools	H	H	H	M	H							H	H	L	H

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO BIOINFORMATICS**	**9 hours**

Introduction to the biomolecules (DNA, RNA, Proteins, Lipids and Carbohydrates); gene, genome, DNA and Protein sequence, sequence assembly, sequence comparison. Overview of biological databases, nucleic acid & protein databases.

UNIT II	**BIOLOGICAL DATABASES**	**9 hours**

Primary, secondary, composite, structural classification database, Sequence formats & storage, Access databases, GenBank, NCBI, DDBJ, Heuristic approach: BLAST, FASTA in DNA and protein sequence. Protein databases: SwissProt, PIR, PRF, PDB and STRING.

UNIT III	**SEQUENCE ALIGNMENT**	**9 hours**

Introduction to Next Generation Sequencing technologies. Local alignment, Global alignment, Whole Genome Assembly and challenges, Sequencing and analysis of large genomes, Gene prediction, Functional annotation, Comparative genomics, Probabilistic functional gene networks,

UNIT IV	**STRUCTURE ANALYSIS**	**9 hours**

Dynamic programming approach: Needleman and Wunsch Algorithm, Smith and Waterman, Multiple sequence alignment: progressive alignment, iterative alignment, pairwise sequence alignment: CLUSTAL W, Clustal Omega, ClustalW2. Scoring matrices - PAM, BLOSUM, Gaps and penalties, Dot plots.

UNIT V	**BIOINFORMATICS IN DRUG DEVELOPMENT**	**9 hours**

Introduction to drug discovery, genomic sequence and exome data in drug discovery, genetic diseases, human diseases caused by pathogens, drug target identification using bioinformatics, clinical application and other applications of bioinformatics.

LEARNING RESOURCES	
Text Books / Reference Books	1. Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. 2. Bourne, P. E., & Gu, J. (2009). Structural Bioinformatics. Hoboken, NJ: Wiley-Liss. 3. Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press. 4. Campbell, M & Heyer, L. J. (2006), Discovering Genomics, Proteomics and Bioinformatics, Pearson Education. 5. Oprea, T. (2005). Chemoinformatics in Drug Discovery, Volume 23. Wiley Online Library. 6. Gasteiger, J. & Engel,T. (2003), Chemoinformatics: a Textbook, Wiley Online Library.
Reference videos	https://www.youtube.com/watch?v=qhoDiwEX8mI https://www.youtube.com/watch?v=JmKD5SnQtFE https://www.youtube.com/watch?v=jFCD8Q6qSTM https://www.youtube.com/watch?v=ipp-pNRIp4g https://www.youtube.com/watch?v=DhxD6sVQEYc
Reference NPTEL	https://archive.nptel.ac.in/courses/102/106/102106065/
Reference research/ review articles	1. Abarca-Cabrera, L., Fraga-García, P., & Berensmeier, S. (2021). Bio-nano interactions: binding proteins, polysaccharides, lipids and nucleic acids onto magnetic nanoparticles. Biomaterials research, 25(1), 12. 2. Dörpinghaus, J., Weil, V., Schaaf, S., & Apke, A. (2023). Sequence Analysis. In Computational Life Sciences: Data Engineering and Data Mining for Life Sciences (pp. 415-437). Cham: Springer International Publishing. 3. Zheng, S., Wolff, G., Greenan, G., Chen, Z., Faas, F. G., Bárcena, M., ... & Agard, D. A. (2022). AreTomo: An integrated software package for automated marker-free, motion-corrected cryo-electron tomographic alignment and reconstruction. Journal of Structural Biology: X, 6, 100068. 4. Xia, Z., Cui, Y., Zhang, A., Tang, T., Peng, L., Huang, C., ... & Liao, X. (2021). A review of parallel implementations for the Smith–Waterman algorithm. Interdisciplinary Sciences: Computational Life Sciences, 1-14. 5. Zhang, X. M., Liang, L., Liu, L., & Tang, M. J. (2021). Graph neural networks and their current applications in bioinformatics. Frontiers in genetics, 12, 690049.

Course Code	Course Title	L	T	P	C
10211BT116	IMMUNOLOGY AND IMMUNOTECHNOLOGY	3	0	0	3

Course Category	*Program Core*
Preamble	*This introduces and elaborates on the mechanisms involved in Immunology and its implications in life sciences.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Impart the basic knowledge of immune system and to identify the fundamental characteristics of both the innate and adaptive immune systems	K2
CO2	Describe the properties of antigen, antibodies and their interactions	K2
CO3	Demonstrate the antigen presenting cells and its regulations.	K2
CO4	Illustrate the mechanism of hypersensitivity, autoimmunity and the concept of vaccination.	K2
CO5	Apply various analytical techniques for different immunological diagnosis	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Impart the basic knowledge of immune system and to identify the fundamental characteristics of both the innate and adaptive immune systems	H	M										H	H		
CO2	Describe the properties of antigen, antibodies and their interactions	M	H	H									H	H	H	
CO3	Demonstrate the antigen presenting cells and its regulations.	H	H	M	M				H				H	H	H	L

CO4	Illustrate the mechanism of hypersensitivity, autoimmunity and the concept of vaccination.	H	H	M	M				H				H	H	H	L
CO5	Apply various analytical techniques for different immunological diagnosis	H	H	H	H	H	M		M				H	H	H	H

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO IMMUNE SYSTEM**	**9 hours**

Introduction to immunology; cells of the immune system: types of immune response; lymphoid organs: primary and secondary lymphoid organs; Natural killer Cells. Activation and differentiation of T-cells and B-cells; Receptors and Signaling: T- cell and B-cell receptors.

UNIT II	**ANTIGEN AND ANTIBODY INTERACTION**	**9 hours**

Antibodies: structure, gene organization and functions; antigens: chemical andmolecular nature; haptens; adjuvants; B and T-cell epitopes; antigenic determinants on antibodies; antigen-antibody reactions; Monoclonal and Polyclonal antibodies: principles and applications-Hybridoma technology.

UNIT III	**ANTIGEN PROCESSING AND PRESENTATION**	**9 hours**

Classes of MHC – MHC/HLA genetic loci. Molecular structure and assembly of MHC molecules, Antigen presenting cells- antigen processing and presentation; regulation of T-cell and B-cell responses; cytokines.

UNIT IV	**AUTOIMMUNITY, HYPERSENSITIVITY AND IMMUNODEFICIENCY**	**9 hours**

Autoimmunity, Auto immune diseases: systemic and organ specific autoimmune disorders, proposed mechanisms for induction of Autoimmunity, Treatment of Autoimmune diseases; complement system; immunosuppression- Graft versus host reaction; tolerance; allergy and hypersensitivity - Types of hypersensitivity; Immunodeficiency -AIDS; Vaccines-resistance and immunization.

UNIT V	**IMMUNO-TECHNIQUES**	**9 hours**

Immunoelectrophoresis, ELISA, RIA, non-isotopic methods for detection of antigens, Immunoprecipitaion, chemiluminescence assay, immunohistochemistry, purification techniques of antigens and antibodies. Flowcytometry, FISH, application of recombinant DNA

technology for the study of the immune system, Immunotherapy with genetically engineered antibodies.	
LEARNING RESOURCES	
Text Books	1. Kuby J., "Immunology", WH Freeman & Co., 2000. 2. Roitt I., MaleBrostoff.,"Immunology", Mosby Publ., 2002.
Reference Books	1. Ashim K. Chakravarthy, "Immunology", TataMcGraw-Hill, 1998. 2. Coico Richard, "Immunology: A Short Course", 5th Edition, John Wiley, 2003. 3. Khan, Fahim Halim, "Elements of Immunology", Pearson Education, 2009.
Reference videos	https://www.youtube.com/watch?v=xQiF2ZwI2uo https://www.youtube.com/watch?v=GzuM_nfrXLk https://www.youtube.com/watch?v=R69M7NuBNBA https://www.youtube.com/watch?v=v2najhx2PPs https://www.youtube.com/watch?v=ERk0hwqhyDw
Reference NPTEL	https://archive.nptel.ac.in/courses/102/105/102105083/
Reference research/ review articles	1. Varadé, J., Magadán, S., & González-Fernández, Á. (2021). Human immunology and immunotherapy: main achievements and challenges. Cellular & Molecular Immunology, 18(4), 805-828. 2. Megha, K. B., & Mohanan, P. V. (2021). Role of immunoglobulin and antibodies in disease management. International journal of biological macromolecules, 169, 28-38. 3. Naito, T., & Okada, Y. (2022, January). HLA imputation and its application to genetic and molecular fine-mapping of the MHC region in autoimmune diseases. In Seminars in immunopathology (Vol. 44, No. 1, pp. 15-28). Berlin/Heidelberg: Springer Berlin Heidelberg. 4. Nymark, L. S., Miller, A., & Vassall, A. (2021). Inclusion of additional unintended consequences in economic evaluation: a systematic review of immunization and tuberculosis cost-effectiveness analyses. PharmacoEconomics-open, 1-17. 5. Ahsan, H. (2022). Monoplex and multiplex immunoassays: approval, advancements, and alternatives. Comparative clinical pathology, 31(2), 333-345.

Course Code	Course Title	L	T	P	C
10211BT307	IMMUNOLOGY LABORATORY	0	0	2	1

Course Category	*Program Core*
Preamble	*To understand and practice the Immunological techniques.*
Prerequisite Courses	*NIL*

Course Outcomes	***Upon successful completion of the course, students will be able to:***	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Make use of the animal handling techniques for in vivo studies.	K3, S2
CO2	Identify and classify the cells and blood group.	K3, S3
CO3	Analyze the antibody and antigen interactions by qualitative and quantitative methods.	K4, S4
CO4	Distinguish the peripheral blood mononuclear cells and monocytes from the blood.	K4, S5
CO5	Discover and localize wide variety of antigens by immunochemical methods.	K4, S5

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Make use of the animal handling techniques for in vivo studies.	H	M	M	H	M	M	-	H	M	H	-	H	H	H	H
CO2	Identify and classify the cells and blood group.	H	H	M	H	M	M	-	L	M	H	-	H	H	H	H
CO3	Analyze the antibody and antigen interactions by qualitative and quantitative methods.	H	H	H	H	H	M	-	L	M	H	-	H	H	H	H
CO4	Distinguish the peripheral blood mononuclear cells and monocytes from the blood.	H	H	M	H	M	M	-	L	M	H	-	H	H	H	H
CO5	Discover and localize wide variety of antigens by immunochemical methods.	H	H	H	H	H	M	-	L	M	H	-	H	H	H	H

H – High; M- Medium; L- Low

Course Content:	
LIST OF EXPERIMENTS:	
1. Handling of animals, immunization and raising antisera. 2. Identification of leukocytes from blood smear by differential staining (Geimsa stain). 3. Separation of Peripheral Blood Mononuclear Cells (PBMC) by Ficoll –Hypaque. 4. Isolation of monocytes from blood. 5. Agglutination reaction to determine blood group. 6. Immunodiffusion and immunoelectrophoresis. 7. Enzyme Linked Immuno Sorbent Assay (ELISA). 8. Testing for typhoid antigens by Widal test. 9. Identification of T cells by T-cell rossetting using sheep RBC. 10. Western blotting.	
LEARNING RESOURCES	
Reference Books	1. Roitt I, Male, Brostoff,"Immunology", Mosby Publ., 2002. 2. Kuby J, "Immunology", 7th Edition, WH Freeman & Co., 2013. 3. Ashim K. Chakravarthy, "Immunology", TataMcGraw-Hill, 1998. 4. Edward A. Greenfield, Dana-Farber, "Antibodies: A Laboratory Manual", Second Edition, Cancer Institute, Cold Spring Harbour Laboratory, 2014.
Virtual Lab	https://www.sinobiological.com/resource/antibody-technical/pab-production https://www.macsenlab.com/blog/giemsa-stain-overview/ https://www.stemcell.com/isolating-mononuclear-cells-from-whole-blood-by-density-gradient-centrifugation.html https://www.reprocell.com/blog/cls/protocol-isolating-pbmcs-whole-blood https://www.medicine.mcgill.ca/physio/vlab/bloodlab/ABO_n.htm https://microbenotes.com/immunoelectrophoresis-principle-procedure-results-and-applications-advantages-and-limitations/ https://bio.libretexts.org/Bookshelves/Biotechnology/Lab_Manual%3A_Introduction_to_Biotechnology/01%3A_Techniques/1.17%3A_ELISA https://www.metropolisindia.com/blog/health-wellness/widal-test-introduction-principle-procedure-preparation-price#:~:text=The%20Widal%20test%20is%20an,threatening%20illnesses%20like%20typhoid%20fever. https://www.stemcell.com/products/brands/rosettesep-immunodensity-cell-separation.html https://vlab.amrita.edu/?sub=3&brch=187&sim=1331&cnt=2

PROGRAM ELECTIVE COURSES
VTR UGE 2021

INDUSTRIAL DOMAIN

Course Code	Course Title	L	T	P	C
10212BT101	FLUID MECHANICS AND TRANSPORT PHENOMENA	3	0	0	3

Course Category	*Program Elective*
Preamble	*To understand the basic concepts of fluid mechanics and transport phenomena and its application in biological system.*
Prerequisite Courses	*10211BT112 – Unit Operations in Biotech Industry*

Course Outcomes — *Upon successful completion of the course, students will be able to:*

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Summarize the fundamentals of fluid mechanics.	K2
CO2	Explain the process involved in transport phenomena.	K2
CO3	Utilize the momentum transport of different operations.	K3
CO4	Develop the knowledge about energy transport.	K3
CO5	Apply the concepts of transport phenomena in biological system.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Summarize the fundamentals of fluid mechanics.	H	H		H	H							H	H	H	
CO2	Explain the process involved in transport phenomena.	H	H		H	H							H	H	H	
CO3	Utilize the momentum transport of different operations.	H	H	H	H	H							H	H	H	
CO4	Develop the knowledge about energy transport.	H	H	M	H	H							H	H	H	
CO5	Apply the concepts of transport phenomena in biological system.	H	H	H	H	H							H	H	H	

H – High; M- Medium; L- Low

Course Content:		
UNIT I	**BASICS OF FLUID MECHANICS**	**9 hours**
Fluid definition and classification, Rheological behaviour of fluids & Newton's Law of viscosity. – Density, specific gravity, specific weight, surface tension, vapour pressure and viscosity. Fluid statics-Pascal's law, Hydrostatic equilibrium, Barometric equation and pressure measurement(problems),Basic equations of fluid flow – Continuity equation, Euler's equation and Bernoulli equation, Reynolds experiment; Flow through circular and non-circular conduits – Hagen Poiseuille equation (no derivation).Flow past immersed bodies – drag and drag co-efficient, application of KozneyKarmen& Burke Plummer equation; Flow through stagnant fluids – theory of Settling and Sedimentation –Equipment (cyclones, thickners) Conceptual numerical.		
UNIT II	**INTRODUCTION TO TRANSPORT PHENOMENA**	**9 hours**
Philosophy and fundamentals of transport phenomena: Importance of transport phenomena; analogous nature of transfer process; basic concepts, conservation laws. Molecular transport of momentum, Heat and mass, laws of molecular transport, Newton's law of viscosity, Fourier law of heat conduction, and Fick's law of diffusion. Transport coefficients – viscosity, thermal conductivity and mass diffusivity.		
UNIT III	**MOMENTUM TRANSPORT**	**9 hours**
Viscosity, temperature effect on viscosity of gases and liquids, Newton's law, mechanism of momentum transport, shell balance method, pressure and velocity distributions in falling film, circular tube, annulus, slit.		
UNIT IV	**ENERGY TRANSPORT**	**9 hours**
Thermal conductivity, temperature and pressure effect on thermal conductivity of gases and liquids, Fourier's law, mechanism of energy transport, shell energy balance, temperature distribution in solids and laminar flow, with electrical, nuclear, viscous, chemical heat source, heat conduction through composite walls, cylinders, spheres, fins, slits.		
UNIT V	**TRANSPORT PHENOMENA IN MICROBIAL SYSTEM**	**9 hours**
Unified theory of momentum, energy and mass transfer; Flow and mixing of Newtonian and non-Newtonian fluids; Gas-liquid mass transfer in microbial systems; Oxygen transfer rates; Single and multiple bubble aeration; Design of spargers and aeration equipment; Mass transfer across free surface as well as freely rising or falling bodies; Basic concept of oxygen transfer coefficient (KLa) and its measurement; Correlation of KLa with other operating variables; Factors affecting the KLa.		

LEARNING RESOURCES	
Text Books	1. Bird R.B., Stewart W.E. and LighfootE.W., "Transport Phenomena", John Wiley, New York, 1960. 2. Wilty J.R., Wilson R.W. and Wicks C.W., "Fundamentals of Momentum Heat and Mass Transfer",5th Edition, John Wiley, New York, 2007.
Reference Books	1. Christie J. Geankopolis, "Transport Processes and Separation Process Principles", 4th Edition, PrenticeHall, 2015. **2.** Shuler M.L. and FikretKargi, "Bioprocess Engineering: Basic Concepts", 2nd Edition, Prentice Hall, 2001.
Reference videos	https://youtu.be/d6N9kShpzLA https://youtu.be/m6FmA0nclM8 https://youtu.be/KM_BstD6wbI https://youtu.be/hDP6egLrsdM https://youtu.be/_5I7v0r6Vfg https://youtu.be/O9VL-QHpxiU
Reference NPTEL	https://archive.nptel.ac.in/courses/112/105/112105269/
Reference research/ review articles	1. Patra, A. K., Nayak, M. K., & Misra, A. (2020). Viscosity of nanofluids-A Review. Int. J. Thermofluid Sci. Technol, 7(2), 070202. 2. Junker, M. A., te Brinke, E., Compte, C. M. V., Lammertink, R. G., de Grooth, J., & de Vos, W. M. (2023). Asymmetric polyelectrolyte multilayer nanofiltration membranes: Structural characterisation via transport phenomena. Journal of Membrane Science, 681, 121718. 3. Karmakar, A., & Acharya, S. (2021). Numerical simulation of falling film flow hydrodynamics over round horizontal tubes. International Journal of Heat and Mass Transfer, 173, 121175. 4. Hummel, M., Müller, A., Forthuber, S., Kranzl, L., Mayr, B., & Haas, R. (2023). How cost-efficient is energy efficiency in buildings? A comparison of building shell efficiency and heating system change in the European building stock. Energy Efficiency, 16(5), 32. 5. Deaton, K. E., de León, L. R. L., Pascual, S., & Deshusses, M. A. (2022). Critical assessment of gassing-in methods to determine mass transfer coefficient in miniature and microbioreactors with gas-liquid flow. Biochemical Engineering Journal, 187, 108655.

Course Code	Course Title	L	T	P	C
10212BT102	BIOENERGY	3	0	0	3

Course Category	*Program Elective*
Preamble	*This course introduces the basics of Bioenergy and proceeds to explain the basic and advanced concepts, culminating in sustainability concepts.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Outline the basic concepts and types of Bioenergy and their global impact.	K2
CO2	Illustrate the various Biomass conversion technologies to obtain the bio substrates	K2
CO3	Utilize the biomass feed stock to produce biofuel	K3
CO4	Develop biofuel by using microbial technology and nanotechnology concepts with higher yield.	K3
CO5	Analysis the life cycles of biofuel generators in environment for sustainability maintenance	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Outline the basic concepts and types of Bioenergy and their global impact.	H					H	H					H	H	H	M
CO2	Illustrate the various Biomass conversion technologies to obtain the bio substrates	H			H		H	H	H				H	H	H	H
CO3	Utilize the biomass feed stock to produce biofuel	H	H	H	H		H	H	M				H	H	H	H

CO4	Develop biofuel by using microbial technology and nanotechnology concepts with higher yield.	H	H	M	H		H	M	M				H	M	M	H
CO5	Analysis the life cycles of biofuel generators in environment for sustainability maintenance	H	H	H	H	H							H	H	H	H

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO BIOENERGY**	**9 hours**

Introduction to energy and energy sources, Classification of energy, Environmental impacts of the conventional and renewable sources, Indian and global energy sources, issues, Concept of Bioenergy.

UNIT II	**BIOMASS CONVERSION TECHNOLOGIES**	**9 hours**

Energy crops: wood (Lignocellulose), Microbial degradation, Bioenergy technologies: Thermochemical and biochemical, Thermochemical: Incineration, Combustion, Pyrolysis, Liquefaction, gasification, Fischer-Tropsch process for liquid biofuels, Hydrolysis, Enzyme and acid hydrolysis, Fermentation.

UNIT III	**BIOFUELS**	**9 hours**

Introduction to First, Second and Third generation biofuels, Biomass and feedstock for first, second and third generation biofuels, development of new biomass feedstocks and technical constraints, Approximate and ultimate analysis of Biomass, Biomass logistics involved in harvesting, collecting, densification, transport and storage.

UNIT IV	**ADVANCED BIOENERGY CONCEPTS**	**9 hours**

Advanced bioenergy concepts, Microbial fuel cells, working principle and applications of biological fuel cells, Biocoal, Nanotechnology and its role in Bioenergy, Advanced low carbon fuels.

UNIT V	**BIOENERGY AND SUSTAINABILITY**	**9 hours**

Sustainability, Environmental sustainability, Bioenergy & sustainability, Life Cycle Analysis I: General understanding, Cradle-to-grave, field to wheels concepts, Goal and scope determination, defining LCA boundaries; Life Cycle Analysis II, Life Cycle Inventory, Life Cycle Assessment.

LEARNING RESOURCES	
Reference Books	1. Chakraverthy A, "Biotechnology and Alternative Technologies for Utilization ofBiomass or Agricultural Wastes", Oxford & IBH publishing Co., 1989. 2. Mital K.M, "Biogas Systems: Principles and Applications", New Age International publishers (P) Ltd., 1996. 3. NijagunaB.T., "Biogas Technology", New Age International publishers (P) Ltd., 2002. 4. Venkata Ramana P. and Srinivas S.N, "Biomass Energy Systems", Tata EnergyResearch Institute, 1996. 5. Tiwari G.N. and Ghosal M., "Renewable Energy Resources: Basic Principles and Applications",Narosa Publishing House, India, 2004. 6. David M. Mousdale, "Biofuels: Biotechnology, Chemistry, and Sustainable Development', CRC Press, 2008. 7. Gupta, Vijai Kumar, Tuohy, Maria G., "Biofuel Technologies RecentDevelopments", Springer, 2013.
Reference videos	https://youtu.be/Zgp86PVXXuQ https://youtu.be/txRnYTzrb6o https://youtu.be/rjbq_Q0yEbo https://youtu.be/bECIaInLmRw https://youtu.be/_iiAcuOO-Ds
Reference NPTEL	**https://archive.nptel.ac.in/courses/102/104/102104057/**
Reference research/ review articles	1. Anca-Couce, A., Hochenauer, C., & Scharler, R. (2021). Bioenergy technologies, uses, market and future trends with Austria as a case study. Renewable and Sustainable Energy Reviews, 135, 110237. 2. Zang, G., Sun, P., Elgowainy, A. A., Bafana, A., & Wang, M. (2021). Performance and cost analysis of liquid fuel production from H2 and CO2 based on the Fischer-Tropsch process. Journal of CO2 Utilization, 46, 101459. 3. Wang, Y., Wang, J., Schuler, J., Hartley, D., Volk, T., & Eisenbies, M. (2020). Optimization of harvest and logistics for multiple lignocellulosic biomass feedstocks in the northeastern United States. Energy, 197, 117260. 4. Obileke, K., Onyeaka, H., Meyer, E. L., & Nwokolo, N. (2021). Microbial fuel cells, a renewable energy technology for bio-electricity generation: A mini-review. Electrochemistry Communications, 125, 107003. 5. Calvin, K., Cowie, A., Berndes, G., Arneth, A., Cherubini, F., Portugal-Pereira, J., ... & Smith, P. (2021). Bioenergy for climate change mitigation: Scale and sustainability. GCB Bioenergy, 13(9), 1346-1371.

Course Code	Course Title	L	T	P	C
10212BT103	FOOD PROCESSING TECHNOLOGY	3	0	0	3

Course Category	*Program Elective*
Preamble	*To understand the importance and techniques of food processing.*
Prerequisite Courses	*10211BT101 - Microbiology*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Infer the various constituents of food, their sources and properties.	K2
CO2	Identify and select the additives that aid in food processing.	K2
CO3	Utilize the knowledge of beneficial microorganisms in food processing and preservation.	K2
CO4	Identify the various food borne diseases such as food infections and intoxications caused by food spoilage.	K2
CO5	Make use of food preservation (sterilization, pasteurization and blanching) methods to increase the life time to food	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Infer the various constituents of food, their sources and properties.	H		H	M								H	H	H	M
CO2	Identify and select the additives that aid in food processing.	H	M	H	L								H	H	H	H
CO3	Utilize the knowledge of beneficial microorganisms in food processing and preservation.	H	M	M	M								H	H	H	H

CO4	Identify the various food borne diseases such as food infections and intoxications caused by food spoilage.	H	M	M			H	H	H				H	M	M	H
CO5	Make use of food preservation (sterilization, pasteurization and blanching) methods to increase the life time to food	H	H	H	H	H							H	H	H	H

H – High; M- Medium; L- Low

Course Content:

UNIT I	**FOOD AND ENERGY**	**9 hours**

Constituents of food – carbohydrates, lipids, proteins, water, vitamins and minerals, dietary sources, role and functional properties in food, contribution to organoleptic and textural characteristics.

UNIT II	**FOOD ADDITIVES**	**9 hours**

Classification, intentional and non-intentional additives, functional role in foodprocessing and preservation; food colorants – natural and artificial; food flavors; enzymes as food processing aids

UNIT III	**MICROORGANISMS ASSOCIATED WITH FOOD**	**9 hours**

Bacteria, yeasts and molds – sources, types and species of importance in foodprocessing and preservation; fermented foods and food chemicals, single cell protein.

UNIT IV	**FOOD BORNE DISEASE**	**9 hours**

Classification – food infections – bacterial and other types; food intoxications and poisonings – bacterial and non-bacterial; food spoilage – factors responsible for spoilage, spoilage of vegetable, fruit, meat, poultry, beverage and other food products.

UNIT V	**FOOD PRESERVATION**	**9 hours**

Principles involved in the use of sterilization, pasteurization and blanching, thermal death curve of microorganisms, canning; frozen storage-freezing characteristics of foods, microbial activity at low temperatures, traditional methods of foodpreservation- picking, salting, sun drying.

LEARNING RESOURCES

Text Books	1. CoultateT.P., "Food – The Chemistry of Its Components", 2nd Edition, Royal Society, London, 1992.

	2. SivasankarB., "Food Processing and Preservation", Prentice-Hall of India Pvt. Ltd., New Delhi, 2002.
Reference Books	1. FrazierW.C.andWesthoffD.C., "Food Microbiology", 4th Edition, McGraw-Hill Book Co., New York, 1988. **2.** JayJ.M., "Modern Food Microbiology", Cbs Pub., New Delhi, 1987.
Reference videos	https://www.youtube.com/watch?v=OjhbTvyR-Ts https://www.youtube.com/watch?v=jSgILz https://www.youtube.com/watch?v=W81V-d36y5k&list=PL1-n1zj2ZzWtztfCAebd5ORTBRMr55dpu https://www.youtube.com/watch?v=L3pI6CISTZE https://www.youtube.com/watch?v=wWLm290vamg
Reference NPTEL	https://archive.nptel.ac.in/courses/126/105/126105011/
Reference research/ review articles	1. Cuéllar, A. D., & Webber, M. E. (2010). Wasted food, wasted energy: the embedded energy in food waste in the United States. Environmental science & technology, 44(16), 6464-6469. 2. Sowbhagya, H. B., & Chitra, V. N. (2010). Enzyme-assisted extraction of flavorings and colorants from plant materials. Critical reviews in food science and nutrition, 50(2), 146-161. 3. Elkenany, R., Eltaysh, R., Elsayed, M., Abdel-Daim, M., & Shata, R. (2022). Characterization of multi-resistant Shigella species isolated from raw cow milk and milk products. The Journal of veterinary medical science, 84(7), 890–897. https://doi.org/10.1292/jvms.22-0018 4. Lorenzo, J. M., Munekata, P. E., Dominguez, R., Pateiro, M., Saraiva, J. A., & Franco, D. (2018). Main Groups of Microorganisms of Relevance for Food Safety and Stability: General Aspects and Overall Description. Innovative Technologies for Food Preservation, 53–107. https://doi.org/10.1016/B978-0-12-811031-7.00003-0 5. Ferreira, S. M., Matos, L. C., & Santos, L. (2024). Harnessing the potential of chestnut shell extract to enhance fresh cheese: A sustainable approach for nutritional enrichment and shelf-life extension. Journal of Food Measurement and Characterization, 18(2), 1559-1573.

Course Code	Course Title	L	T	P	C
10212BT104	AGRICULTURAL BIOTECHNOLOGY	3	0	0	3

Course Category	*Program Elective*
Preamble	*To comprehend the knowledge and applications of biotechnology in agriculture field.*
Prerequisite Courses	*NIL*

Course Outcomes	***Upon successful completion of the course, students will be able to:***	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Understand the basic concepts of normal and hybrid plant cells development for agricultural applications.	K2
CO2	Apply the various genetic engineering tools and methods to improve the growth and production of plant.	K2
CO3	Solve plant growth promotion related problems in agricultural field with organic products with microbes and biomass.	K2
CO4	Apply proper plan for rare species conservation and degradation of materials by plants	K2
CO5	Make use of ethical knowledge of GM for agricultural development	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand the basic concepts of normal and hybrid plant cells development for agri cultural applications.	H		L	M			L					H	H	M	
CO2	Apply the various genetic engineering tools and methods to improve the growth and production of plant.	H	H	M	M	M	H	M	M				H	H	M	L

CO3	Solve plant growth promotion related problems in agricultural field with organic products with microbes and biomass.	H		L	M		H	H	H				H	H	H	H
CO4	Apply proper plan for rare species conser vation and degradation of materials by plants	H	H	L	H		H	M	H				H	H	M	H
CO5	Make use of ethical knowledge of GM for agricultural development	H	M	H	M		H	H	M				H	H	M	M

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION**	**9 hours**

Basic concepts of Agriculture, Role of Genetic engineering for increasing crop productivity, Agricultural Applications of Genetic Engineering, : shoot - tip - cultures, shoot - tip - grafting, viricidal compound, Protoplast isolation: culture and fusion, selection of hybrid cells and regeneration of hybrid plants, somatic hybridization, Introducing genes into pro-and eukaryotes using gene transfer methods, DNA mediated and Agrobacterium mediated transfers, microinjection, electroporation, somatic cell hybridization.

UNIT II	**GENETIC ENGINEERING TECHNOLOGIES IN AGRICULTURE**	**9 hours**

Techniques for the insertion of genes into plant cells, Ti plasmid and vectors, (i) Transgenic plants (ii) Gene cloning, Restriction Fragment Length Polymorphisms, Transposons, and Insertional mutagenesis. Molecular Farming: Plants As factories for biopharmaceuticals, Transgenic value added specialty crops, Use of antisense RNA and other technologies, Developing stress tolerant varieties, vaccine and antibody producing plants. Terminator technology, Introduction of male sterility through genetic engineering. Genetic engineering in improving nitrogen fixation in plants.

UNIT III	**BIOFERTILIZERS AND ORGANIC FARMING**	**9 hours**

Biofertilizer: Mass cultivation of microbial inoculants, green manuring, algalization, Azolla. Microbial products and plant health: PGPR (plant growth promoting Rhizobacteria), significance of mycorrhizae, toxin producing microbes (antibiotics, aflatoxin, and others), microbial herbicides, Organic Farming: Introduction and sustainable use of natural and bioresources, Organic standards and certification of organic produce and products, Biological control, Global initiatives and future prospects.

UNIT IV	BIODIVERSITY AND ENVIRONMENTAL PRESERVATION	9 hours
Preservation of rare plant species germplasm collection and conservation, Soil Reclamation: Phytoremediation		
UNIT V	**ISSUES IN AGRICULTURE AND FOOD SECURITY**	**9 hours**
World Food Security: Causes of food insecurity, social economic issues, ensuring food security, BIS regulations, GM food, GM Crops – Ethical challenges.		
LEARNING RESOURCES		
Reference Books	1. Arie Altman, "Agricultural Biotechnology', Marcel Dekker, Inc., 2001. 2. Henry R.J., "Practical applications of Plant Molecular Biology", Chapman & Hall London, UK, 1997. 3. Chrispeels M.J. and Sadava D.E., "Plants, Genes and Crop Biotechnology", 2nd Edition, American Society of Plant Biologists, Jones and Bartlett Publishers, USA, 2003. 4. Lindsey K, Jones M.G.K., "Plant biotechnology In Agriculture", Prentice hall, 1990. 5. Bhojwani S.S. and Razdan M.K., "Plant Tissue culture Theory and Practice", Elsevier Science, Netherlands, 2004.	
Reference videos	https://www.youtube.com/watch?v=ICv9o3dexrc https://www.youtube.com/watch?v=Un_LA9s9y-E https://www.youtube.com/watch?v=2wStx02R_qg https://www.youtube.com/watch?v=dtKThKBq454 https://www.youtube.com/watch?v=tLMW96vkduI https://www.youtube.com/watch?v=iyT0wTEPOO8	
Reference NPTEL	https://onlinecourses.nptel.ac.in/noc24_ag08/preview	
Reference research/ review articles	1. Ye, R., Yang, X., & Rao, Y. (2022). Genetic Engineering Technologies for Improving Crop Yield and Quality. Agronomy, 12(4), 759. https://doi.org/10.3390/agronomy12040759 2. Aziz, Mughair Abdul, Faical Brini, Hatem Rouached, and Khaled Masmoudi. "Genetically engineered crops for sustainably enhanced food production systems." Frontiers in Plant Science 13 (November 8, 2022). https://doi.org/10.3389/fpls.2022.1027828. 3. Aloo, Becky N., Vishal Tripathi, Billy A. Makumba, and Ernest R. Mbega. "Plant growth-promoting rhizobacterial biofertilizers for crop production: The past, present, and future." Frontiers in Plant Science 13 (September 16, 2022). https://doi.org/10.3389/fpls.2022.1002448. 4. "Origins of food crops connect countries worldwide." Proceedings - Royal Society. Biologica Sciences/Proceedings - Royal Society. Biological Sciences 283, no. 1832 (June 15, 2016): 20160792. https://doi.org/10.1098/rspb.2016.0792. 5. Ahmad, N., Alam, Z., SK, S., & Husain, M. (2021). Food insecurity: concept, causes, Effects and Possible Solutions. IAR Journal of Humanities and Social Science, 2(1), 105-113.	

Course Code	Course Title	L	T	P	C
10212BT105	ALGAL BIOTECHNOLOGY	3	0	0	3

Course Category	*Program Elective*
Preamble	*To have an in depth knowledge on the various aspects of algal growth and development.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Utilize the sterilization techniques to prepare medium for micro algae cultivation	K2
CO2	Develop the micronutrient enriched microalgal with proper cultivation techniques.	K3
CO3	Identify the physiochemical parameters for microalgae cultivation at pilot and industrial level.	K3
CO4	Utilize the microalgae biomass for various industrial product separation and commercialization.	K3
CO5	Make use of the microalgae to produce the biofuel in freshwater and marine water.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Utilize the sterilization techniques to prepare medium for micro algae cultivation	H					H	H					H	H	H	M
CO2	Develop the micronutrient enriched microalgal with proper cultivation techniques.	H		H	H		H	H	H				H	H	H	H
CO3	Identify the physiochemical parameters for microalgae cultivation at pilot and industrial level.	H	H	H	H	M	H	H	M				H	H	H	H

CO4	Utilize the microalgae biomass for various industrial product separation and commercialization.	H		H	H			M	M				H	M	M	H
CO5	Make use of the microalgae to produce the biofuel in freshwater and marine water.	L	H	L	H	H							H	H	H	H

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO ALGAE**	**9 hours**

Classification and systematic, occurrence and distribution. Structure of microalgae. Nutrition, media-marine and fresh water culture media. Types of media and sterilization techniques. Microalgal pigments–PC, PE and APC. Photo-chromatic effects and their adaptations of microalgae. Culture methods. Measurement of growth.

UNIT II	**GROWTHANDCULTIVATIONOFALGAE**	**9 hours**

Microalgae Basic cultural techniques. Indoor (photobioreactor) and open pond mass culture methods, biotechnological approaches for production of important microalgae. Single cell protein from Spirulina, race way system of microalgae culture, vitamins, minerals and omega3fatty acids from microalgae, enrichment of microalgae with micronutrients.

UNIT III	**ALGAE INBIOTECHNOLOGY**	**9 hours**

Marine and freshwater microalgae. An integral event in the development of algae and higher organisms. Spirulina: Superfood and Medicine. UV-B Radiation induced stress and protection strategies in cyanobacteria. Growth Response of cyanobacteria from sandy soil and mine waste burdened; Soil to different environmental variables; Prospective in diatom nanotechnology.

UNIT IV	**APPLICATIONOFALGALBIOTECHNOLOGY**	**9 hours**

Biotechnological applications of microalgae. Biotechnological Relevance of Microbes in Agriculture. Role of Blue Green Algae in Rice Production. Responses of Rice Field Cyanobacteria to Insecticides and fungicides. Lipids and Fatty Acids from Marine microalgae: A Potential Biofuel Resource, Algal Biodiesel: Procedures and Resources for Laboratory Study. Industrial Utilization of microalgal Fatty Acids. Cyanobacterial Toxins and Public Health.

UNIT V	**ALGAE ASA FUEL–ANAPPLICATION**	**9 hours**

Algae Fuel, Type, Freshwater algae, Marine algae, Production, Treatment process, Application.

LEARNING RESOURCES

Text Books	1. Wolfgang E.,"Microalgae: Biotechnology and Microbiology", Cambridge University Press, 1994. 2. Robert A. Andersen, "Algae Culturing Techniques", Elsevier academicpress, 2005.
Reference Books	1. Stevenson R.J., "Algal Ecology", Academic Press,1996. 2. Robert Edward Lee, "Phycology", Cambridge University press,2008.
Reference videos	https://www.youtube.com/watch?v=UbxNCG8xEy0&list=PLgrPoGl4jGdoYfkcMnTsP8Aj5EDOE7Rk-

	https://www.youtube.com/watch?v=IJPfaqXbm0A https://www.youtube.com/watch?v=F2kSA70Ivig https://www.youtube.com/watch?v=bEl_a8vVVvQ https://www.youtube.com/watch?v=IKsYzZfXIEk
Reference NPTEL	https://onlinecourses.swayam2.ac.in/cec23_bt22/preview
Reference research/ review articles	1. Kumar, P.S., Thomas, J. Seasonal distribution and population dynamics of limnic microalgae and their association with physico-chemical parameters of river Noyyal through multivariate statistical analysis. Sci Rep 9, 15021 (2019). https://doi.org/10.1038/s41598-019-51542-w 2. Nalley, J. O., O'Donnell, D. R., & Litchman, E. (2018). Temperature effects on growth rates and fatty acid content in freshwater algae and cyanobacteria. Algal research, 35, 500-507. 3. Dwivedi, S., & Ahmad, I. Z. (2023). Evaluation of the effect of UV-B radiation on growth, photosynthetic pigment, and antioxidant enzymes of some cyanobacteria. Environmental Research, 218, 114943. 4. Haldar, C., Ram, R., Kumar, S., & Menna, L. L. (2018). Microalgae as a potential source of biofuels and its current advances. Examines Mar Biol Oceanogr, 2(1). 5. Faried, M., Samer, M., Moselhy, M. A., Yousef, R. S., Ali, A. S., Ahmed, R. H., ... & Abdelsalam, E. M. (2024). Photobiostimulation of green microalga Chlorella sorokiniana using He–Ne red laser radiation for increasing biodiesel production. Biomass Conversion and Biorefinery, 14(1), 117-131.

Course Code	Course Title	L	T	P	C
10212BT106	NANOBIOTECHNOLOGY AND APPLICATION	3	0	0	3

Course Category	*Program Elective*
Preamble	*To study the advancement of Nanobiotechnology and its application in medical field.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Illustrate the basics of nanotechnology and its synthesis process.	K2
CO2	Demonstrate the techniques used in nanotechnology.	K2
CO3	Extend the importance of nano in biotechnology.	K2
CO4	Outline the applications of nano devices in medical field.	K2
CO5	Build the strong knowledge about drug delivery process with the help of nano particles.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Illustrate the basics of nanotechnology and its synthesis process.	H	L	M	M								H	H	H	
CO2	Demonstrate the techniques used in nanotechnology.	H	M	H	H								H	H	H	
CO3	Extend the importance of nano in biotechnology.	H	H	H	H		H	H					H	H	H	L
CO4	Outline the applications of nano devices in medical field.	H	H	M			H	L					M	M	H	L
CO5	Build the strong knowledge about drug delivery process with the help of nano particles.	H	H	M	M			L					H	H	H	

H – High; M- Medium; L- Low

Course Content:		
UNIT I	**BASICS OF NANOTECHNOLOGY**	**9 hours**
A Brief History and development of Nanotechnology, Definition of nanotechnology, Nano*bio*technology v/s Bionanotechnology, Bottom-Up versus Top-Down approaches; Methods of synthesis of nanoparticles or fabrication, Surface property relationship.		
UNIT II	**METHODS IN NANOTECHNOLOGY**	**9 hours**
Types of Nanomaterials, Characterization techniques by SEM, TEM, Atomic force microscopy, Dynamic light scattering (DLS), XRD. Surface Plasmon resonance (SPR), Raman shift, FTIR.		
UNIT III	**BIONANOTECHNOLOGY**	**9 hours**
Lipid Bilayers, liposomes, neosomes, Polysacharides, Peptides, Nucleic acids, DNA scaffolds, Enzymes, Biomolecular motors: linear, rotary mortors, Immunotoxins, Membrane transporters and pumps; *S*-layer proteins: structure, chemistry and assembly; engineered Nanopores.		
UNIT IV	**CLINICAL APPLICATIONS OF NANODEVICES**	**9 hours**
Artificial neurons. Real-time nanosensors- Synthetic retinyl chips based on bacteriorhodopsins. High throughput DNA sequencing with nanocarbon tubules, Nanoparticles for Bioanalytical Applications; Applications in cancer biology.		
UNIT V	**NANOPARTICLES IN DRUG DELIVER**	**9 hours**
Delivery of Nanoparticles: Brain Delivery, Ocular Drug Delivery, Gene Delivery Systems and Carriers in Cancer Therapy; Natural polymers in tissue engineering applications, Degradable polymers for tissue engineering, Controlled release strategies in tissue engineering and Nanotoxicology.		

LEARNING RESOURCES	
Text Books	1. David S Goodsell, "Bionanotechnology", John Wiley & Sons, 2004. 2. Christof M. Niemeyer, Chad A. Mirkin, "Nanobiotechnology: Concepts, Applications and Perspectives", 1st Edition, Wiley-VCH, 2006. 3. Charles P. Poole Jr. and Frank J. Owens, "Introduction to Nanotechnology", A Wiley-Interscience publication, India, 2003.
Reference Books	1. Bernd Rehm, "Microbial bionanotechnology: Biological Self-Assembly Systems and Biopolymer-Based Nanostructures", Taylor and Francis, 2006. 2. Salata O.V.,"Applications of nanoparticles in biology & medicine", Journal of nanobiotechnology, 2004. 3. Vladimir P Torchilin, "Nanoparticulates Drug Carriers", Imperial College Press, 2006.
Reference videos	https://youtu.be/DAOFpgocfrg https://youtu.be/a0G7iyz4McM https://youtu.be/J5pWH1r3pgU https://youtu.be/psJ5J0daSsk https://youtu.be/wYnCYq93c9s

Reference NPTEL	**https://archive.nptel.ac.in/courses/118/107/118107015/**
Reference research/ review articles	1. Harish, V., Ansari, M. M., Tewari, D., Gaur, M., Yadav, A. B., García-Betancourt, M. L., ... & Barhoum, A. (2022). Nanoparticle and nanostructure synthesis and controlled growth methods. Nanomaterials, 12(18), 3226. 2. Patil, R. M., Deshpande, P. P., Aalhate, M., Gananadhamu, S., & Singh, P. K. (2022). An Update on Sophisticated and Advanced Analytical Tools for Surface Characterization of Nanoparticles. Surfaces and Interfaces, 33, 102165. https://doi.org/10.1016/j.surfin.2022.102165. 3. Lu, D., Wu, P., Yang, W., Wang, Y., Yang, J., Zhang, G., Wang, C., Yang, L., Zhu, L., & Sun, Z. (2023). Recent advances in lipid nanovesicles for targeted treatment of spinal cord injury. Frontiers in Bioengineering and Biotechnology, 11. https://doi.org/10.3389/fbioe.2023.1261288 4. Ohshiro, T. (2021). Nanodevices for Biological and Medical Applications: Development of Single-Molecule Electrical Measurement Method. Applied Sciences, 12(3), 1539. https://doi.org/10.3390/app12031539 5. Mundekkad, D., & Cho, W. C. (2022). Nanoparticles in Clinical Translation for Cancer Therapy. International Journal of Molecular Sciences, 23(3). https://doi.org/10.3390/ijms23031685

Course Code	Course Title	L	T	P	C
10212BT107	FERMENTATION TECHNOLOGY	3	0	0	3

Course Category	*Program Elective*
Preamble	*This course provides the importance of process involved in fermentation and its application in various field.*
Prerequisite Courses	*10211BT101 – Microbiology* *10211BT110 – Bioprocess Engineering*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Extend the basic idea towards fermentation processes.	K2
CO2	Interpret the Instrumentation and control involved in the fermentation process.	K2
CO3	Demonstrate the recovery and purification of fermentation products.	K2
CO4	Construct the Effluent treatment involved in fermentation process.	K3
CO5	Build the Fermentation economics involved in commercial aspect.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Extend the basic idea towards fermentation processes.	M	L	L										M	M	
CO2	Interpret the Instrumentation and control involved in the fermentation process.	M	L	L									L	M	L	H
CO3	Demonstrate the recovery and purification of fermentation products.	M	L	L									L	M		H
CO4	Construct the Effluent treatment involved in fermentation process.	M	L	L									L	M	M	L

CO5	Build the Fermentation economics involved in commercial aspect.	M	L	L								M	L	M	L	H

H – High; M- Medium; L- Low

Course Content:

UNIT I	**AN INTRODUCTION TO FERMENTATION PROCESS**	**9 hours**

Microbial Biomass, Microbial Enzymes, Microbial Metabolites, Recombinant Products, Transformation Process, Microbial Growth, Isolation and Preservation.

UNIT II	**INSTRUMENTATION AND CONTROL**	**9 hours**

Temperature measurement and its control, Flow measurement and control, gases and liquids, pressure measurement and control analysis, control system.

UNIT III	**IIIRECOVERY AND PURIFICATION OF FERMENTATION PRODUCTS**	**9 hours**

Microbial Cells removal, Separation of foam, Filtration via Precipitation, Different Filtration Process, Centrifugation, Different Centrifuge Cell Description, Recovery methods, Solvent Recovery, Supercritical fluid Extraction, Chromatography, Membrane Processes, Drying, Crystallization, Whole Broth Processing.

UNIT IV	**EFFLUENT TREATMENT**	**9 hours**

Strength of Fermentation Effluent, Treatment and Disposal, Treatment Processes: Physical, Chemical and Biological, Aerobic Process, Anaerobic Treatment.

UNIT V	**FERMENTATION ECONOMICS**	**9 hours**

Introduction to Isolation of microorganisms of industrial interest, Strain improvement, Market potential, Plant and equipment, Media, air sterilization, heating and cooling, recovery costs.

LEARNING RESOURCES

Text Books	1. Stanbury P., "Principles of Fermentation Technology', ButtuworthHanman, 1999. 2. Haber C.C. and William Andrew,"Fermentation and Biochemical Engineering Handbook", IIndEdition, 2007. 3. Hydersen B.K., Nancy A.Dela, NelsenK.L.,"Bioprocess Engineering', Wiley Interscience, 1994.
Reference videos	https://youtu.be/JOuGdhl_hWU https://youtu.be/vSIJ8e7IpMI https://youtu.be/SnbXQTTHGs4 https://youtu.be/Qc63YTeNrh8 https://youtu.be/QRItTCQVAb4
Reference NPTEL	https://archive.nptel.ac.in/courses/118/107/118107015/

Reference research/ review articles	1. Amin, F., Bhatti, H. N., & Bilal, M. (2019). Recent advances in the production strategies of microbial pectinases—A review. International journal of biological macromolecules, 122, 1017-1026. 2. Schmidt, F. R. (2005). Optimization and scale up of industrial fermentation processes. Applied microbiology and biotechnology, 68, 425-435. 3. Parente, E. U. G. E. N. I. O., & Ricciardi, A. (1999). Production, recovery and purification of bacteriocins from lactic acid bacteria. Applied microbiology and biotechnology, 52, 628-638. 4. Judd, S. J. (2016). The status of industrial and municipal effluent treatment with membrane bioreactor technology. Chemical Engineering Journal, 305, 37-45. 5. Sharma, D., Saini, A., Sharma, D., & Saini, A. (2020). Fermentation Economics and Future Prospects. Lignocellulosic Ethanol Production from a Biorefinery Perspective: Sustainable Valorization of Waste, 217-227.

Course Code	Course Title	L	T	P	C
10212BT108	PROTEIN ENGINEERING	3	0	0	3

Course Category	*Program Elective*
Preamble	*To study and characterize the protein structure with its application.*
Prerequisite Courses	*10212BT144 – Advanced Biochemistry* *10212BT143 - Computational Biology: Techniques and Applications*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Illustrate the interaction of proteins with various bonds using electromagnetic radiation.	K2
CO2	Model the primary, secondary and super secondary structure of proteins with respective dimensions.	K3
CO3	Make use of basic structural knowledge about proteins to understand the tertiary and quaternary structure.	K3
CO4	Apply the spectroscopic methods to study the protein characters	K3
CO5	Utilize the engineering techniques to modify the proteins for various medical and industrial applications.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Illustrate the interaction of proteins with various bonds using electro magnetic radiation.	H		M									M	H	M	
CO2	Model the primary, secondary and super secondary structure of proteins with respective dimensions.	H		H	H	H							H	H	H	
CO3	Make use of basic structural knowledge about proteins to understand the tertiary and quaternary structure.	H	H	H		H							H	H	H	

CO4	Apply the spectroscopic methods to study the protein characters	H	M	M	L	H	M						H	H	H	L
CO5	Utilize the engineering techniques to modify the proteins for various medical and industrial applications.	H		H	H	H							H	H	H	

H – High; M- Medium; L- Low

Course Content:

UNIT I	**BONDS, ENERGIES, BUILDING BLOCKS OF PROTEINS**	**9 hours**

Covalent, Ionic, Hydrogen, Coordinate, hydrophobic and Vander walls interactions in protein structure. Interaction with electromagnetic radiation (radio, micro, infrared, visible, ultraviolet, X-ray) and elucidation of protein structure.

UNIT II	**PROTEIN ARCHITECTURE**	**9 hours**

Primary structure: peptide mapping, peptide sequencing - automated Edman method &Protein Engineering and Design: Methods in protein engineering and design – physical, computational, biochemical and molecular techniques; High-throughput protein sequencing setup Secondary structure: Alpha, beta and loop structures and methods to determine Super-secondary structure: Alpha-turnalpha, beta-turn- beta (hairpin), beta-sheets, alpha-beta-alpha, topology diagrams, up and down & TIM barrel structures nucleotide binding folds.

UNIT III	**TERTIARY STRUCTURE**	**9 hours**

Prediction of substrate binding sites, Tertiary structure: Domains, folding, denaturation and renaturation, overview of methods to determine 3D structures. Quaternary structure: Modular nature, formation of complexes, protein-protein interactions and methods.

UNIT IV	**CHARACTERIZATION OF PROTEINS**	**9 hours**

NMR spectroscopy, crystallography, spectroscopic and calorimetric methods.

UNIT V	**APPLICATIONS OF PROTEIN ENGINEERING**	**9 hours**

Design of polymeric biomaterials, nicotinic acetylcholine receptors as a model for a super family of ligand - gated ion channel proteins.

LEARNING RESOURCES

Text Books	1. Branden C and Tooze J., "Introduction to Protein Structured", 2nd Edition, GarlanPublishing, 1999. 2. Thomas E. Creighton, "Protein Structure and Protein function", Oxford University Press, 2ndEdition, 2003.

Reference Books	1. LiLiaAlberghina, "Protein engineering in industrial biotechnology", Harwood academic publication, 2003.
Reference videos	https://youtu.be/YbNKagnCwis https://youtu.be/k9mydcmkXGk https://youtu.be/9IrPVXn-x5k https://youtu.be/RZLew6Ff-JE https://youtu.be/BYW7IzqxdWQ
Reference NPTEL	https://archive.nptel.ac.in/courses/106/105/106105230/
Reference research/ review articles	1. Ferruz, N., Schmidt, S., & Höcker, B. (2021). ProteinTools: a toolkit to analyze protein structures. Nucleic acids research, 49(W1), W559-W566. 2. Wakolbinger, S., Geisenhof, F. R., Winterer, F., Palmer, S., Crimmann, J. G., Watanabe, K., ... & Weitz, R. T. (2020). Locally-triggered hydrophobic collapse induces global interface self-cleaning in van-der-Waals heterostructures at room-temperature. 2D Materials, 7(3), 035002. 3. Georgakopoulos-Soares, I., Chan, C. S., Ahituv, N., & Hemberg, M. (2022). High-throughput techniques enable advances in the roles of DNA and RNA secondary structures in transcriptional and post-transcriptional gene regulation. Genome biology, 23(1), 159. 4. Reif, B., Ashbrook, S. E., Emsley, L., & Hong, M. (2021). Solid-state NMR spectroscopy. Nature Reviews Methods Primers, 1(1), 2. 5. Wittenberg, R. E., Wolfman, S. L., De Biasi, M., & Dani, J. A. (2020). Nicotinic acetylcholine receptors and nicotine addiction: A brief introduction. Neuropharmacology, 177, 108256.

Course Code	Course Title	L	T	P	C
10212BT109	PROCESS INSTRUMENTATION AND DYNAMIC CONTROL	3	0	0	3

Course Category	*Program Elective*
Preamble	*To introduce control equipment used to control the production process of a chemical factory and to introduce the control mechanism through automation and computers.*
Prerequisite Courses	*10211BT110 – Bioprocess Engineering*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Classify instruments for the measurement of pressure, temperature, fluid flow and liquid level.	K2
CO2	Understand the dynamic behavior of bioprocesses	K2
CO3	Understand the mathematical models in biochemical engineering systems	K3
CO4	Classify biosensors and transducers used in bioprocesses	K4
CO5	Analyze stability of feedback control system.	K4

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Classify instruments for the measurement of pressure, temperature, fluid flow and liquid level.	H	H	H	H	M							M	H	H	M
CO2	Understand the dynamic behavior of bioprocesses	H	H	H	H	H	L						M	H	H	M
CO3	Understand the mathematical models in biochemical engineering systems	H	H	H	H	H	M						M	H	H	M
CO4	Classify biosensors and transducers used in bioprocesses	H	H	H	H	H	M						M	H	H	M

CO5	Analyze stability of feedback control system.	H	H	H	H	H	M						M	H	H	L

H – High; M- Medium; L- Low

Course Content:

UNIT I	**PROCESS INSTRUMENTATION**	**9 hours**

Principles of measurements and classification of process control instruments, measurements of temperature, pressure, fluid flow, liquid weight and weight flow rate, viscosity and consistency, pH, concentration, electrical and thermal conductivity, humidity of gases, composition by physical and chemical properties.

UNIT II	**BIOPROCESSINSTRUMENTATION**	**9 hours**

Monitoring and control of bioreactors, Biochemical Reactor Instrumentation, physical, chemical and bio-chemical parameters, Introduction to flow, pressure, temperature, pH, foam, DO, redox and level measurements, sensors for medium and gases; Online and offline monitoring.

UNIT III	**MATHEMATICAL MODELS FOR BIOCHEMICAL ENGINEERING SYSTEMS**	**9 hours**

Continuous flow tanks– mixing vessel– mixing with reaction-reversible reaction. Steam jacketed vessel-boiling of single component liquid-open and closed vessel-continuous boiling system-Batch distillation.

UNIT IV	**BIOSENSORS**	**9 hours**

Types, Transducers in biosensors- calorimetric, optical, potentiometric / amperometric, conductometric / resistometric, piezoelectric, semiconductor, mechanical and molecular electronics based, molecular wires and switches, development of molecular arrays as memory stores, design for a biomolecular photomic computers-information processing.

UNIT V	**INSTRUMENTATION AND CONTROL**	**9 hours**

Physical and chemical sensors for the medium and gases, online and offline sensors, process control- Concept of Cascade control, Selective control system, split range control, Feed forward & Feedback control, Ratio control, Adaptive control and Inferential control. Computer based control– Basic functional elements, Computer interfaces for fermentation process and Cascade control of metabolism.

LEARNING RESOURCES	
Text Books	1. Coughnowr and Koppel, "Process Systems Analysis and Control", McGraw-Hill, New York, 1986. 2. George Stephanopolous, "Chemical Process Control", Prentice-Hall of India Pvt. Ltd., New Delhi, 1990. 3. Luben W.L., "Process Modelling Simulation and Control for Chemical Engineers", McGraw Hill International, New York, 1990.
Reference Books	1. Ekman D.P., "Industrial Instrumentation", Wiley, 1978. 2. Shulerand Kargi, "Bioprocess Engineering, Prentice Hall, 2002. 3. Bailey and Ollis, "Biochemical engineering fundamentals", McGraw Hill, 2003. 4. Tarun K Ghosh, "Biotechnology and bioprocess engineering: Proceedings, VII international biotechnology symposium, Delhi, 2004.
Reference videos	https://youtu.be/DUsSWd4ZRUo https://youtu.be/FNRUzG9EVuc https://youtu.be/A7Gb7sF4sjk https://youtu.be/6Y5FDMw65O4 https://youtu.be/z7_g7euL2nE
Reference NPTEL	https://archive.nptel.ac.in/courses/103/105/103105064/
Reference research/ review articles	1. Salehi, F., & Inanloodoghouz, M. (2024). Modeling the effect of ultrasound on viscosity, consistency coefficient, and flow behavior index of different concentrations of xanthan gum. Journal of food science and technology (Iran), 21(146), 158-168. 2. Wei, Y., Cheng, G., Ho, H. P., Ho, Y. P., & Yong, K. T. (2020). Thermodynamic perspectives on liquid–liquid droplet reactors for biochemical applications. Chemical Society Reviews, 49(18), 6555-6567. 3. Dallinger, D., Gutmann, B., & Kappe, C. O. (2020). The concept of chemical generators: on-site on-demand production of hazardous reagents in continuous flow. Accounts of chemical research, 53(7), 1330-1341. 4. Polat, E. O., Cetin, M. M., Tabak, A. F., Bilget Güven, E., Uysal, B. Ö., Arsan, T., ... & Gül, S. B. (2022). Transducer technologies for biosensors and their wearable applications. Biosensors, 12(6), 385. 5. Alarcon, C., & Shene, C. (2021). Fermentation 4.0, a case study on computer vision, soft sensor, connectivity, and control applied to the fermentation of a thraustochytrid. Computers in Industry, 128, 103431.

Course Code	Course Title	L	T	P	C
10212BT110	BIOREACTOR DESIGN AND INSTRUMENTATION CONTROL	3	0	0	3

Course Category	*Program Elective*
Preamble	*To understand various types of process equipment, principles involved in their function, and its industrial applications.*
Prerequisite Courses	*10211BT112 – Unit Operations in Biotech Industry* *10211BT110 – Bioprocess Engineering*

Course Outcomes	***Upon successful completion of the course, students will be able to:***	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Outline the operational procedures for bioreactors.	K2
CO2	Demonstrate the suitable P&I symbols used in P&IDs for the bioprocess plant design.	K2
CO3	Construct and scale-up the bioreactors with transport phenomena.	K3
CO4	Examine and classify the Bioreactor with industrial modelling	K4
CO5	Interpret the reactor optimization principles for the design of bioreactors for industrially important biological products, primary and secondary products.	K5

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Outline the operational procedures for bioreactors.	H	H	H	H	M							M	H	H	M
CO2	Demonstrate the suitable P&I symbols used in P&IDs for the bioprocess plant design.	H	H	H	H								M	H	H	M
CO3	Construct and scale-up the bioreactors with transport phenomena.	H	H	H	H								M	H	H	M
CO4	Examine and classify the Bioreactor with industrial modelling	H	H	H	H								M	H	H	M

CO5	Interpret the reactor optimization principles for the design of bioreactors for industrially important biological products, primary and secondary products.	H	H	H	H								M	H	H	L

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO BIOREACTOR DESIGN**	**9 hours**

Basics and importance of bioreactors - Guidelines for bioreactor design- Mechanical aspects of bioreactor design- Requirements for construction of a bioreactor- Development of bioreactors- Instrumentation to control a bioreactor- Common operations of bioreactor

UNIT II	**DESIGN CRITERIA AND SCALE-UP**	**9 hours**

Design criteria for airlift, bubble column, and chemostat bioreactors, power requirements for Newtonian/non-Newtonian broths and gassed fluids, Bioreactor scale-up based on constant power consumption per volume (P/V), mixing time, shear, mass transfer coefficients, Effect of variables on bioreactor performance while scaling up: aeration and agitation, mixing, sterilization of media and bioreactor, inoculum development, nutrient availability, shear, pH, and Temperature.

UNIT III	**TRANSPORT PHENOMENA AND SCALEUP OF BIOREACTORS**	**9 hours**

Transport phenomena in bioreactors- Parameters influencing transfer operations- Scale-up of bioreactors-Criteria of scale-up- Scale-up methods- Generalized approaches to scale-up in combination of methods.

UNIT IV	**INDUSTRIAL MODELLING OF REACTORS**	**9 hours**

Bioreactor modelling, the batch fermenter, the chemostat, the fed batch fermenter, biomass productivity, modelling of tubular plug flow bioreactors, gas absorption with bioreaction in the liquid phase,liquid-liquid extraction with bioreaction in one phase, steady-state gas balance for the biological uptake rate, determination of kla using the sulfite oxidation reaction determination of kla by a dynamic method, model for oxygen gradients in a bubble column bioreactor , model for a multiple impeller fermenter.

UNIT V	**SIMULATION EXAMPLES OF BIOLOGICAL REACTION**	**9 hours**

Processes using BerkeleyMadonna, batch fermentation (batferm), chemostat fermentation (chemo), fed batch fermentation (fedbat), kinetics of enzyme action (mmkinet), repeated fed

batch culture (repfed), lineweaver-burk plot (lineweav), steady-state chemostat (chemosta), variable volume fermentation (varvol and varvold), penicillin fermentation using elemental balancing (penferm), fluidized bed recycle reactor (fbr).	
LEARNING RESOURCES	
Text Books	1. Brownell L.E. and Young E.H.,"Process Equipment Design", Wiley India Pvt. Ltd., 2015. 2. Dunn J., Heinzle E., Ingham J., Pfenosil J.E., "Biological Reaction Engineering: Dynamic Modelling Fundamentals with Simulation Examples", Wiley, 2003. 3. Bailey J.E. and OllisD.F., "Biochemical Engineering Fundamentals", McGraw Hill, 2010. 4. Joshi M.V. and MahajaniV.V.,"Process Equipment Design", MacMillan Company of India Ltd., 2009. 5. Atkinson B. and Mavituna F., "Biochemical Engineering and Biotechnology Handbook", 2nd Edition, McGraw Hill, 1993.
Reference Books	1. Sinnott R.K., "Chemical Engineering Series: An Introduction to Chemical Engineering Design", Maxwell Macmillan Pergamon Publishing Corporation, 2005. 2. McCabe W.L. and Smith J.C., "Unit Operations in Chemical Engineering", McGraw-Hill, 1976. 3. Stanbury P.F., Whitaker A. and Hall S.J., "Principles of Fermentation Technology", 2ndEdition, 1997. 4. Vogel H.C., "Fermentation and Biochemical Engineering Handbook: Principles, Process design, and Equipment", Noyes Publications, 1983. 5. Shule and Kargi, "Bioprocess Engineering", Prentice Hall, Second Indian Reprint, 2004. 6. Harvey W. Blanch and Duoglas S. Clark, "Biochemical Engineering", Marcel Dekker Inc., 1997. 7. Pauline Doran, "Bioprocess Engineering Principles", Academic Press, 2012.
Reference videos	https://youtu.be/azdVSr7DBlg https://youtu.be/jj92shxeFeU https://youtu.be/7zhA4s0QI6U?list=PL1A176s4-oBlXPqB7uzUzfkmZhMpIsrdS https://youtu.be/XApUZukvbmQ https://youtu.be/fuM13fVk0CA
Reference NPTEL	https://archive.nptel.ac.in/courses/102/106/102106086/
Reference research/ review articles	1. Mitra, S., & Murthy, G. S. (2022). Bioreactor control systems in the biopharmaceutical industry: A critical perspective. Systems Microbiology and Biomanufacturing, 1-22. 2. Amani, A., Balcázar, N., Naseri, A., & Rigola, J. (2020). A numerical approach for non-Newtonian two-phase flows using a conservative level-set method. Chemical Engineering Journal, 385, 123896. 3. Khairnar, S. V., Pagare, P., Thakre, A., Nambiar, A. R., Junnuthula, V., Abraham, M. C., ... & Dyawanapelly, S. (2022). Review on the scale-up

methods for the preparation of solid lipid nanoparticles. Pharmaceutics, 14(9), 1886.
4. Maluta, F., Paglianti, A., & Montante, G. (2021). Two-fluids RANS predictions of gas cavities, power consumption, mixing time and oxygen transfer rate in an aerated fermenter scale-down stirred with multiple impellers. Biochemical Engineering Journal, 166, 107867.
5. Marcoline, F. V., Furth, J., Nayak, S., Grabe, M., & Macey, R. I. (2022). Berkeley Madonna Version 10–A simulation package for solving mathematical models. CPT: pharmacometrics & systems pharmacology, 11(3), 290-301.
6. Todros, S., Spadoni, S., Maghin, E., Piccoli, M., & Pavan, P. G. (2021). A novel bioreactor for the mechanical stimulation of clinically relevant scaffolds for muscle tissue engineering purposes. Processes, 9(3), 474.

Course Code	Course Title	L	T	P	C
10212BT111	VALORISATION	3	0	0	3

Course Category	*Program Elective*
Preamble	*This course enables the student to become familiarize in the conversion of waste material to valuable products or extraction of high value products from waste is an important emergent concept.*
Prerequisite Courses	*NIL*

Course Outcomes	***Upon successful completion of the course, students will be able to:***	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Understand the basic concepts in transformation of biomass to valuable product.	K2
CO2	Comprehend about the chemical, thermal and thermos chemical methods for conversion of biological material	K2
CO3	Utilize the biomass to produce Biofertilizer and Biofuels	K3
CO4	Planning for Valorization with respect to environmental factors and economical factors	K3
CO5	Solve the biomass accumulation issue by degradation technology and recovering processes.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand the basic concepts in trans formation of biomass to valuable product.	H	M				H	H	H				M	H	M	L
CO2	Comprehend about the chemical, thermal and thermos chemical methods for conversion of biological material	H	H	H	M		H	H	M				M	H	H	M
CO3	Utilize the biomass to produce Biofertilizer and Biofuels	H	M	H	M		L	M	H				M	H	H	
CO4	Planning for Valorization with respect to environmental factors and economic factors	H		H	H		M	M	L			H	M	H	H	M

CO5	Solve the biomass accumulation issue by degradation technology and recovering processes.	H		M	M	H		M					M	H	H	L

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION**	**9 hours**

Waste to wealth concept, Role of Biotechnology in waste to wealth, Understanding waste, Biomass, Energy concepts, physical, chemical and biological aspects of raw material transformation (bio- transformations, extraction, separation and purification of bio-molecules, solid-state reactives, shaping divided solids).

UNIT II	**WASTE TO WEALTH TECHNOLOGIES**	**9 hours**

Waste to energy technologies: Thermal (Direct combustion and Incineration), Thermo-chemical (Torrefaction, Plasma treatment, Gasification and Pyrolysis) and Biochemical (Composting, Ethanol fermentation and Anaerobic Digestion),Flow chemistry principles.

UNIT III	**CONVERSION TECHNOLOGIES AND CONCEPTS**	**9 hours**

Microbial bio degradation of waste, Biofertilizer, Biofuels, Bio oil, Biogas.

UNIT IV	**ECONOMIC FACTORS OF VALORISATION**	**9 hours**

GM Biotechnology and Valorization, Introduction to gene manipulated Environmental biotechnology, applications, Factors underlying Valorization from used natural resources, Market dynamics of Valorization, Minimal waste policies

UNIT V	**EMERGENT TECHNOLOGIES**	**9 hours**

Plasma technology, Torrefaction, Landfill gas recovery, Products from Incineration, Lignocellulosic degradation.

LEARNING RESOURCES

Reference Books	1. Robert Gumisiriza, Joseph FunaHawumba, Mackay Okure and Oliver Hensel, "Biomass waste-to-energy valorisation technologies: a review case for banana processing in Uganda", Biotechnology for Biofuels, 10 (11), 2017. 2. MirjamKnockaert, SophieManigart, SofieCattoird, WillyVerstraete, "A perspective on the economic valorization of gene manipulated biotechnology: Past and future", Biotechnology Reports, 6, 2015.
Reference videos	https://youtu.be/wP-YJsQLhzg https://youtu.be/ZH9O3CpfWrs https://youtu.be/LvqMMfa8ysM https://youtu.be/EghnZaNrnS8

	https://youtu.be/fFsXsUA0704
Reference NPTEL	https://nptel.ac.in/courses/126105023
Reference research/ review articles	1. Corrêa, P. S., Morais Júnior, W. G., Martins, A. A., Caetano, N. S., & Mata, T. M. (2020). Microalgae biomolecules: Extraction, separation and purification methods. Processes, 9(1), 10. 2. Oliveira, M., Ramos, A., Ismail, T. M., Monteiro, E., & Rouboa, A. (2022). A review on plasma gasification of solid residues: recent advances and developments. Energies, 15(4), 1475. 3. Ru, J., Huo, Y., & Yang, Y. (2020). Microbial degradation and valorization of plastic wastes. Frontiers in Microbiology, 11, 507487. 4. Sharma, M., Usmani, Z., Gupta, V. K., & Bhat, R. (2021). Valorization of fruits and vegetable wastes and by-products to produce natural pigments. Critical Reviews in Biotechnology, 41(4), 535-563. 5. Domonkos, M., Tichá, P., Trejbal, J., & Demo, P. (2021). Applications of cold atmospheric pressure plasma technology in medicine, agriculture and food industry. Applied Sciences, 11(11), 4809.

Course Code	Course Title	L	T	P	C
10212BT112	ENVIRONMENTAL BIOTECHNOLOGY	3	0	0	3

Course Category	*Program Elective*
Preamble	*To study the basic concepts and emergent trends and techniques in Environmental Biotechnology.*
Prerequisite Courses	*10211BT114 – Green Biotechnology & Pollution Abatement*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Demonstrate the basic dynamics of the Environment and Environmental pollution.	K2
CO2	Illustrate the implications of Biological wastewater treatment.	K2
CO3	Infer the various types and management methods involved in Solid waste management.	K2
CO4	Identify the importance of air pollution in Environmental perspective.	K3
CO5	Analyze and apply the various concepts in current and emergent environmental biotechnology.	K4

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Demonstrate the basic dynamics of the Environment and Environmental pollution.	H	H		H	H		H	H				H	H	H	M
CO2	Illustrate the implications of Biological wastewater treatment.	H		H	M	M		M	H				H	H	H	L
CO3	Infer the various types and management methods involved in Solid waste management.	H	H	L	H	L	H	M	H				H	H	H	M

CO4	Identify the importance of air pollution in Environmental perspective.	H	M	L	H	M	H	H	M				H	H	H	M
CO5	Analyze and apply the various concepts in current and emergent environmental biotechnology.	H	L	M	L	H	L	M	M				H	H	H	

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO ENVIRONMENTAL BIOTECHNOLOGY**	**9 hours**

Introduction to Environment, Ecosystem and Biodiversity concepts; Introduction to Environmental Pollution, types of Pollutants; Introduction to Microbial degradation and decay, Bioremediation technologies and their role in environmental protection and conservation, Introduction to modern wastes such as E-Waste.

UNIT II	**BIOLOGICAL WASTEWATER TREATMENT**	**9 hours**

Introduction to Water and Wastewater treatment, Principles and Microbiology of Water and Wastewater treatment, Aerobic and Anaerobic wastewater treatment, Types and operation of aerobic and anaerobic digesters used in wastewater treatment, Phytoremediation of contaminated effluents.

UNIT III	**SOLID WASTE MANAGEMENT**	**9 hours**

Introduction to solid waste, Principles of solid waste management, Types and design of Landfills, Introduction to composting technologies, Bioenergy recovery from solid waste.

UNIT IV	**AIR POLLUTION MANAGEMENT**	**9 hours**

Introduction to air pollution, Role of aerosols and droplet nuclei, Methods of controlling air pollution by biotechnology, Odour control using biological methods, Control of air borne pathogens in human and livestock.

UNIT V	**MAJOR CONCEPTS IN ENVIRONMENTAL BIOTECHNOLOGY**	**9 hours**

Introduction to Environmental Genetics, Factors involving release of genetically engineered organisms into environment, Direct and Indirect mechanisms of Biooxidation, Biomonitoring, Bioleaching and Biomining, Introduction to Metagenomics and Metablomics, Conventional and emergent techniques used in Environmental Biotechnology.

LEARNING RESOURCES	
Text Books	1. Rittmann B. and McCarty P., "Environmental Biotechnology: Principles and Applications", McGraw-Hill, 2006. 2. Bhattacharya B.C. and Ritu Banerjee, "Environmental Biotechnology", Oxford Press, 2007.
Reference Books	1. Scargg A., "Environmental Biotechnology", Longman, 1999. 2. Wainwright M., "An Introduction to Environmental Biotechnology", Kluwer Academic Press, 1999. 3. Singh D.P. and Dwivedi S.K., "Environmental Microbiology & Biotechnology", New Age International Publishers, 2004.
Reference videos	https://youtu.be/FHyrZASHCck https://youtu.be/oD5tb6pSCSc https://youtu.be/94Qqzbz7hZE https://youtu.be/5QxrZz6QYFI https://youtu.be/iFkY5Ltl9Gk
Reference NPTEL	https://archive.nptel.ac.in/courses/102/105/102105088/
Reference research/ review articles	1. Díaz, S., & Malhi, Y. (2022). Biodiversity: Concepts, patterns, trends, and perspectives. Annual Review of Environment and Resources, 47, 31-63. 2. Kumar, V. (2021). Phytoremediation of distillery effluent: current progress, challenges, and future opportunities. Bioremediation for Environmental Sustainability, 349-374. 3. Ochieng, R., Gebremedhin, A., & Sarker, S. (2022). Integration of waste to bioenergy conversion systems: a critical review. Energies, 15(7), 2697. 4. Quintana, Á. R., Seseña, S., Garzón, A., & Arias, R. (2020). Factors affecting levels of airborne bacteria in dairy farms: A review. Animals, 10(3), 526. 5. Pekkala, S. (2023). Fecal metagenomics and metabolomics identifying microbial signatures in non-alcoholic fatty liver disease. International Journal of Molecular Sciences, 24(5), 4855.

Course Code	Course Title	L	T	P	C
10212BT113	ENZYME TECHNOLOGY AND BIOTRANSFORMATION	3	0	0	3

Course Category	*Program Elective*
Preamble	*To have insight knowledge about the applications of enzymes and biotransformation.*
Prerequisite Courses	*10212BT144 – Advanced Biochemistry*

Course Outcomes	***Upon successful completion of the course, students will be able to:***	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Classify the different types of enzymes.	K2
CO2	Relate the single and multi-substrate reactions in enzyme kinetics and inhibition.	K2
CO3	Utilize the principles and techniques involved in enzyme kinetics and immobilization for its application in biosensors.	K3
CO4	Select and characterize the enzymes from different sources.	K3
CO5	Experiment with enzymatic biotransformation for various applications.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Classify the different types of enzymes.	M		M									M	H	M	
CO2	Relate the single and multi-substrate reactions in enzyme kinetics and inhibition.	H	H	H	H	H							H	H	H	
CO3	Utilize the principles and techniques involved in enzyme kinetics and immobilization for its application in biosensors.	H	H	H	H	H							H	H	H	H
CO4	Select and characterize the enzymes from different sources.	H	H	H	H	H							H	H	H	H

CO5	Experiment with enzymatic biotransformation for various applications.	H	H	H	H	H		M	H				H	H	H	H

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO ENZYMES**	**9 hours**

Classification of enzymes; Mechanisms of enzyme action; concept of active site and energetics of enzyme substrate complex formation; specificity of enzyme action; principles of catalysis – collision theory, transition state theory; role of entropy in catalysis.

UNIT II	**KINETICS OF ENZYMES ACTION**	**9 hours**

Kinetics of single substrate reactions; estimation of Michelis – Menten parameters, turnover number; types of inhibition & models –substrate, product. Allosteric regulation of enzymes, Koshland, Némethy, Filmer and Monod Changeux Wyman models, pH and temperature effect on enzymes & deactivation kinetics.

UNIT III	**ENZYME IMMOBILIZATION AND BIOSENSORS**	**9 hours**

Physical and chemical techniques for enzyme immobilization – adsorption, matrix entrapment, encapsulation, cross-linking, covalent binding etc., - examples, advantages and disadvantages; Introduction to Biosensors - design of enzyme electrodes and their application as biosensors in industry, healthcare and environment.

UNIT IV	**ENZYMES FROM NATURALSOURCES**	**9 hours**

Production and purification of crude enzyme extracts from plant, animal and microbial sources; methods in characterization of enzymes; development of enzymatic assays.

UNIT V	**BIOTRANSFORMATION APPLICATIONS OF ENZYMES**	**9 hours**

Hydrolytic- Ester bond, Amide, Epoxides, Nitriles, Reduction reactions –aldehydes, Ketones, C=C, Oxidation reactions – , Enzymes in organic synthesis– esters, amide, peptide, Modified and Artificial Enzymes, Catalytic antibodies.

LEARNING RESOURCES

Text Books	1. Trevor Palmer, "Enzymes", IInd Edition, Horwood Publishing Ltd, 2007. 2. Faber K, "Biotransformations in Organic Chemistry", IV edition, Springer, 2000.
Reference Books	1. Harvey W. Blanch, Douglas S. Clark, "Biochemical Engineering", Marcel Dekker Inc., 1997. 2. James M. Lee, "Biochemical Engineering", Prentice Hall Inc., 1992. 3. James. E. Bailey and David F. Ollis, "Biochemical Engineering Fundamentals", 2nd Edition, McGrawHill, 1986.

	4. Wiseman, “Enzyme Biotechnology”, Ellis Horwood Pub., 1995.
Reference videos	https://youtu.be/s2Y-S3V0pLY https://youtu.be/mJecSUWeoTc https://youtu.be/_379SFo_jFo https://youtu.be/IXPrRSBxx6E https://youtu.be/l_WuC4vpTsY
Reference NPTEL	https://archive.nptel.ac.in/courses/102/103/102103097/
Reference research/ review articles	1. Jha, R., Pal, R., Chakraborty, D., & Chattaraj, P. K. (2023). Principles of Catalysis. In Metal Phosphates and Phosphonates: Fundamental to Advanced Emerging Applications (pp. 95-113). Cham: Springer International Publishing. 2. Srinivasan, B. (2022). A guide to the Michaelis–Menten equation: steady state and beyond. The FEBS journal, 289(20), 6086-6098. 3. Bollella, P., & Katz, E. (2020). Enzyme-based biosensors: tackling electron transfer issues. Sensors, 20(12), 3517. 4. Kim, S. B., Koo, J., Yoon, J., Hourlier-Fargette, A., Lee, B., Chen, S., ... & Rogers, J. A. (2020). Soft, skin-interfaced microfluidic systems with integrated enzymatic assays for measuring the concentration of ammonia and ethanol in sweat. Lab on a Chip, 20(1), 84-92. 5. Lubberink, M., Finnigan, W., & Flitsch, S. L. (2023). Biocatalytic amide bond formation. Green Chemistry, 25(8), 2958-2970.

Course Code	Course Title	L	T	P	C
10212BT114	SYNTHETIC BIOLOGY	3	0	0	3

Course Category	*Program Elective*
Preamble	*To have insight information about the advanced techniques used in synthetic biology for the better understanding of biological system.*
Prerequisite Courses	*10211BT104 – Molecular Biology: Concepts and Techniques* *10211BT105 - Genetic Engineering*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Explain the Structure, expression and regulation in Prokaryotic and Eukaryotic systems	K2
CO2	Summarize the various mechanisms underlying Recombinant DNA technology	K2
CO3	Utilize the computational tools to study the genome and Protein structure	K3
CO4	Make use of computational concepts for characterization and quality control DNA and Protein	K3
CO5	Develop suitable synthetic biology tools to study the GMOs according to its ethical challenges	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Explain the basic concepts of Synthetic Biology.	H	M	H									M	H	H	
CO2	Experiment with the various mechanisms underlying Recombinant DNA technology.	H											M	H	H	
CO3	Make use of the molecular basis of Genome and Protein design.	H	H	H	H	H	L	L					M	H	L	L
CO4	Analyze the specific methods involved in Synthetic Biology.	M	L	H	M	L							M	M	M	M

CO5	Examine the advanced and emergent concepts of Synthetic Biology.	H	H	H	H	H	L	L	H				H	H	M	M

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO SYNTHETIC BIOLOGY**	**9 hours**

Covalent, Ionic, Hydrogen, Coordinate, hydrophobic and Vander walls interactions in protein structure. Interaction with electromagnetic radiation (radio, micro, infrared, visible, ultraviolet, X-ray) and elucidation of protein structure.

UNIT II	**RECOMBINANT DNA TECHNOLOGY**	**9 hours**

Advanced biotechnological methods - Cloning, Mutagenesis, Synthesis of nucleic acids, DNA sequence determination, Gene delivery vectors, Plasmic extraction, Genomics and Proteomics.

UNIT III	**GENOME AND PROTEIN DESIGN**	**9 hours**

Introduction to gene assembly and protein modelling, CRISPR-Cas9 complex, directed evolution, alternative splicing, Methods and uses of DNA sequencing, computational modelling- Basic theoretical and computational modelling

UNIT IV	**SPECIFIC METHODS OF SYNTHETIC BIOLOGY**	**9 hours**

Foundations and basic principles of methodologies followed in Synthetic Biology, BioBricks concept of physical DNA composition, PoPs and RiPs - transcriptional standards for functional DNA composition, Designing biological system from BioBricks, iGEM Registry, Biological part characterization and quality control.

UNIT V	**ADANCED CONCEPTS IN SYNTHETIC BIOLOGY**	**9 hours**

Synthetic Biology in GMO's, Metabolic Engineering, Nitrogen Fixation refactoring,Importance of Quorum sensing and environmental impact of Synthetically designed organisms, MAGE (Multiplex Automated Genomic Engineering), Ethical challenges of Synthetic Biology.

LEARNING RESOURCES

Reference Books	1. Paul S. Freemont, Richard I. Kitney,"Synthetic Biology - A Primer",1st Edition, Imperial College Press, 2012. 2. Huimin Zhao, "Synthetic Biology: Tools and Applications", 1stEdition, Academic Press, 2013. 3. Daniel G. Gibson, Clyde A. Hutchison III, Hamilton O. Smith and Craig Venter J., "Synthetic Biology: Tools for Engineering Biological Systems", A Cold Spring Harbor Perspectives in Biology Collection, 2017.
Reference videos	https://youtu.be/YbNKagnCwis https://youtu.be/SR4FX6O2u98 https://youtu.be/IiPL5HgPehs https://youtu.be/neSdRJRVNJY

	https://youtu.be/rD5uNAMbDaQ?list=PLuJ9u3pztP-30JKJERK_Ts5H6yc7zHWsi
Reference NPTEL	https://nptel.ac.in/courses/102106102
Reference research/ review articles	1. Ou, X., Chen, X., Xu, X., Xie, L., Chen, X., Hong, Z., ... & Yang, H. (2021). Recent development in x-ray imaging technology: Future and challenges. Research. 2. Badua, C. L. D., Baldo, K. A. T., & Medina, P. M. B. (2021). Genomic and proteomic mutation landscapes of SARS-CoV-2. Journal of medical virology, 93(3), 1702-1721. 3. Hu, T., Chitnis, N., Monos, D., & Dinh, A. (2021). Next-generation sequencing technologies: An overview. Human Immunology, 82(11), 801-811. 4. Radde, N., Mortensen, G. A., Bhat, D., Shah, S., Clements, J. J., Leonard, S. P., ... & Barrick, J. E. (2024). Measuring the burden of hundreds of BioBricks defines an evolutionary limit on constructability in synthetic biology. bioRxiv 5. Wannier, T. M., Ciaccia, P. N., Ellington, A. D., Filsinger, G. T., Isaacs, F. J., Javanmardi, K., ... & Church, G. M. (2021). Recombineering and MAGE. Nature Reviews Methods Primers, 1(1), 7..

MEDICAL DOMAIN

Course Code	Course Title	L	T	P	C
10212BT115	CANCER BIOLOGY	3	0	0	3

Course Category	*Program Elective*
Preamble	*To create a clear and thorough understanding on Cancer Biology from the fundamental principles to the most recent advances in its detection, tracking and therapy.*
Prerequisite Courses	*10211BT102 – Cell Biology* *10211BT104 – Molecular Biology: Concepts and Techniques*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Illustrate and diagnosis the regulations of cell cycle checkpoints in cancer cells	K2
CO2	Comprehend the various types of Carcinogenic materials and its regulatory mechanisms	K2
CO3	Explain different stages of cancers based on its molecular level understanding	K3
CO4	Identify the cause of cancer stimulation at Metastasis stage and its regulatory proteins	K3
CO5	Choose the proper therapy for different types of cancer according to their markers and proteins	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Illustrate and diagnosis the regulations of cell cycle checkpoints in cancer cells	H	M										H	H	M	
CO2	Comprehend the various types of Carcinogenic materials and its regulatory mechanisms	H		M	M	L						H	H	H	H	
CO3	Explain different stages of cancers based on its molecular level understanding	H	M	H	L							H	M	H	H	

CO4	Identify the cause of cancer stimulation at Metastasis stage and its regulatory proteins	H	H	M	H	H						H	M	H	H	M
CO5	Choose the proper therapy for different types of cancer according to their markers and proteins	H	H	M	H	L							M	H	H	L

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO CANCER BIOLOGY**	**9 hours**

Nomenclature, Historical perspective, regulation of cell cycle, check points, Basic mechanism of cancer, Signal molecules, signal transduction, mutations that cause changes in signal molecules, Modulation of cell cycle, receptors, oncogenesis, diagnostic tools for screening and early detection. Different forms of cancer.

UNIT II	**PRINCIPLES OF CARCINOGENESIS**	**9 hours**

Theory of Carcinogenesis, Metabolism of carcinogenesis, Physical and Chemical Carcinogenesis, Radiation carcinogenesis, ionizing and non-ionization radiation effects, CYP450 reductase mechanism, Retroviruses-RSV life cycle and role in cancer, Identification of carcinogens with long term and short term bioassays, other methods.

UNIT III	**MOLECULAR BASIS OF CANCER BIOLOGY**	**9 hours**

Principles of molecular cell biology of cancer - Differentiation, local invasion, Metastasis; Pathways of spread, Progression of Tumor, Signal targets and cancer, Identification, activation and detection of Oncogenes, activation of kinases, growth factors related to transformation, Telomerases

UNIT IV	**CANCER METASTASIS, ONCOGENES, ONCOPROTEINS**	**9 hours**

Introduction to Metastasis and cascade, Invasion-three step theory, Heterogeneity of metastatic phenotype, Proteinases and tumor cell invasion, Introduction to oncogenes and oncoproteins, tumor suppression genes - p53 genes, activation, evasion of apoptosis, DNA repair defects and instability of genes in cancer cells, chromosomal changes, gene amplification, molecular profile of cancer cells.

UNIT V	**CANCER THERAPY**	**9 hours**

Introduction and different types of cancer therapy, Chemotherapy, radiation therapy,Tumor markers, molecular tools for early detection of cancer, prediction of aggressiveness of cancer, advances in cancer detection, use of signal targets towards therapy of cancer, Gene therapy

LEARNING RESOURCES	
Reference Books	1. Weinberg R.A., "The Biology of Cancer", Garland Science, 2007. 2. Ian F.Tannock, Richard P. Hill, Robert G. Bristow and Lea Harrington, "The Basic Sciences of Oncology, 4th Edition, McGraw-Hill, 2005. 3. PelengarisS. and Khan M.,"The Molecular Biology of Cancer", Wiley Blackwell Publishing, USA, 2006. 4. Margaret A. Knowles and Peter T. Selvo, "An introduction to cellular and molecular biology of cancer", Oxford Medical publication,1991.
Reference videos	https://www.youtube.com/watch?v=46Xh7OFkkCE https://www.youtube.com/watch?v=NO0eKiIUcBg https://www.youtube.com/watch?v=8fwmSnkdY8Q https://www.youtube.com/watch?v=bdWRZd19swg https://www.youtube.com/watch?v=-6j0e_lZC6o
Reference NPTEL	https://nptel.ac.in/courses/102106025
Reference research/ review articles	1. Huang, Z., Xie, N., Illes, P., Di Virgilio, F., Ulrich, H., Semyanov, A., ... & Tang, Y. (2021). From purines to purinergic signalling: molecular functions and human diseases. Signal transduction and targeted therapy, 6(1), 162. 2. Stading, R., Gastelum, G., Chu, C., Jiang, W., & Moorthy, B. (2021, November). Molecular mechanisms of pulmonary carcinogenesis by polycyclic aromatic hydrocarbons (PAHs): Implications for human lung cancer. In Seminars in cancer biology (Vol. 76, pp. 3-16). Academic Press. 3. Schulz, W. A. (2023). Molecular biology of human cancers. Springer Nature Switzerland AG. 4. Schiller, J. T., & Lowy, D. R. (2021). An introduction to virus infections and human cancer. Viruses and human cancer: from basic science to clinical prevention, 1-11. 5. Gavas, S., Quazi, S., & Karpiński, T. M. (2021). Nanoparticles for cancer therapy: current progress and challenges. Nanoscale research letters, 16(1), 173.

Course Code	Course Title	L	T	P	C
10212BT116	MOLECULAR PATHOGENESIS	3	0	0	3

Course Category	*Program Elective*
Preamble	*To introduce the molecular basis and factors behind pathogenesis and the various strategies designed to study, diagnose and treat pathogenesis.*
Prerequisite Courses	*10211BT101 – Microbiology* *10211BT116 - Immunology and Immunotechnology*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Explain the historical background of molecular pathogenesis and basic mechanisms.	K2
CO2	Comprehend the interactions mechanism of pathogens toward host organism and resistance development.	K2
CO3	Identify the molecular mechanisms of various Enteric pathogens for disease causing in human.	K3
CO4	Make use of molecular level experiments to understand host pathogen interactions	K3
CO5	Develop the diagnosis and prevention tools for various pathogenic infections.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Explain the historical background of molecular pathogenesis and basic mechanisms.	H	M										H	H	M	
CO2	Comprehend the inter actions mechanism of pathogens toward host organism and resistance development.	H	H										H	H	H	
CO3	Identify the molecular mechanisms of various Enteric pathogens for disease causing in human.	H	M		L								H	H	H	

CO4	Make use of molecular level experiments to understand host pathogen interactions	H	H	M	H	H							H	H	H	M
CO5	Develop the diagnosis and prevention tools for various pathogenic infections.	H	H	M	H	L	H						H	H	H	L

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO MOLECULAR PATHOGENESIS**	**9 hours**

Historical background, Introduction to infectious diseases, Concepts of virulence, pathogenicity, commensalism, symbiosis, opportunism, parasitism; Significance of the discovery of Microscope in pathogenesis, Significant contributions of Louis Pasteur, Robert Koch postulates, Microbial toxins - discovery, assays, underlying mechanisms of bacterial colonization and infection.

UNIT II	**HOST DEFENSE AGAINST PATHOGENS, STRATEGIES**	**9 hours**

Basic components and nature of pathogenesis, Host defense mechanisms - Skin, Mucosa, Cilia, Secretions, Physical movements, limitation of free iron, antimicrobial compounds, mechanism of killing by humoral and cellular defense mechanisms, resistance development in pathogens, Pathogenic adaptations.

UNIT III	**MECHANISM IN MOLECULAR PATHOGENESIS**	**9 hours**

Underlying mechanisms of Molecular pathogenesis, Role of Molecular genetics and gene regulation in virulence of pathogens, Influence of lifestyle factors on virulence, Clinical features and molecular mechanism of pathogenesis: Enteric pathogens- Enteropathogenic (EPEC), Enteroinvasive (EIEC), Enteroaggressive *E.coli* (EAEC),Shigella, Salmonella, Dermatophytes, Candidiasis, Plasmodium - Life cycle, Malaria, different stages of Influenza virus.

UNIT IV	**EXPERIMENTAL STUDIES ON HOST PATHOGEN INTERACTIONS**	**9 hours**

Assays for Virulence, Principles of Adherence, Invasion, Cytopathic effects; Tests in identifying virulence factors, attenuated mutants, Molecular characterization of virulence factors, Signal transduction and host responses.

UNIT V	**PATHOGEN DIAGNOSIS AND CONTROL METHODS**	**9 hours**

Classical methods- Serotyping, Diagnosis using Virulence factors, Immuno, DNA based techniques, Precipitation, Agglutination, ELISA, RIA, PCR, Blotting techniques - Southern and

Western blotting, Bioinformatics/whole genome analysis for pathogen diagnosis, Vaccines - Types, applications, advantages and disadvantages, Cocktail vaccines, New therapeutic strategies based on recent findings on molecular pathogenesis of pathogens.	
LEARNING RESOURCES	
Text Books	
Reference Books	1. Iglewski B.H. and Clark V.L., "Molecular basis of Bacterial Pathogenesis", Academic Press, 1990. 2. Eduardo A. Groisman, "Principles of Bacterial Pathogenesis", Academic Press, 2001. 3. Peter Williams, Julian Ketley and George Salmond, "Methods in Microbiology: Bacterial Pathogenesis", Academic Press, 1998. 4. Brenda B. Wilson, Abigail A. Salyers, Dixie D. Witt and Malcolm E. Winkler, "Bacterial Pathogenesis", 3rdEdition, ASM press, 2011.
Reference videos	https://www.youtube.com/watch?v=_2vTa4P6Tbg https://www.youtube.com/watch?v=X6wrFMvK804 https://www.youtube.com/watch?v=oaqwrJ-SZGE https://www.youtube.com/watch?v=XvlY0zvKbm4 https://www.youtube.com/watch?v=SwNXNFBIGKc
Reference NPTEL	https://nptel.ac.in/courses/102106025
Reference research/ review articles	1. Milgroom, M. G. (2023). The Germ Theory Paradigm. In Biology of Infectious Disease: From Molecules to Ecosystems (pp. 9-22). Cham: Springer International Publishing. 2. Iannacone, M., & Guidotti, L. G. (2022). Immunobiology and pathogenesis of hepatitis B virus infection. Nature Reviews Immunology, 22(1), 19-32. 3. Alfinete, N. W., Bolukaoto, J. Y., Heine, L., Potgieter, N., & Barnard, T. G. (2022). Virulence and phylogenetic analysis of enteric pathogenic Escherichia coli isolated from children with diarrhoea in South Africa. International Journal of Infectious Diseases, 114, 226-232. 4. Ahmadi, M., Ranjbar, R., Behzadi, P., & Mohammadian, T. (2022). Virulence factors, antibiotic resistance patterns, and molecular types of clinical isolates of Klebsiella Pneumoniae. Expert Review of Anti-infective Therapy, 20(3), 463-472. 5. Sanya, D. R. A., Onésime, D., Vizzarro, G., & Jacquier, N. (2023). Recent advances in therapeutic targets identification and development of treatment strategies towards Pseudomonas aeruginosa infections. BMC microbiology, 23(1), 86.

Course Code	Course Title	L	T	P	C
10212BT117	BIOPHARMACEUTICAL TECHNOLOGY	3	0	0	3

Course Category	*Program Elective*
Preamble	*To understand drug development process for the preparation of medicine as per norms.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Understand the various types of therapeutic agents used in pharmaceutical industry, their use and regulatory aspects.	K2
CO2	Elucidate the drug metabolism involving the physico-chemical properties and pharmacokinetics of drugs.	K2
CO3	Demonstrate the different types of reaction process involved in bulk drug manufacture.	K2
CO4	Apply the analytical methods in drug manufacture and packing techniques.	K3
CO5	Identify the various pharmaceutical products, current medicines and their applications in therapeutic and diagnostic fields.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand the various types of therapeutic agents used in pharmaceutical industry, their use and regulatory aspects.	M		M									M	H	M	
CO2	Elucidate the drug metabolism involving the physico-chemical properties and pharmacokinetics of drugs.	H	H	H	H	H							H	H	H	

CO3	Demonstrate the different types of reaction process involved in bulk drug manufacture.	H	H	H	H	H							H	H	H	H
CO4	Apply the analytical methods in drug manufacture and packing techniques.	H	H	H	H	H							H	H	H	H
CO5	Identify the various pharmaceutical products, current medicines and their applications in therapeutic and diagnostic fields.	H	H	H	H	H		M	H				H	H	H	H

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION**	**9 hours**

Development of Drug and Pharmaceutical Industry, types of therapeutic agents and their uses; economics and regulatory aspects.

UNIT II	**DRUG METABOLISM AND PHARMACOKINETICS**	**9 hours**

Drug metabolism – physico chemical principles, radioactivity – pharmacokinetics-action of drugs on human bodies.

UNIT III	**MANUFACTURE OF DRUGS, PROCESS AND APPLICATIONS**	**9 hours**

Bulk drug manufacturers, Type of reactions in bulk drug manufacture and processes. Special requirement for bulk drug manufacture.

UNIT IV	**MANUFACTURING PRINCIPLES**	**9 hours**

Compressed table, wet granulation-dry granulation or slugging-direct compression-tablet presses, coating of tablets, capsules, sustained action dosage forms-parental solution-oral liquids-injections-ointment-topical applications, Preservation, analytical methods and test for various drug and pharmaceuticals, packing-packing techniques, quality Management, GMP.

UNIT V	**PHARMACEUTICAL PRODUCTS**	**9 hours**

Therapeutic categories such as vitamins, laxatives, analgesics, non-steroidal contraceptives, Antibiotics, biological, Hormones.

LEARNING RESOURCES

Text Books	1. Finkel Richard, *et al*., "Lippincott's Illustrated Reviews: Pharmacology", 4th Edition, Wolters Kluwer / Lippincott Williams & Wilkins, 2009.

	2. Shayne Cox Gad,"Pharmaceutical Manufacturing Handbook", John Wiley &Sons, Inc., 2008. 3. Bernd Meibohm,"Pharmacokinetics and Pharmacodynamics of biotech drugs", Wiley-VCH, 2006.
Reference Books	1. Leon Lachman,"Theory and Practice of Industrial Pharmacy", 3rdEdition, Lea and Febiger, 1986. 2. Remington,"Pharmaceutical Sciences", 17thEdition, Mark Publishing & co, 1985.
Reference videos	https://www.youtube.com/watch?v=FPLzzuwZyMo https://www.youtube.com/watch?v=qvucMHUVZA4 https://www.youtube.com/watch?v=u0ulEC-shAI https://www.youtube.com/watch?v=bGwR_7BqXfA https://www.youtube.com/watch?v=ElTMeiMgsG8
Reference NPTEL	**https://archive.nptel.ac.in/courses/102/107/102107028/**
Reference research/ review articles	1. Sharma, D., Patel, P., & Shah, M. (2023). A comprehensive study on Industry 4.0 in the pharmaceutical industry for sustainable development. Environmental Science and Pollution Research, 30(39), 90088-90098. 2. Yadav, U., & Bhatted, S. K. (2023). A comparative analysis of Vamana and Shamana Chikitsa in prediabetes management: A randomized clinical trial. Journal of Ayurveda and Integrative Medicine, 14(5), 100764. 3. Panchal, K., Katke, S., Dash, S. K., Gaur, A., Shinde, A., Saha, N., ... & Chaurasiya, A. (2023). An expanding horizon of complex injectable products: Development and regulatory considerations. Drug Delivery and Translational Research, 13(2), 433-472. 4. Gozdzialski, L., Wallace, B., & Hore, D. (2023). Point-of-care community drug checking technologies: an insider look at the scientific principles and practical considerations. Harm Reduction Journal, 20(1), 39. 5. Kiruba, J., Justin Thenmozhi, A., Jayalakshmi, M., & Arockia Jeya Yasmi Prabha, E. (2023). Role of Vitamins in Alzheimer's Disease. In Nutraceuticals for Alzheimer's Disease: A Promising Therapeutic Approach (pp. 27-42). Singapore: Springer Nature Singapore.

Course Code	Course Title	L	T	P	C
10212BT118	STEM CELL TECHNOLOGY	3	0	0	3

Course Category	*Program Elective*
Preamble	*To study the unique properties of stem cell with its classification and to understand its application in the treatment of diseases.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Outline the properties, classification and preservation of stem cell	K2
CO2	Comprehend the source and characterization of human embryonic stem cell.	K2
CO3	Identify and study about the properties of different types of adult stem cell.	K2
CO4	Make use of the hematopoietic stem cells for bone repair with tissue engineering tools	K3
CO5	Identify the solution for various diseases by using stem cell technology.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Outline the properties, classification and preservation of stem cell	H		H									M	H	M	
CO2	Comprehend the source and characterization of human embryonic stem cell.	H											H	H	M	
CO3	Identify and study about the properties of different types of adult stem cell.	H											H	H	M	
CO4	Make use of the hematopoietic stem cells for bone repair with tissue engineering tools	H	M	H	H	H	M		H				H	H	H	M

CO5	Identify the solution for various diseases by using stem cell technology.	H	H	H	H	H	M	H	H				H	H	H	L

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO STEM CELLS**	**9 hours**

Scope of Stem Cells -Unique properties of stem cells – differentiation, maturation, proliferation, pluripotency, self – maintenance and self – renewal –classification- problems in measuring stem cells – preservation protocols.

UNIT II	**HUMAN EMBRYONIC STEM CELL**	**9 hours**

Stem cells and their developmental potential. In vitro fertilization-culturing of embryos-blastocyst-inner cell mass-isolation and growing ES cells in lab Identification and characterization of human ES cells-Cloning and controlled differentiation of human embryonic stem cells. Applications of Embryonic stem cells. Ethical issues and regulations.

UNIT III	**HUMAN ADULT STEM CELL**	**9 hours**

Somatic stem cells-test for identification of adult stem cells- adult stem cell differentiation-trans differentiation-plasticity-different types of adult stem cells-liver stem cells-skeletal muscle stem cells-bone marrow derived stem cells.

UNIT IV	**STEM CELLS IN TISSUE ENGINEERING**	**9 hours**

Haematopoietic Stem Cells-Growth factors and the regulation of haematopoietic stem cells-clinical applications of haematopoietic stem cells. Mesenchymal stem cells and their role in bone tissue engineering-bone repair. Stem cell based gene therapy and benefits to human.

UNIT V	**APPLICATIONS OF STEM CELL**	**9 hours**

Therapeutic applications-Parkinsons disease, Cancer stem cell – Neural stem cell for central nervous system repair – Spinal cord injury – use of ESC to treat heart disease – Burns and skin ulcers – Orthopaedic applications of stem cell - Insulin-producing Cells Derived from Stem Cells: A Potential Treatment for Diabetes.

LEARNING RESOURCES

Text Books	1. Potten C.S., "Stem Cells," Elsevier, 1996. 2. Robert Lanza, "Essentials of Stem Cell Biology," Academic Press, 2009.
Reference Books	1. AriffBongso, EngHin Lee, "Stem Cells: From Bench to Bedside," World Scientific, 2011. 2. Daniel R. Marshak, "Stem cell biology," Cold Spring Harbor Laboratory Press, 2001. 3. Peter Quesenberry, "Stem cell biology and Gene Therapy," Wiley-Liss, 1998.

Reference videos	https://www.youtube.com/watch?v=evH0I7Coc54 https://www.youtube.com/watch?v=gxAVnoarveE https://www.youtube.com/watch?v=fp5H3SslskQ https://www.youtube.com/watch?v=ca3H2vemYXo https://www.youtube.com/watch?v=o7dDKMOMYWk
Reference NPTEL	https://nptel.ac.in/courses/102106036
Reference research/ review articles	1. Das, M., & Sloan, A. J. (2023). Stem cell sources from human biological waste material: a role for the umbilical cord and dental pulp stem cells for regenerative medicine. Human Cell, 36(4), 1312-1325. 2. Abel, A., & Sozen, B. (2023). Shifting early embryology paradigms: Applications of stem cell-based embryo models in bioengineering. Current Opinion in Genetics & Development, 81, 102069. 3. Tkemaladze, J. (2023). Reduction, proliferation, and differentiation defects of stem cells over time: a consequence of selective accumulation of old centrioles in the stem cells?. Molecular Biology Reports, 50(3), 2751-2761. 4. Plakhova, N., Panagopoulos, V., Vandyke, K., Zannettino, A. C., & Mrozik, K. M. (2023). Mesenchymal stromal cell senescence in haematological malignancies. Cancer and Metastasis Reviews, 42(1), 277-296. 5. Wu, B., Shi, X., Jiang, M., & Liu, H. (2023). Cross-talk between cancer stem cells and immune cells: potential therapeutic targets in the tumor immune microenvironment. Molecular Cancer, 22(1), 38.

Course Code	Course Title	L	T	P	C
10212BT119	BIOSENSOR AND INSTRUMENTATION	3	0	0	3

Course Category	*Program Elective*
Preamble	*To understand the importance of sensors in biological field.*
Prerequisite Courses	*10212BT144 – Advanced Biochemistry* *10211BT106 - Analytical and Instrumentation Engineering*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Explain the application of biomolecules in sensing applications.	K2
CO2	Make use of chromophores and fluorophore to construct enzyme based fiberoptic biosensors.	K3
CO3	Apply the biochemical and electrochemical mechanism to develop biosensors and oligonucleotide sensitive electrodes.	K3
CO4	Make use of chromophores and fluorophore to construct enzyme based fiberoptic biosensors.	K3
CO5	Identify the metals and minerals by using biosensors.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Explain the application of biomolecules in sensing applications.	H	H	H	H								H	H	M	L
CO2	Make use of chromo phores and fluorophore to construct enzyme based fiberoptic biosensors.	H	H	M	H		H						H	H	H	
CO3	Apply the biochemical and electrochemical mechanism to develop biosensors and oligonucleotide sensitive electrodes.	H	H	H	H	H	H	M					M	M	M	H

CO4	Make use of chromophores and fluorophore to construct enzyme based fiberoptic biosensors.	H	H	M	H		H						H	H	H	
CO5	Identify the metals and minerals by using biosensors.	M	H	H	H	H	H	H	L				M	H	H	L

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO BIOSENSORS**	**9 hours**

Introduction to protein/enzyme based sensors-amperometric enzyme electrodes-characteristics- enzyme activity determinations– biosensors for enzyme immunoassay– potentiometric enzyme electrodes–electrode characteristics and performance –pH glass and ion-selective electrodes– solid-state pH and redox electrodes-gas electrodes.

UNIT II	**ENZYME BASED BIOSENSORS**	**9 hours**

Potentiometric immune biosensors, immobilization techniques. Principle and measurement devices. Immobilized enzymes – immobilized cells-determination of enzyme activities in solution.

UNIT III	**TECHNIQUES IN BIOSENSORS**	**9 hours**

Materials used in sensing techniques and their chemistry, types of transducer. Fiber optic biosensors-Optical biosensors based on competitive binding. Electron conducting redox polymer in enzyme based biosensors. Hybridization at oligonucleotide sensitive electrodes with hybridization sensitivity–hybridization conditions– hybridization kinetics.

UNIT IV	**FIBER OPTIC BIOSENSORS**	**9 hours**

Enzyme based non-mediated fiber optic biosensors towards detection of chromophores and flurophore. Bioluminescence and chemiluminescence based fiber opticsensors, analytical potential of luminescent reactions and its applications.

UNIT V	**IONS SPECIFIC BIOSENSORS**	**9 hours**

Determination of metal ions– fluorescent aryl sulfonamides for zinc determination- removal of zinc from carbonic anhydrase– determination of zinc using reagent approach– determination of copper and other ions.

LEARNING RESOURCES

Text Books	1. Copper J.M. and Cass E.G.A., "Biosensors", Oxford UniversityPress, 2004. 2. BrianEggins, "ChemicalSensorsand Biosensors", JohnWilley&Sons, 2002.
Reference Books	BlumL.J.andCoulet P. R., "Biosensor PrinciplesandApplications", Marcel DekkerInc., 1991.

Reference videos	https://www.youtube.com/watch?v=9IVmGDgVFdQ https://www.youtube.com/watch?v=Cm6IKECsWpA https://www.youtube.com/watch?v=9ZvJr3kzM8M https://www.youtube.com/watch?v=GNE81hbCggQ https://www.youtube.com/watch?v=6Ti83oO2ml4
Reference NPTEL	https://nptel.ac.in/courses/115107122
Reference research/ review articles	1. Barhoum, A., Altintas, Z., Devi, K. S., & Forster, R. J. (2023). Electrochemiluminescence biosensors for detection of cancer biomarkers in biofluids: Principles, opportunities, and challenges. Nano Today, 50, 101874. 2. Lu, J., Zhuang, X., Wei, H., Liu, R., Ji, W., Yu, P., ... & Mao, L. (2024). Enzymatic Galvanic Redox Potentiometry for In Vivo Biosensing. Analytical Chemistry. 3. Singh, A. K., Mittal, S., Das, M., Saharia, A., & Tiwari, M. (2023). Optical biosensors: A decade in review. Alexandria Engineering Journal, 67, 673-691. 4. Selvolini, G., & Marrazza, G. (2023). Sensor principles and basic designs. In Fundamentals of Sensor Technology (pp. 17-43). Woodhead Publishing. 5. Rubino, A., & Queirós, R. (2023). Electrochemical determination of heavy metal ions applying screen-printed electrodes based sensors. A review on water and environmental samples analysis. Talanta Open, 100203.

Course Code	Course Title	L	T	P	C
10212BT120	BIOMATERIALS	3	0	0	3

Course Category	*Program Elective*
Preamble	*This course will give a broad view towards various types of biomaterials, its properties, manufacturing methods and its applications.*
Prerequisite Courses	*10211BT102 – Cell Biology*

Course Outcomes	***Upon successful completion of the course, students will be able to:***	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Understand the physiochemical properties of Biomaterials	K2
CO2	Apply the Metallic and Ceramic biomaterials for various medical applications	K2
CO3	Make use of biopolymers for various industrial applications.	K2
CO4	Select the biomaterials according to the mechanisms and regularities of tissues replacement.	K3
CO5	Develop and identify the toxicity and blood compatibility of implantable biomaterials	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand the physio chemical properties of Biomaterials	M		M									H	H	M	
CO2	Apply the Metallic and Ceramic biomaterials for various medical applications	H	M	M									H	H	H	
CO3	Make use of biopolymers for various industrial applications.	H	M	M									H	H	H	L
CO4	Select the biomaterials according to the mechanisms and regularities of tissues replacement.	H	H	H	M								H	H	M	L

CO5	Develop and identify the toxicity and blood compatibility of implantable biomaterials	H	H	H	M			H					H	H	M	L

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO BIOMATERIALS**	**9 hours**

Introduction to biomaterials, Physical and chemical properties, biomaterial performance, response to implants, blood compatibility, Nanoscale phenomena.

UNIT II	**METALLIC AND CERAMIC MATERIALS**	**9 hours**

Different implants - Stainless steels, cobalt-based alloys, Titanium-based alloys, shape memory alloy, ceramic implant, nanostructured metallic implants, biodegradable or bioresourceable, bioactive ceramics, nanostructured bio ceramics.

UNIT III	**POLYMERIC IMPLANT MATERIALS**	**9 hours**

Polymer as biomaterials, Polymerization, properties of polymers, biodegradable polymers, Introduction bio polymers: Collagen, Elastin and chitin, Medical Textiles.

UNIT IV	**TISSUE REPLACEMENT IMPLANTS**	**9 hours**

Soft tissue replacements, Percutaneous and skin implants, Vascular grafts, hard tissue replacement Implants, tissue scaffolding and engineering using Nano biomaterials.

UNIT V	**TESTING OF BIOMATERIALS**	**9 hours**

Biocompatibility, blood compatibility and tissue compatibility tests, Toxicity tests, sensitization, carcinogenicity, *In vitro* and *In vivo testing*; Sterilization of implants and devices, Effects of sterilization.

LEARNING RESOURCES

Text Books	1. Sujata V. Bhatt, "Biomaterials", Second Edition, Narosa Publishing House, 2005. 2. Sreeram Ramakrishna, Murugan Ramalingam, Sampath Kumar T.S., and Winston O. Soboyejo, "Biomaterials: A Nano Approach", CRC Press, 2010.
Reference videos	https://www.youtube.com/watch?v=XqFSlG6WKO0 https://www.youtube.com/watch?v=k_ftHmWEHm8 https://www.youtube.com/watch?v=QBDsAR2Dw6g https://www.youtube.com/watch?v=og4BLTXJv-o https://www.youtube.com/watch?v=wxaPXGcC-SU
Reference NPTEL	https://nptel.ac.in/courses/113104009

Reference research/ review articles	1. Deng, J., & Gao, C. (2023). An introduction to scaffolds, biomaterial surfaces, and stem cells. In Polymeric Biomaterials for Tissue Regeneration: From Surface/Interface Design to 3D Constructs (pp. 1-38). Singapore: Springer Nature Singapore. 2. Que, Y., Zhang, Z., Zhang, Y., Li, X., Chen, L., Chen, P., ... & Chang, J. (2023). Silicate ions as soluble form of bioactive ceramics alleviate aortic aneurysm and dissection. Bioactive materials, 25, 716-731. 3. Pires, P. C., Mascarenhas-Melo, F., Pedrosa, K., Lopes, D., Lopes, J., Macário-Soares, A., ... & Paiva-Santos, A. C. (2023). Polymer-based biomaterials for pharmaceutical and biomedical applications: A focus on topical drug administration. European Polymer Journal, 187, 111868. 4. Bienz, S. P., Vaquette, C., Ioannidis, A., Hämmerle, C. H., Jung, R. E., Ivanovski, S., & Thoma, D. S. (2023). Tissue integration and biodegradation of soft tissue substitutes with and without compression: an experimental study in the rat. Clinical Oral Investigations, 27(1), 313-328. 5. Colaço, R., & Serro, A. P. (2024). Sterilization methods. In Hydrogels for Tissue Engineering and Regenerative Medicine (pp. 139-159). Academic Press.

Course Code	Course Title	L	T	P	C
10212BT121	BIOCHIPS AND MICROARRAY TECHNOLOGIES	3	0	0	3

Course Category	*Program Elective*
Preamble	*To know the essential concepts of biochips and microarray with major applications in medical field.*
Prerequisite Courses	*10212BT143 - Computational Biology: Techniques and Applications*

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

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Understand the working principles of biochips and detection mechanism	K2
CO2	Develop Acquisition and analysis techniques with micro array for various applications.	K3
CO3	Utilize different computational tools and statistical frame work to Analysis the Microarray Data	K3
CO4	Analyse the DNA biomolecules in computing and bimolecular device	K4
CO5	Examine the biochips for molecular diagnostics, pharmaco genomics, drug discovery and epidemiology applications.	K4

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand the working principles of biochips and detection mechanism	H	M											H	M	
CO2	Develop Acquisition and analysis techniques with micro array for various applications.	H	M	L										H	M	
CO3	Utilize different computational tools and statistical frame work to Analysis the Microarray Data	H	H	M	L	L	H						M	M	M	

CO4	Analyse the DNA biomolecules in computing and bimolecular device	H	H	M	H	H	H	H					H	H	H	
CO5	Examine the biochips for molecular diagnostics, pharmaco genomics, drug discovery and epide miology applications.	M	H	M	M	M	L	L	L				M	H	H	L

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION**	**9 hours**

Basics of Biochips and Microarray Technology; Types of Biochips - DNA Microarrays, Protein Microarrays, Oligonucleotide, cDNA and genomic microarrays; Integrated biochip system; Biochip versus gel based methods; Microarray Data analysis: Introduction, Image Acquisition and Analysis, Detection of differential gene expression; Pathway analysis tools and Data validation; Limitations of biochip technology.

UNIT II	**BIOCHIPS AND MICROARRAY CONSTRUCTION**	**9 hours**

Megacne technology for fluid microarrays, Microarray labels, Microarray scanners, Microarray robotics; Microfluidics systems; Chips and Mass Spectrometry; Electrical detection methods for microarrays; Microarray data processing - data quality control, background correction and empirical models for RNA hybridization, normalization methods (local regression, variance stabilization); Bioinformatics tools for microarray data analysis.

UNIT III	**GENOME SIGNAL PROCESSING**	**9 hours**

Introduction, Mathematical models and Modeling DNA Microarray data - Singular Value Decomposition algorithm; Online Analysis of Microarray Data Using Artificial Neural Networks.

UNIT IV	**DNA COMPUTING**	**9 hours**

Introduction, Junctions, other shapes, Biochips and large scale structures; Strand algebras for DNA computing – Introduction; Discussion of Robinson and Kallenbach's methods for designing DNA shapes, DNA cube, computing with DNA, Electrical analogies for biological circuits, Challenges; Future Trends with case studies.

UNIT V	**APPLICATIONS OF BIOCHIPS**	**9 hours**

Biochip assays; Combination of microarray and biosensor technology; Applications of Biochips in Molecular Diagnostics and Pharmacogenomics, application of microarray technology in drug

discovery development and drug delivery; Microarray in Differential expression analysis in cancer, Tumor classification and prognosis; genetic disease monitoring, forensics.	
LEARNING RESOURCES	
Text Books	
Reference Books	1. Isaac S. Kohane, Alvin Kho, Atul J. Butte., "Microarrays for an Integrative Genomics (Computational Molecular Biology)", 1st edition, MIT Press, 2002. 2. Helen C. Causton, John Quackenbush, Alvis Brazma., "Microarray Gene Expression Data Analysis: A Beginner's Guide", 1st edition, Wiley-Blackwell, 2003. 3. Sorin Draghici, "Data Analysis Tools for DNA Microarrays", Har/Cdr Re edition, Chapman & Hall/CRC, 2003. 4. DNA Computing: 15th International Meeting on DNA Computing, DNA 15, Fayetteville, AR, USA, June 8-11, 2009, Springer, 2009. 5. Grigorenko E., "DNA Arrays: Technology and Experimental Strategies", Vth Edition, CRC Press, 2002. **6.** Wan-Li Xing and Jing Cheng., "Biochips: Technology and Applications", Springer, 2003.
Reference videos	https://www.youtube.com/watch?v=k_1YSdmBmo0 https://www.youtube.com/watch?v=0ws2WX1IyhM https://www.youtube.com/watch?v=nSlhCaJKhjY https://www.youtube.com/watch?v=UTOspULanZ0 https://www.youtube.com/watch?v=kX70WLM9nHA&t=37s
Reference NPTEL	https://nptel.ac.in/courses/102101054
Reference research/ review articles	1. Kuru, C. İ., Ulucan-Karnak, F., & Akgöl, S. (2023). Lab-on-a-chip sensors: recent trends and future applications. Fundamentals of Sensor Technology, 65-98. 2. Chen, X., Yao, C., & Li, Z. (2023). Microarray-based chemical sensors and biosensors: Fundamentals and food safety applications. TrAC Trends in Analytical Chemistry, 158, 116785. 3. Pantic, I., Paunovic, J., Cumic, J., Valjarevic, S., Petroianu, G. A., & Corridon, P. R. (2023). Artificial neural networks in contemporary toxicology research. Chemico-Biological Interactions, 369, 110269. 4. Meng, X., O'Hare, D., & Ladame, S. (2023). Surface immobilization strategies for the development of electrochemical nucleic acid sensors. Biosensors and Bioelectronics, 115440. 5. Akinnuwesi, B. A., Olayanju, K. A., Aribisala, B. S., Fashoto, S. G., Mbunge, E., Okpeku, M., & Owate, P. (2023). Application of support vector machine algorithm for early differential diagnosis of prostate cancer. Data Science and Management, 6(1), 1-12.

Course Code	Course Title	L	T	P	C
10212BT122	PLANT BIOTECHNOLOGY	3	0	0	3

Course Category	*Program Elective*
Preamble	*To study the plant cells with its functions and applications in plant biotechnology.*
Prerequisite Courses	*10211BT104 - Molecular Biology: Concepts and Techniques* *10211BT105 – Genetic Engineering*

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

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Understand the basic fundamentals of plant cells, structure and function at molecular level.	K2
CO2	Outline about genes involved and regulatory mechanism of nitrogen fixation process.	K2
CO3	Develop the transgenic plant by gene transfer method with the significant viral vectors.	K2
CO4	Utilize the transgenic plants to produce the therapeutically valuable products.	K3
CO5	Make use of plant tissue culture techniques for various cultures developments.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand the basic fundamentals of plant cells, structure and function at molecular level.	H											H	H	M	
CO2	Outline about genes involved and regulatory mechanism of nitrogen fixation process.	H	M										H	H	M	
CO3	Develop the transgenic plant by gene transfer method with the significant viral vectors.	H	M	H	H	H		L					H	H	M	L

CO4	Utilize the transgenic plants to produce the therapeutically valuable products.	H	L	L	M	M	L	L	L				H	H	H	M
CO5	Make use of plant tissue culture techniques for various cultures developments.	H	L	L	M	M							H	H	H	L

H – High; M- Medium; L- Low

Course Content:

UNIT I	**PLANT GENETIC MATERIAL**	**9 hours**

Genetic Material Of Plant Cells – Nucleosome Structure and Its Biological Significance; Junk And Repeat Sequences; Outline Of Transcription and Translation. Chloroplast and mitochondria genome.

UNIT II	**RUBISCO AND NITROGEN FIXATION**	**9 hours**

Rubisco synthesis and assembly, Nitrogen fixation: Nitrogenase Activity, Nod Genes, Nif Genes, Bacteroids.

UNIT III	**GENE TRANSFER MECHANISM**	**9 hours**

Gene transfer mechanism - Direct and Indirect methods, Agrobacterium mediated gene transfer, Viral Vectors: Gemini Virus, Cauliflower Mosaic Virus, Viral Vectors and Its Benefits.

UNIT IV	**APPLICATIONS OF TRANSGENIC PLANTS**	**9 hours**

Production of transgenic plants for herbicide resistance, Insect resistance and stress tolerance. Plants as bioreactors, Plant derived vaccines-edible vaccines, Plantibodies, Recombinant and subunit vaccines.

UNIT V	**PLANT TISSUE CULTURE TECHNOLOGY**	**9 hours**

Outline of plant tissue culture, Plant tissue culture media, Types of cultures, Callus cultures, Cell and suspension cultures, Single cell clones, Protoplast culture and somatic hybridization.

LEARNING RESOURCES

Text Books	1. Chawla H.S., "Introduction to Plant Biotechnology", 3rd Edition, Science Publishers, 2009. 2. Gamburg O.L. and Philips G.C., "Plant Tissue & Organ Culture fundamental Methods", Narosa Publications, 1995. 3. Adrian Slator, Nigel W. Scott and Mark R. Fowler,"Plant Biotechnology: the genetic manipulation of plants", Oxford University Press, 2008.
Reference Books	1. Stewart Jr. C.N., "Plant Biotechnology and Genetics: Principles, Techniques and Applications" Wiley-Interscience, 2008. 2. HeldtH.W., "Plant Biochemistry & Molecular Biology", Oxford University Press, 1997. 3. Ignacimuthu S., "Applied Plant Biotechnology", Tata McGraw Hill, 1996.

Reference videos	https://www.youtube.com/watch?v=2vqpZqitVGA https://www.youtube.com/watch?v=1G3HM7l5HIo https://www.youtube.com/watch?v=08Q-MVeNeTU https://www.youtube.com/watch?v=kZIYkYNpnP0 https://www.youtube.com/watch?v=kK5jj1_iGM4
Reference NPTEL	https://archive.nptel.ac.in/courses/102/103/102103016/
Reference research/ review articles	1. Gilbert, C., & Maumus, F. (2023). Sidestepping Darwin: horizontal gene transfer from plants to insects. Current Opinion in Insect Science, 101035. 2. Rydzy, M., Kolesiński, P., Szczepaniak, A., & Grzyb, J. (2023). DnaK and DnaJ proteins from Hsp70/40 family are involved in Rubisco biosynthesis in Synechocystis sp. PCC6803 and sustain the enzyme assembly in a heterologous system. BMC Plant Biology, 23(1), 109. 3. Farzanehpour, M., Miri, A., Alvanegh, A. G., & Gouvarchinghaleh, H. E. (2023). Viral Vectors, Exosomes, and Vexosomes: Potential armamentarium for delivering CRISPR/Cas to cancer cells. Biochemical Pharmacology, 115555. 4. Majumder, S., Datta, K., & Datta, S. K. (2024). Pyramided transgenic jute (Corchorus capsularis) with biotic stress resistance and herbicide tolerance. Industrial Crops and Products, 208, 117776. 5. Mackowska, K., Stelmach-Wityk, K., & Grzebelus, E. (2023). Early selection of carrot somatic hybrids: a promising tool for species with high regenerative ability. Plant Methods, 19(1), 104.

Course Code	Course Title	L	T	P	C
10212BT123	ANIMAL BIOTECHNOLOGY	3	0	0	3

Course Category	*Program Elective*
Preamble	*To provide the fundamentals of animal cell culture, details of the diseases and therapy and the knowledge about the micromanipulation and transgenic animals.*
Prerequisite Courses	*10211BT105 – Genetic Engineering* *10211BT116 - Immunology and Immunotechnology*

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

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Summarize the knowledge of isolation, maintenance and growth of cells.	K2
CO2	Relate the concept of Animal Disease and its Diagnosis	K2
CO3	Understand the Diagnosis of the animal Diseases	K3
CO4	Illustrate the concepts of micromanipulation technology and transgenic animal technology	K3
CO5	Apply the transgenic techniques to produce the transgenic animal	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Summarize the knowledge of isolation, maintenance and growth of cells.	H	L	H	L				L	M			M	H	H	H
CO2	Relate the concept of Animal Disease and its Diagnosis	L	L	M					L				M	H	H	H
CO3	Understand the Diagnosis of the animal Diseases	H	H	H		M			M			M	M	H	L	L
CO4	Illustrate the concepts of micromanipulation technology and transgenic animal technology	M	L	L					L				M	L	L	M

CO5	Apply the transgenic techniques to produce the transgenic animal	M		H		H		M		L		M				M

H – High; M- Medium; L- Low

Course Content:

UNIT I	INTRODUCTION TO ANIMAL CELL CULTURE	9 hours

Introduction to basic tissue culture techniques; chemically defined and serum free media; animal cell cultures, their maintenance and preservation; various types of cultures suspension cultures, continuous flow cultures, immobilized cultures; somatic cell fusion; cell cultures as a source of valuable products; organ cultures.

UNIT II	DISEASE AND DIAGNOSIS IN ANIMALS	9 hours

Bacterial and viral diseases in animals; monoclonal antibodies and their use in diagnosis; molecular diagnostic techniques like PCR, in-situ hybridization; northern and southern blotting; RFLP.

UNIT III	THERAPY AND DIAGNOSIS FOR ANIMALS	9 hours

Recombinant cytokines and their use in the treatment of animal infections; monoclonal antibodies in therapy- VACCINES- Common viral, bacterial and parasitic diseases affecting animals- Live vaccines, killed vaccines- Conjugate vaccines- Anti Idiotypic vaccine- Subunit vaccines- Recombinant vaccines – DNA vaccines.

UNIT IV	MICROMANIPULATION AND INVITRO FERTILIZATION TECHNIQUES	9 hours

What is micromanipulation technology; equipment's used in micromanipulation; enrichment of x and y bearing sperms from semen samples of animals; artificial insemination and germ cell manipulations; *In vitro* fertilization technology *in vitro* maturation of oocytes, culture of *in vitro* fertilized embryos, embryo cloning- quadriparental hybrid, nuclear transplantation (Dolly), embryonic stem cells.

UNIT V	TRANSGENIC ANIMALS	9 hours

Concepts of transgenic animal technology; strategies for the production of transgenic animals and their importance in biotechnology; stem cell cultures in the production of transgenic animals.

LEARNING RESOURCES	
Text Books	1. Freshney R.I., "Culture of Animal Cells: A Manual of Basic Techniques and Specialized Applications", 6th Edition, John Wiley & Sons, 2010. 2. Ramadass P, Meera Rani S.,"Text Book of Animal Biotechnology", Akshara Printers, 1997
Reference Books	1. Ranga M.M.,"AnimalBiotechnology"Agrobios India Limited, 2002. 2. Portner, R., "Animal Cell Biotechnology: Methods and Protocols", 2nd Edition, Humana Press, 2007. 3. Masters J.R.W.,"Animal Cell Culture: Practical Approach", Oxford University Press, 2000.
Reference videos	https://www.youtube.com/watch?v=RpDke-Sadzo https://www.youtube.com/watch?v=oNwjMD5C29A https://www.youtube.com/watch?v=meX_OhC2qjE https://www.youtube.com/watch?v=dtJ-fBt1TaQ https://www.youtube.com/watch?v=RzYhcXjksKc
Reference NPTEL	https://archive.nptel.ac.in/content/storage2/courses/102103045/module1/lec1/5.html
Reference research/ review articles	1. Yamanaka, K., Haraguchi, Y., Takahashi, H., Kawashima, I., & Shimizu, T. (2023). Development of serum-free and grain-derived-nutrient-free medium using microalga-derived nutrients and mammalian cell-secreted growth factors for sustainable cultured meat production. Scientific Reports, 13(1), 498. 2. Yehia, N., Salem, H. M., Mahmmod, Y., Said, D., Samir, M., Mawgod, S. A., ... & Zanaty, A. M. (2023). Common viral and bacterial avian respiratory infections: an updated review. Poultry science, 102(5), 102553. 3. Zhao, K., Li, X., Lei, B., Han, Y., An, T., Zhang, W., ... & Yuan, W. (2023). Recombinant porcine Interferon-α and Interleukin-2 fusion protein (rPoIFNα+ IL-2) shows potent anti-pseudorabies virus activity in vitro and in vivo. Veterinary Microbiology, 279, 109678. 4. Liu, Y., Yin, Q., Luo, Y., Huang, Z., Cheng, Q., Zhang, W., ... & Ma, Z. (2023). Manipulation with sound and vibration: A review on the micromanipulation system based on sub-MHz acoustic waves. Ultrasonics Sonochemistry, 106441. 5. Shakweer, W. M. E., Krivoruchko, A. Y., Dessouki, S. M., & Khattab, A. A. (2023). A review of transgenic animal techniques and their applications. Journal of Genetic Engineering and Biotechnology, 21(1), 55.

Course Code	Course Title	L	T	P	C
10212BT124	TISSUE ENGINEERING	3	0	0	3

Course Category	*Program Elective*
Preamble	*This course will give a thorough understanding on the concepts of tissue organization and strategies for restoration of tissue function and their clinically relevant situations.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Identify the different types of biomaterials applied in tissue engineering and practical applications.	K2
CO2	Summarize the cellular Interactions and cellular Signaling in the process of cell growth	K2
CO3	Annotate the non-cellular component of the tissue and organs, and provide essential physical scaffolding	K2
CO4	Determine the Measurement of cell characteristics like shape, function and mortality.	K3
CO5	Study the different types of biomaterials applied in tissue engineering and practical applications.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Identify the different types of biomaterials applied in tissue engineering and practical applications.	H	L	H	L				L	M			M	H	H	H
CO2	Summarize the cellular Interactions and cellular Signaling in the process of cell growth	L	L	M					L				M	H	H	H
CO3	Annotate the non-cellular component of the tissue and organs, and provide essential physical scaffolding	H	H	H		M			M			M	M	H	L	L

CO4	Determine the Measurement of cell characteristics like shape, function and mortality.	M	L	L					L				M	L	L	M
CO5	Study the different types of biomaterials applied in tissue engineering and practical applications.	M		H		H		M		L		M				M

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION**	**9 hours**

Introduction to tissue engineering, Cells as therapeutic Agents, Cell growth rates, Tissue organization and Components, Tissue types, Homeostasis in highly prolific tissues and Tissue repair. Angiogenesis.

UNIT II	**CELL INTERACTIONS AND CELL SIGNALING**	**9 hours**

Cell differentiation, Cell migration – underlying biochemical process. Cell division, Cell death, apoptosis. Cellular Interactions– soluble signals, types of growth factors and chemokines, sending and receiving a signal, processing a signal, integrated responses, soluble growth factor receptors, Malfunctions in soluble signaling.

UNIT III	**TISSUE ARCHITECTURE**	**9 hours**

Tissue types and tissue components, tissue repair, Cell-extracellular matrix interactions, Modified ECM, Malfunctions in ECM signaling. Direct Cell-Cell contact, Response to mechanical stimuli.

UNIT IV	**BASICS OF TISSUE CELL CULTURE**	**9 hours**

Measurement of cell characteristics– cell morphology, cell number and viability, cell-fate processes, cell motility, cell function. Cell and tissue culture - types of tissue culture, media, culture environment and maintenance of cells *in vitro*, cryopreservation.

UNIT V	**APPLICATIONS OF TISSUE ENGINEERING**	**9 hours**

Biomaterials in tissue engineering, Application of tissue engineering and in Artificial skin, Artificial blood vessels, Regeneration of bone, muscle.

LEARNING RESOURCES

Text Books	1. Bernhard O. Palsson and SangeetaN.Bhatia, “Tissue Engineering", Pearson Publishers, 2009. 2. Meyer, U., Meyer, Th., Handschel, J. andWiesmann, H.P., “Fundamentals of Tissue Engineering and Regenerative Medicine”, 2009.

Reference Books	1. Mao J.J., Vunjak-Novakovic G., *et al*., (Eds), "Translational Approaches in Tissue Engineering &Regenrative Medicine", Artech House, INC Publications, 2008.
Reference videos	https://www.youtube.com/watch?v=PlEb50m7v_k https://www.youtube.com/watch?v=-dbRterutHY https://www.youtube.com/watch?v=i5tR3csCWYo https://www.youtube.com/watch?v=x7HVw1Va4qs https://www.youtube.com/watch?v=EYmLEw3ilqo
Reference NPTEL	https://archive.nptel.ac.in/courses/102/106/102106081/
Reference research/ review articles	1. Jadav, M., Pooja, D., Adams, D. J., & Kulhari, H. (2023). Advances in xanthan gum-based systems for the delivery of therapeutic agents. Pharmaceutics, 15(2), 402. 2. Vasudevan, J., Jiang, K., Fernandez, J. G., & Lim, C. T. (2023). Extracellular matrix mechanobiology in cancer cell migration. Acta Biomaterialia, 163, 351-364. 3. Saraswathibhatla, A., Indana, D., & Chaudhuri, O. (2023). Cell–extracellular matrix mechanotransduction in 3D. Nature Reviews Molecular Cell Biology, 24(7), 495-516. 4. Khan, T. A., Saleem, M., & Fariduddin, Q. (2023). Melatonin influences stomatal behavior, root morphology, cell viability, photosynthetic responses, fruit yield, and fruit quality of tomato plants exposed to salt stress. Journal of Plant Growth Regulation, 42(4), 2408-2432. 5. Wang, Y., Wang, Z., & Dong, Y. (2023). Collagen-based biomaterials for tissue engineering. ACS Biomaterials Science & Engineering, 9(3), 1132-1150.

Course Code	Course Title	L	T	P	C
10212BT125	HERBAL AND PHYTOCHEMICAL ENGINEERING	3	0	0	3

Course Category	*Program Elective*
Preamble	*To study and understand various basic concepts on Secondary metabolites from the plant resources and its isolation characterization techniques.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Summarize the different types of alkaloids and its isolation methods	K2
CO2	Utilize and categorize the different types alkaloids based its structural and functional properties	K3
CO3	Utilize and categorize the different types Steroids based its structural and functional properties	K3
CO4	Develop the drugs by using medicinal compounds of marine and plant sources	K3
CO5	Make use of chromatography techniques and analytical calculations to for phytocompound estimations.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Summarize the different types of alkaloids and its isolation methods	H	H	H	L				L	M			M	H	H	H
CO2	Utilize and categorize the different types alkaloids based its structural and functional properties	L	L	M					L				M	H	H	H
CO3	Utilize and categorize the different types Steroids based its structural and functional properties	H	H	H		M			M			M	M	H	L	L

CO4	Develop the drugs by using medicinal compounds of marine and plant sources	M	L	H					L				M	M	M	M
CO5	Make use of chromatography techniques and analytical calculations to for phytocompound estimations.	M		H		H		M		L		M			M	M

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO PHYTOCHEMISTRY**	**9 hours**

Introduction to alkaloids, classification, physical, chemical and general methods for isolation of alkaloids –Phenyl alkyl amine alkaloids.

UNIT II	**SYNTHESIS OF HERBAL- PHYTO CONSTITUENTS –I**	**9 hours**

Alkaloids: Ephedrine, Quinine, Strychynine, Piperine, Berberine, Taxol, Vinca alkoloids, Glycosides: Digitoxin, Glycyrrhizin, Sennosides, Bacosides, Quercitin.

UNIT III	**SYNTHESIS OF HERBAL- PHYTO CONSTITUENTS –II**	**9 hours**

Steroids: Hecogenin, guggulosterone and withanolides- Coumarin: Umbelliferone - Terpenoids: Cucurbitacins.

UNIT IV	**NATURAL PRODUCTS AS MEDICINE**	**9 hours**

Marine Drugs, cardiovascular, cytotoxic or anticancer, antimicrobials, anti-inflammatory & marine toxins;Antibiotics, definition, classification, natural sources and therapeutic indications.

UNIT V	**ANALYTICAL METHODS IN PHYTOCHEMISTRY**	**9 hours**

Chromatography techniques- Paper-Thin Layer- GC- GCMS-UV-IR-HPLC-HPTLC – NMR.

LEARNING RESOURCES

Text Books	1. Harbone J.B., "Phytochemical Method-- A guide to modern techniques of plant analysis", Third edition ,Chapman and Hall, 2005. 2. Trease and Evans, 'Pharmacognosy",16th Edition, Elsevier, New York, 2009. 3. Dewick P.M., "Medicinal Natural products – a biosynthetic approach", John Wiley & Sons, 2009.
Reference Books	1. Sarker S. D., Latif Z. and Gray A.I., "Methods in Biotechnology -Natural Product Isolation", Second Edition, Humana Press, 2006. 2. Bruneton J, "Pharmacognosy& Phytochemistry of Medicinal Plants", Interceptt Ltd., New York. 3. Jarald E.E. and Jarald S.E., "Textbook of Pharmacognosy and Phytochemistry", CBS Publishers & Distributors, New Delhi, 2009.

	4. Jean Bruneton, "Pharmacognosy, Phytochemistry, Medicinal plants", English edition,Levoisier Publishing, Paris, 1995.
Reference videos	https://www.youtube.com/watch?v=aLfabuFo7qo https://www.youtube.com/watch?v=6ZCnbCrYlJo https://www.youtube.com/watch?v=nVEopYV7dK4 https://www.youtube.com/watch?v=3wvwtv4sAPA https://www.youtube.com/watch?v=ByJ6lzD2Vbg
Reference NPTEL	https://nptel.ac.in/courses/102105342
Reference research/ review articles	1. Faisal, S., Badshah, S. L., Kubra, B., Emwas, A. H., & Jaremko, M. (2023). Alkaloids as potential antivirals. A comprehensive review. Natural Products and Bioprospecting, 13(1), 4. 2. Liu, W., Tang, X., Fan, C., He, G., Wang, X., Liang, X., & Bao, X. (2023). Chemical constituents, pharmacological action, antitumor application, and toxicity of strychnine semen from Strychnons pierriana AW Hill.: a review. Journal of Ethnopharmacology, 116748. 3. Bai, B., Liu, C., Zhang, C., He, X., Wang, H., Peng, W., & Zheng, C. (2023). Trichoderma species from plant and soil: An excellent resource for biosynthesis of terpenoids with versatile bioactivities. Journal of advanced research, 49, 81-102. 4. Hu, D., Jin, Y., Hou, X., Zhu, Y., Chen, D., Tai, J., ... & Lu, Y. (2023). Application of marine natural products against Alzheimer's disease: past, present and future. Marine Drugs, 21(1), 43. 5. Demyanovich, R. J. (2024). High energy dissipation rates from the impingement of free paper-thin sheets of liquids: Determination of the volume of the energy dissipation zone. Chemical Engineering Science, 294, 120128.

Course Code	Course Title	L	T	P	C
10212BT126	MEDICAL GENOMICS AND PROTEOMICS	3	0	0	3

Course Category	*Program Elective*
Preamble	*To know more about the techniques involved in the genomics and proteomics for medical applications.*
Prerequisite Courses	*10211BT108 - Molecular Biology: Concepts and Techniques* *10211BT112 – Genetic Engineering*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Summarize the basic structure and organization of genomes of prokaryotes and eukaryotes.	K2
CO2	Illustrate the physical mapping techniques.	K2
CO3	Develop the knowledge on various techniques in genomics.	K3
CO4	Construct the importance of techniques involved in proteomic analysis.	K3
CO5	Apply the knowledge of proteomics for protein profiling.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Summarize the basic structure and organization of genomes of prokaryotes and eukaryotes.	L											H	L	L	
CO2	Illustrate the physical mapping techniques.	L											H	L		M
CO3	Develop the knowledge on various techniques in genomics.	M	L	L	L								M	M		
CO4	Construct the importance of techniques involved in proteomic analysis.	M	L	L	L								H	M		
CO5	Apply the knowledge of proteomics for protein profiling.	M	L	L	L								H	M		

H – High; M- Medium; L- Low

Course Content:		
UNIT I	**OVERVIEW OF GENOMES OF BACTERIA, ARCHAEA ANDEUKARYOTA**	**9 hours**
Genome organization of prokaryotes and eukaryotes, Gene structure of Bacteria, Archaea and Eukaryotes, Human genome project, Introduction to functional and comparative genomics.		
UNIT II	**PHYSICAL MAPPING TECHNIQUES**	**9 hours**
Cytogenetic mapping, Radiation hybrid mapping, Fish-STS mapping, SNP mapping, Optical mapping. Top down and bottom up approach, Linking and jumping of clones, Gap closure, Pooling strategies, Automation in Genome sequencing-Next Generation Sequencing.		
UNIT III	**FUNCTIONAL GENOMICS**	**9 hours**
Gene finding, Annotation of genome – experimental and computational approach. ORF and functional prediction, Subtractive DNA library screening, Differential display and representational difference analysis, SAGE.		
UNIT IV	**PROTEOMICS TECHNIQUES**	**9 hours**
Protein level estimation-Edman protein microsequencing, Protein cleavage, 2D gel electrophoresis, metabolic labelling. Detection of proteins on SDS gels. Mass spectrometry principles of MALDITOF, Fourier Transform Ion Cyclotron Resonance Mass Spectrometer, Orbitrap Mass Analyzer, Tandem MS, Peptide mass fingerprinting.		
UNIT V	**PROTEIN PROFILING**	**9 hours**
Post translational modification, Protein-protein interactions, Glycoprotein analysis, Phosphoprotein analysis.		
LEARNING RESOURCES		
Text Books	1. Twyman R.M. and PrimroseS.B., "Principle of Genome Analysis and Genomics", Wiley Blackwell Publications, 2007. 2. Brown T.A., "Introduction to Genetic: A molecular Approach", Garland Science, Taylor and Francis, 2012.	
Reference Books	1. Liebler, "Introduction to Proteomics", Humana Press, 2002 **2.** Veenstra T.W. andTates III Jr, "Proteomics for Biological Discovery", Wiley Publications, 2006.	
Reference videos	https://www.youtube.com/watch?v=mg6tXQaiBaI https://www.youtube.com/watch?v=KXn533DTrsM https://www.youtube.com/watch?v=D-Ljd5Uex0s https://www.youtube.com/watch?v=k2ie0sWZKkc https://www.youtube.com/watch?v=5h3JGVlwR_8	
Reference NPTEL	https://nptel.ac.in/courses/102101072	
Reference research/	1. Shine, M., Gordon, J., Schärfen, L., Zigackova, D., Herzel, L., & Neugebauer, K. M. (2024). Co-transcriptional gene regulation in eukaryotes and prokaryotes. Nature Reviews Molecular Cell Biology, 1-21.	

review articles	2. Puebla-Aparicio, M., Ascencio-Elizondo, C., Vieira, M., Amorim, M. C. P., Duarte, R., & Fonseca, P. J. (2024). Characterization of the fish acoustic communities in a Mozambican tropical coral reef. Marine Ecology Progress Series, 727, 143-158. 3. Lang, B. F., Beck, N., Prince, S., Sarrasin, M., Rioux, P., & Burger, G. (2023). Mitochondrial genome annotation with MFannot: a critical analysis of gene identification and gene model prediction. Frontiers in Plant Science, 14, 1222186. 4. Gosset-Erard, C., Aubriet, F., Leize-Wagner, E., François, Y. N., & Chaimbault, P. (2023). Hyphenation of Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR MS) with separation methods: The art of compromises and the possible-A review. Talanta, 257, 124324. 5. Lee, J. M., Hammarén, H. M., Savitski, M. M., & Baek, S. H. (2023). Control of protein stability by post-translational modifications. Nature Communications, 14(1), 201.

Course Code	Course Title	L	T	P	C
10212BT127	Cellular Engineering	3	0	0	3

Course Category	*Program Elective*
Preamble	*To know more about the techniques involved in the Cellular Engineering for medical applications.*
Prerequisite Courses	*10211BT108 - Molecular Biology: Concepts and Techniques* *1151BT106 - CELL BIOLOGY*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Summarize the basic structure and functions of cellular organs	K2
CO2	Illustrate Mathematical modeling to explain the mechanical properties of cells	K2
CO3	Model the adherent cell with thermodynamic and kinetic models.	K3
CO4	Identify the importance of molecular motors for cell motion.	K3
CO5	Make use of cell receptor mediated signaling process.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Summarize the basic structure and functions of cellular organs	L											H	L	L	
CO2	Illustrate Mathematical modeling to explain the mechanical properties of cells	L	H	H	M	M	L						H	L	L	M
CO3	Model the adherent cell with thermodynamic and kinetic models.	M	L	L	L	H	H						M	M	L	
CO4	Identify the importance of molecular motors for cell motion.	M	L	L	L	H	M						H	M	M	
CO5	Make use of cell receptor mediated signaling process.	M	L	L	L	M	M						H	M	L	

H – High; M- Medium; L- Low

Course Content:		
UNIT I	**CELLULAR STRUCTURE, ORGANIZATION, AND FUNCTION**	**9 hours**
Cellular structures and organizations: Membrane, the nucleus, organelles, cytoskeleton, and ECM. Cellular functions and their control: Proteins and enzymes, DNA, RNA, and recombinant DNA Technology.		
UNIT II	**CELLULAR ENGINEERING**	**9 hours**
The cell as an engineering system: Mathematical modeling of calcium transient. Mechanical properties of cells: Experiments and Analyses.		
UNIT III	**CELL ADHESION**	**9 hours**
Cell adhesion: Adhesion molecules, Intercellular and interfacial forces, Mechanical and thermodynamic models, Kinetic and transport models.		
UNIT IV	**CELL LOCOMOTION**	**9 hours**
Cell locomotion: Molecular motors, Forces generated by a cell and a motor molecule, Forces generated by a cell and a motor molecule, Models of cell locomotion.		
UNIT V	**RECEPTOR-MEDIATED PROCESSES IN CELL**	**9 hours**
Other receptor-mediated processes: Binding, trafficking, and signaling. Effects of physical (e.g. shear stress, strain), chemical (e.g. cytokines, growth factors), and electrical stimuli on cell function**,** emphasizing topics on gene regulation and signal transduction processes.		
LEARNING RESOURCES		
Text Books	1. Gibson, L. J., and M. F. Ashby. Cellular Solids: Structure and Properties. 2nd ed. Cambridge University Press, 1997. ISBN: 9780521495608. *2. Essential Cell Biology (3rd edition)* **3.** Alberts et al., Garland Science (2009).	
Reference Books	1. Gibson, L. J., M. F. Ashby, and B. A. Harley. *Cellular Materials in Nature and Medicine*. Cambridge University Press, 2010. ISBN: 9780521195447.	
Reference videos	https://www.youtube.com/watch?v=URUJD5NEXC8 https://www.youtube.com/watch?v=KMF3QwoT5c8 https://www.youtube.com/watch?v=UM8i1Lfoc6U https://www.youtube.com/watch?v=O3MqraaLTsc https://www.youtube.com/watch?v=udzhuFz3HKw	
Reference NPTEL	https://nptel.ac.in/courses/102106036	
Reference research/ review articles	1. Kanchanawong, P., & Calderwood, D. A. (2023). Organization, dynamics and mechanoregulation of integrin-mediated cell–ECM adhesions. Nature Reviews Molecular Cell Biology, 24(2), 142-161. 2. Jędrzejewska-Szmek, J., Dorman, D. B., & Blackwell, K. T. (2023). Making time and space for calcium control of neuron activity. Current opinion in neurobiology, 83, 102804.	

	3. Ahmad, T., Rehman, L. M., Al-Nuaimi, R., de Levay, J. P. B. B., Thankamony, R., Mubashir, M., & Lai, Z. (2023). Thermodynamics and kinetic analysis of membrane: Challenges and perspectives. Chemosphere, 139430. 4. Lu, W., & Gelfand, V. I. (2023). Go with the flow–bulk transport by molecular motors. Journal of cell science, 136(5), jcs260300. 5. Zhang, L., Wei, X., Wang, Z., Liu, P., Hou, Y., Xu, Y., ... & Zhang, C. (2023). NF-κB activation enhances STING signaling by altering microtubule-mediated STING trafficking. Cell Reports, 42(3).

Course Code	Course Title	L	T	P	C
10212BT128	BIOPRINTING	3	0	0	3

Course Category	*Program elective*
Preamble	*Course will give a broad view toward Bioprinting its properties, manufacturing methods and its applications.*
Prerequisite Courses	*Biomaterials Engineering*

Course Outcomes	*Upon the successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Illustrate the basic principles and introduction pertaining to Bio printing	K2
CO2	Understand the basic principles involved in Biomaterial synthesis and characterization.	K2
CO3	Identify the Biocompatibility of Biomaterials.	K3
CO4	Model the scaffolds with soft hydrogel materials	K3
CO5	Build the knowledge in tissue engineering and soft lithography	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Illustrate the basic principles and introduction pertaining to Bio printing	L											H	L	M	
CO2	Understand the basic principles involved in Biomaterial synthesis and characterization.	L					L	M					H	L	H	
CO3	Identify the Biocompatibility of Biomaterials.	M	L	L	L									M		
CO4	Model the scaffolds with soft hydrogel materials	M	L	L	L									M		
CO5	Build the knowledge in tissue engineering and soft lithography	M	L	L	L									M		

H – High; M- Medium; L- Low

Course Content:

UNIT I	INTRODUCTION TO BIOPRINTING	9 hours
Introduction to Bioprinting: Types of Bioprinting: Prebioprintig, Bioprinting and Post Bioprinting, Applications of Bioprinting in Transplantation, Biofilms and Environmental remediation.		
UNIT II	**INTRODUCTION TO BIOMATERIALS**	**9 hours**
Introduction to Biomaterials: Synthesis, Characterization and functional properties of organic and inorganic biomaterials-Natural biopolymers, synthetic polymers, and soft materials with additional treatment of metals and ceramics.		
UNIT III	**BIOCOMPATIBILITY OF BIOMATERIALS**	**9 hours**
Biocompatibility of Biomaterials, blood compatibility and tissue compatibility tests, Toxicity tests, sensitization, carcinogenicity of synthesized biomaterials.		
UNIT IV	**BIOPRINTING & BIOFABRICATION**	**9 hours**
Bioprinting & Biofabrication- Fabrication of scaffolds often used in tissue engineering, drug delivery, and some medical devices. FDM (filament deposition methods) to 3D print thermoplastic materials and molds for casting soft hydrogel materials.		
UNIT V	**CELLULAR AND TISSUE ENGINEERING**	**9 hours**
Tissue Engineering-cellular and tissue engineering, physical, mechanical, and chemical manipulation to direct cell and tissue function. cell culture, immunofluorescent imaging, soft lithography, variable stiffness substrates, and the application.		
LEARNING RESOURCES		
Text Books	1. Bronzino, J. D. (2000). The Biomedical Engineering Handbook. Germany: CRC Press. 2. Artificial Organs. (2009). Netherlands: Springer London. 3. Miller, G. E. (2006). Artificial Organs. United States: Morgan & Claypool Publishers. 4. Schoen, F. J., Ratner, B. D., Hoffman, A. S., Lemons, J. E. (2004). Biomaterials Science: An Introduction to Materials in Medicine. Netherlands: Elsevier Science.	
Reference videos	https://www.youtube.com/watch?v=uHbn7wLN_3k https://www.youtube.com/watch?v=XqFSlG6WKO0&t=1s https://www.youtube.com/watch?v=Xf0LMCgol-U https://www.youtube.com/watch?v=r4Fj_CwEhvk https://www.youtube.com/watch?v=pteO6FRWo3g	
Reference NPTEL	https://nptel.ac.in/courses/102106095	

Reference research/ review articles	1. Karvinen, J., & Kellomäki, M. (2023). Design aspects and characterization of hydrogel-based bioinks for extrusion-based bioprinting. Bioprinting, e00274. 2. Kim, H. S., Kumbar, S. G., & Nukavarapu, S. P. (2023). Amorphous silica fiber matrix biomaterials: An analysis of material synthesis and characterization for tissue engineering. Bioactive Materials, 19, 155-166. 3. Chong, W. J., Shen, S., Li, Y., Trinchi, A., Simunec, D. P., Kyratzis, I. L., ... & Wen, C. (2023). Biodegradable PLA-ZnO nanocomposite biomaterials with antibacterial properties, tissue engineering viability, and enhanced biocompatibility. Smart Materials in Manufacturing, 1, 100004. 4. Suamte, L., Tirkey, A., Barman, J., & Babu, P. J. (2023). Various manufacturing methods and ideal properties of scaffolds for tissue engineering applications. Smart Materials in Manufacturing, 1, 100011. 5. Marin, E. (2023). Forged to heal: The role of metallic cellular solids in bone tissue engineering. Materials Today Bio, 23, 100777.

Course Code	Course Title	L	T	P	C
10212BT129	AUGMENTED AND VIRTUAL REALITY	3	0	0	3

Course Category	*Program Elective*
Preamble	*Revolutionizing industries from gaming and entertaining to healthcare and education*
Prerequisite Courses	*NIL*

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

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Understand the concept of augmented and virtual reality principles and Techniques	K2
CO2	Discuss the different perceptions of AR and VR approaches	K2
CO3	Explain the AR and VR features and Interfaces towards real-time Use cases	K2
CO4	Describe the concept of AR/VR modelling in different environment	K2
CO5	Build an AR/VR model for validation and testing with user end.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand the concept of augmented and virtual reality principles and Techniques	L	L			H	M	L					H	L	M	
CO2	Discuss the different perceptions of AR and VR approaches	L	M	H	L	M	H						H	L		
CO3	Explain the AR and VR features and Interfaces towards real-time Use cases	M	L	L	L	M	H						H	M		
CO4	Describe the concept of AR/VR modelling in different environment	M	L	L	L	H	H						M	M		
CO5	Build an AR/VR model for validation and testing with user end.	M	L	L	L	H	H						L	M		

H – High; M- Medium; L- Low		
Course Content:		
UNIT I	**INTRODUCTION**	**9 hours**
Augmented Reality, Virtual Reality, Head Mounted Displays, Visual Perception, Geometry of Camera and Visual World, Light and Optics, Tracking of Camera and Head for assisting Healthcare applications		
UNIT II	**PERCEPTIONS**	**9 hours**
Physiology of Perception, Cutaneous Senses, Pain, Olfaction, Gustation, Auditory System, Auditory Localization, Speech, Visual System, Object Perception, Motion Detection, Depth and Size Perception, psychophysical methods for computing perceptual thresholds		
UNIT III	**VIRTUAL REALITY**	**9 hours**
Defining Virtual Reality, History of VR, Human Physiology and Perception, Key Elements of Virtual Reality Experience, Virtual Reality System, Interface to the Virtual World-Input & output- Visual, Aural & Haptic Displays, Applications of Virtual Reality in Biological application – Drug Discovery, Protein structures and Chemical Bonding structures.		
UNIT IV	**HAPTIC PERCEPTION**	**9 hours**
Kinesthetic and Tactile Senses, Haptic Perception, Haptic Modeling and Rendering of Virtual Environment, Haptics for AR/VR. Human Factors in Virtual Reality, Case study on Construction of Geographic Virtual World.		
UNIT V	**DESIGN THINKING**	**9 hours**
Design Thinking Process, Context Modeling, Ideation and Storyboarding, Prototyping, Evaluation of Interaction and Experience, User Feedback		
LEARNING RESOURCES		
Text Books	1. Virtual Reality, Steven M. LaValle, Cambridge University Press, 2016 2. *GJ Kim*, "Designing VR Systems: The Structured Approach", Springer. 3. *D.A. Bowman* et al., "3D User Interfaces: Theory and Practice", Addison Wesley. **4.** *John Vince*, "Virtual Reality Systems", Pearson Ed.	
Reference Books	1. Burdea, Grigore C and Philippe Coiffet, "Virtual Reality Technology", Wiley Interscience, India, 2003. 2. Oliver Bimber and Ramesh Raskar, "Spatial Augmented Reality: Meging Real and Virtual Worlds", 2005.	
Reference videos	https://www.youtube.com/watch?v=vz0UUVDt2ps https://www.youtube.com/watch?v=udzhuFz3HKw&list=PLJIs8ZcKXHUwLVBUrw8aZJbKtDNfkV0nD https://www.youtube.com/watch?v=0_2JWdIQlhw https://www.youtube.com/watch?v=uPnHzQ7qJ2Y	

	https://www.youtube.com/watch?v=6wJ9Aakddng
Reference NPTEL	https://archive.nptel.ac.in/courses/121/106/121106013/
Reference research/ review articles	1. Al-Ansi, A. M., Jaboob, M., Garad, A., & Al-Ansi, A. (2023). Analyzing augmented reality (AR) and virtual reality (VR) recent development in education. Social Sciences & Humanities Open, 8(1), 100532. 2. Jayakumar, S., Maniglia, M., Guan, Z., Green, C. S., & Seitz, A. R. (2024). PLFest: A New Platform for Accessible, Reproducible, and Open Perceptual Learning Research. Journal of Cognitive Enhancement, 1-12. 3. Li, D., Zhu, L., Wu, Q., Chen, Y., Wu, G., & Zhang, H. (2023). Identification of binding sites for Tartary buckwheat protein-phenols covalent complex and alterations in protein structure and antioxidant properties. International Journal of Biological Macromolecules, 233, 123436. 4. Schöne, B., Kisker, J., Lange, L., Gruber, T., Sylvester, S., & Osinsky, R. (2023). The reality of virtual reality. Frontiers in Psychology, 14, 1093014. 5. Daggubati, L. S. Designing Digital Payment Experiences: The Crucial Role of User-Centered Design and Effective User Feedback Integration.

Course Code	Course Title	L	T	P	C
10212BT130	PRECISION AGRICULTURAL BIOTECHNOLOGY	3	0	0	3

Course Category	*Program Elective*
Preamble	*Provide an in-depth exploration of the principles, technologies, and applications of precision agriculture.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Understand basic concepts, history and basic practices of Precision agriculture	K2
CO2	Identify the soil and soil interactions for farming	K3
CO3	Utilize Geoinformatics tools for Precision Agriculture applications	K3
CO4	Develop electronics and imagery tools for agricultural development	K3
CO5	Model the Greenhouse with latest technologies and strategies	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand basic concepts, history and basic practices of Precision agriculture	H	H										H	H	L	
CO2	Identify the soil and soil interactions for farming	H	H	M	H	M	L						H	L	H	
CO3	Utilize Geoinformatics tools for Precision Agri culture applications	H	M	L	L	M	M						H	M	M	
CO4	Develop electronics and imagery tools for agricultural development	H	M	M	H	L	L						H	M	M	
CO5	Model the Greenhouse with latest technologies and strategies	H	H	M	M	H	M						H	M	L	

H – High; M- Medium; L- Low

Course Content:		
UNIT I	**PRECISION AGRICULTURE**	**9 hours**
Precision agriculture: concepts and techniques; their issues and concerns for Indian agriculture; Historic Perspectives of Precision Agriculture. Laser leveling, mechanized direct seed sowing; seedling and sapling transplanting, mapping of soils and plant attributes, site specific input application, weed management, insect pests and disease management, Good Agricultural Practices in precision farming, yield mapping in horticultural crops. Peat moss and mixtures, rock wool and other inert media for soilless culture, nutrient film technique (NFT)/ hydroponics.		
UNIT II	**CULTIVATION TECHNIQUES**	**9 hours**
Growing media, soil culture, Selection Criteria for soil media, soil pasteurization. Soil Variability and Soil Mapping - Factors affecting soil variability, Digital soil data and sources, Correlating soil data to other crop production data. Proximate Sensors: measure soil parameters - N status and soil pH. Crop discrimination and Yield monitoring, soil mapping; fertilizer recommendation using geospatial technologies		
UNIT III	**GEOINFORAMTICS**	**9 hours**
Geoinformatics- definition, concepts, tool and techniques; their use in Precision Agriculture. Spatial data and their management in GIS; Geodesy and its basic principles; Image processing and interpretation; Global positioning system (GPS), components and its functions; System Simulation- Concepts and principles, Introduction to crop Simulation. STCR approach for precision agriculture; Agricultural GIS software programs. Mobile GIS/GPS software programs. Principles and applications of mapping data in precision agriculture, GIS, GPS, sensors, drones, data acquisition and management. Yield Maps. Applications of Big Data in Precision Agriculture. Variable Rate Technology (VRT) - Grid Sampling, VRT Seeding, Planter Unit Controllers, Variable Hybrid/Variety Planting, VRT Pesticides, Spray Boom and Nozzle Control, Automatic Boom Leveling.		
UNIT IV	**SENSORS**	**9 hours**
Electronic systems and Signal processing: Communications data network for tractors and machinery for agriculture applications. Remote sensing basics- Applications in agriculture, correlating imagery to other crop production data, Remote sensing data sources. Sensors- Sensing Platforms—Satellite, UAV, Aerial, Proximal, The Electromagnetic Spectrum, Active vs. Passive Remote Sensing, Spectral, Spatial, and Temporal Resolution, Soil Sensors, Crop Sensors, Weather Sensors		
UNIT V	**GREEN HOUSE TECHNOLOGY**	**9 hours**
Green house technology - Introduction, Types of Green Houses; Plant response to Greenhouse environment, planning and design of greenhouses, Design criteria of green house for cooling		

and heating purposes. Green house equipments, materials of construction for traditional and low-cost greenhouses. Design and construction of green houses., Greenhouse heating – necessity, components, methods, design of heating system. Root media –types – soil and soil less media, composition, estimation, preparation and disinfection, bed preparation. Irrigation requirement, fertilizer management, cultivation, harvesting and post harvest techniques; Typical applications. Problems/constraints of greenhouse cultivation and future strategies.	
LEARNING RESOURCES	
Text Books	1. Singh Brahma and Balraj Singh. 2014. Advances in protected cultivation, New India Publishing Company. · 2. Sharma P. 2007. Precision Farming. Daya Publishing House New Delhi. 3. Ghosh Arupratan, Green house Technology, the future concept of Horticulture, Kalyani Publishers, Ludhiana. · 4. Tiwari G.N., Green house Technology for Controlled Environment, Narosa Pub. House Pvt. Ltd., New Delhi
Reference videos	https://www.youtube.com/watch?v=WhAfZhFxHTs https://www.youtube.com/watch?v=yEejDAwu4RE https://www.youtube.com/watch?v=6ct7uDKHEj8 https://www.youtube.com/watch?v=Tl1YkbdcEgU https://www.youtube.com/watch?v=8APpeti82hw
Reference NPTEL	https://onlinecourses.nptel.ac.in/noc24_bt30/preview
Reference research/ review articles	1. Ahmad, U., & Sharma, L. (2023). A review of best management practices for potato crop using precision agricultural technologies. Smart Agricultural Technology, 100220. 2. Mwangi, R. W., Mustafa, M., Kappel, N., Csambalik, L., & Szabó, A. (2024). Practical applications of spent mushroom compost in cultivation and disease control of selected vegetables species. Journal of Material Cycles and Waste Management, 1-16. 3. Saranya, T., Deisy, C., Sridevi, S., & Anbananthen, K. S. M. (2023). A comparative study of deep learning and Internet of Things for precision agriculture. Engineering Applications of Artificial Intelligence, 122, 106034. 4. El-Hageen, H. M., Alatwi, A. M., & Zaki Rashed, A. N. (2024). High-speed signal processing and wide band optical semiconductor amplifier in the optical communication systems. Journal of Optical Communications, 44(s1), s1277-s1284. 5. Al-Naemi, S., & Al-Otoom, A. (2023). Smart sustainable greenhouses utilizing microcontroller and IOT in the GCC countries; energy requirements & economical analyses study for a concept model in the state of Qatar. Results in Engineering, 17, 100889.

Course Code	Course Title	L	T	P	C
10212BT143	COMPUTATIONAL BIOLOGY: TECHNIQUES AND APPLICATIONS	2	0	2	3

Course Category	*Program Core*
Preamble	*This course enables the Biotechnologist to make sense of immense amounts of Biologicaldata through computational tools.*
Prerequisite Courses	*10212BT144 – Advanced Biochemistry* *10211BT104 - Molecular Biology: Concepts and Techniques*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Infer the biological sequences using different data bases and bioinformatics programming skills.	K2
CO2	Identify the similarity between multiple sequences by different algorithms.	K3
CO3	Construct, interpret and assess the different molecular sequences in phylogenetic tree arrangement	K3
CO4	Identify the structure and functions of protein for drug discovery algorithms	K3
CO5	Utilize the PERL and PYTHON programming applications in biology.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Infer the biological sequences by using different data bases and bioinformatics programming skills.	H	H	H	M	H							M		H	
CO2	Identify the similarity between multiple sequences by different algorithms.	H	H	H	M	H							M	H	M	
CO3	Construct, interpret and assess the different molecular sequences in phylogenetic tree arrangement	H	H	H	M	H							H	H	M	

CO4	Identify the structure and functions of protein for drug discovery algorithms	H	H	H	M	H							H	H	L	H
CO5	Illustrate the PERL and PYTHON programming applications in biology.	H	H	H	M	H							H	H	L	H

H – High; M- Medium; L- Low

Course Content:

UNIT I	**BIOLOGICAL DATABASES**	**9 hours**

Introduction to bioinformatics, biological databases and their growth. Types of Biological data- Genomic DNA, cDNA, rDNA, ESTs, GSSs; Primary Databases -Nucleotide sequence databases-GenBank, EMBL, DDBJ, Protein Sequence Databases- UniProtKB, UniProt, TrEMBL, Swiss-Prot, UniProt Archive-UniParc, UniProt Reference Clusters-UniRef, UniProt Metagenomic and Environmental Sequences UniMES. Literature Databases- PubMed, PLos, BioMed Central; Secondary databases.

UNIT II	**SEQUENCE ANALYSIS**	**9 hours**

Basic concepts of sequence similarity, identity and homology, definitions of homologues, orthologues, paralogues and xenologues. Scoring matrices: basic concept of a scoring matrix, Matrices for nucleic acid and proteins sequences, PAM and BLOSUM series, matrix derivation methods and principles. Pairwise sequence alignment – Basic concepts of sequence alignment, gap penalties, Needleman and Wunsch, Smith and Waterman algorithms for pairwise alignments and application in Nucleic acid and protein sequences alignments. Multiple sequence alignments (MSA) –The need for MSA.

UNIT III	**FILE FORMATS, SEQUENCE PATTERNS AND PROFILES**	**9 hours**

Sequence file formats – GenBank, FASTA, ALN/ClustalW2, PIR; Basic concept and definition of sequence patterns, motifs and profiles, various types of pattern representations viz. consensus, regular expression (Prosite-type) and sequence profiles; Sequence similarity based search engines (BLAST and FASTA); Pattern based search using MeMe and PRATT); Motif-based search using ScanProsite and eMOTIF; Profile-based database searches using PSI-BLAST and HMMer.

UNIT IV	**PHYLOGENETIC ANALYSIS AND HMM**	**9 hours**

Phylogenetic Analysis Phylogenetic tree and terminology, different methods of Phylogenetic tree prediction: maximum parsimony, distance (UPGMA, NJ), maximum likelihood methods, bootstrapping. Markov Chains and HMM Frequent words in DNA, Application of HMM in gene finding, and Multiple sequence alignment by HMM method.

UNIT V	PROTEIN STRUCTURE PREDICTION	9 hours
Machine learning techniques: Artificial Neural Networks in protein secondary structure prediction, Bioinformatics approaches for drug discovery, Applications of informatics techniques in proteomics: Peptide mass fingerprinting. Protein Secondary structure and tertiary structure prediction methods, Homology modeling, *abinitio* approaches, Threading, Critical Assessment of Structure Prediction.		

LABORATORY EXPERIMENTS:

1. Different sequence formats such as FASTA, PIR, EMBL, PDB, etc. Different sequence databases, retrieval of sequences from those databases and different ways to store the sequences.
2. Use of BLAST on line server to retrieve sequences from a database, Develop a program based on BLAST algorithm to carry out database search.
3. Find the gene sequences of Mouse origin similar to U80226.
4. Determine the number of entries in SWISSPROT for Serinekinase in monkey.
5. Use EBI (European Bioinformatics Institute) Needle sequence alignment tool to align above two sequences and compare your result with that of Needle tool.
6. Collect the any two protein sequences (CAA80512, AAA29341) from the enterz database and align the sequences with each other and report the pair wise score using CLUSTALW.
7. Perform the local alignment and global alignment between the following sequences and score the sequences withthe compositional substitution matrix BLOSUM62.
8. Retrieve and analyze the secondary structures of any one proteinsusing protein secondary structure prediction server.

LEARNING RESOURCES

Text Books	1. Mount D.W., "Bioinformatics: Genome and Sequence Analysis", Cold Spring Harbor Laboratory Press, New York, 2001. 2. Ian Korf Mark and Josaph,"BLAST", Oreilly Publisher, 2003. 3. Durbin R., Eddy S., Krogh A. and Mitchison G., "Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids", Cambridge University Press, 2002. 4. Baxevanis A.D. andOuletteB.F.F., "Bioinformatics – A practical guide to the Analysis of Genes and Proteins", Willey International publishers, 2002. 5. Bishop M.J. and Rawlings C.J.,"DNA and Protein Sequence Analysis - A Practical Approach", Oxford University Press, 1996. **6.** Pevsner J.,"Bioinformatics and Functional Genomics", Cold Spring Harbor Laboratory Press, New York, 2002.
Reference Books	**1.** Setubal J. and Meidanis J., Introduction to Computational Molecular Biology, PWS Publishing Co, 1997.
Online resources	http://hmmer.org/. https://blast.ncbi.nlm.nih.gov/Blast.cgi https://www.genome.jp/tools-bin/clustalw http://meme-suite.org/ http://evolution.genetics.washington.edu/phylip.html https://www.rcsb.org/

	http://www.ncbi.nlm.nih.gov/education/tutorials/ http://www.ncbi.nlm.nih.gov/books/NBK143764/
Reference videos	https://www.youtube.com/watch?v=JmKD5SnQtFE https://www.youtube.com/watch?v=iqAmkNSu3oI https://www.youtube.com/watch?v=KdKqZ6AuDCc https://www.youtube.com/watch?v=mzxS0m-RA6s https://www.youtube.com/watch?v=hMdbSiVUw6w
Reference NPTEL	https://archive.nptel.ac.in/courses/102/106/102106068/
Reference research/ review articles	1. Song, E., Ang, L., Park, J. Y., Jun, E. Y., Kim, K. H., Jun, J., ... & Lee, M. S. (2021). A scoping review on biomedical journal peer review guides for reviewers. PLoS One, 16(5), e0251440. 2. Ranwez, V., & Chantret, N. N. (2020). Strengths and limits of multiple sequence alignment and filtering methods. Phylogenetics in the genomic era, 2-2. 3. Jin, X., Liao, Q., Wei, H., Zhang, J., & Liu, B. (2021). SMI-BLAST: a novel supervised search framework based on PSI-BLAST for protein remote homology detection. Bioinformatics, 37(7), 913-920. 4. Khodaei, A., Feizi-Derakhshi, M. R., & Mozaffari-Tazehkand, B. (2021). A Markov chain-based feature extraction method for classification and identification of cancerous DNA sequences. BioImpacts: BI, 11(2), 87. 5. Pearce, R., & Zhang, Y. (2021). Toward the solution of the protein structure prediction problem. Journal of Biological Chemistry, 297(1).

Course Code	Course Title	L	T	P	C
10212BT144	ADVANCED BIOCHEMISTRY	3	0	0	3

Course Category	*Program Core*
Preamble	*To comprehend the knowledge of biochemistry and explains the processes happening at the cellular and molecular level.*
Prerequisite Courses	10210CH102 - Biochemistry

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

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Identification of metabolic pathways and its thermodynamic principles	K2
CO2	Describe the structure and metabolism of nucleic acids and amino acids	K3
CO3	Outline the different aspects of nucleic acid and lipids metabolism	K3
CO4	Utilize the other biomolecules such as vitamins and coenzymes and its importance.	K3
CO5	Develop drugs for hormone deficiencies related various diseases and disorders.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO2	Identification of metabolic pathways and its thermodynamic principles	M	H		M	M							M	M	L	L
CO3	Describe the structure and metabolism of nucleic acids and amino acids	M	H		M	M							M	M	L	L
CO4	Outline the different aspects of nucleic acid and lipids metabolism	M	H		M	M							M	M	L	L
CO4	Utilize the other biomolecules such as vitamins and coenzymes and its importance.	H	M	M									L	H	M	

CO5	Develop drugs for hormone deficiencies related various diseases and disorders.	M	H	H	M	H		M					M	M	H	L

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTERMEDIARY METABOLISM AND BIOENERGETICS**	**9 hours**

Overview of carbohydrate metabolism (Glycolysis, TCA, gluconeogenesis and Pentose phosphate shunt). Overview of intermediary metabolism: Interconnections and regulation of metabolic pathways. Bioenergetics - High energy compounds, electronegative potential of compounds, respiratory chain, ATP cycle, calculation of ATP yield during oxidation of glucose and fatty acids.

UNIT II	**AMINO ACIDS METABOLISM AND PROTEIN TRANSPORT**	**9 hours**

Metabolism concepts-Nitrogen metabolism and urea cycle, Biosynthesis of six essential amino acids (Met, Thr, Lys, Ile, Val, Leu) and aromatic amino acids- Metabolic disorders associated with chain and aromatic amino acid degradation. Protein targeting, signal sequence, SRP pathway, secretion; Folding, Chaperons and targeting of organelle proteins, Protein degradation, ubiquitination, receptor-mediated endocytosis, turnover.

UNIT III	**METABOLISM OF NUCLEIC ACIDS AND LIPIDS**	**9 hours**

Biosynthesis of nucleotides, de novo and salvage pathways for purines and pyrimidines, regulatory mechanisms: Degradation of nucleic acid by exo and endo nucleases. Triacylglycerol and phospholipid biosynthesis and degradation; Cholesterol biosynthesis and regulation and targets and action of cholesterol lowering drugs, statins.

UNIT IV	**VITAMINS AND COENZYMES**	**9 hours**

Fat Soluble Vitamins, provitamins (A, D, E and K). Structure, physiological significance and deficiency symptoms. Water soluble vitamins, structure, coenzyme role and deficiency symptoms. Thiamine, riboflavin, pyridoxine, niacin, folic acid, biotin and Vitamin B12. Recommended dietary intake. Coenzymes: Their role in metabolic pathways: NAD, FAD,TPP, PLP, carboxybiotin.

UNIT V	**HORMONES**	**9 hours**

Importance of Hormones. Chemical classification of hormones. Peptide hormonevasopressin, protein hormone- insulin. Lipid and phospholipid derived hormones- prostaglandin and phospholipids. Steroid hormones-testosterone, estrogen, cortisol. Monoamines: thyroxine,

adrenaline. Mechanism of action of steroid and peptide hormones, Hormonal disorders- Diabetes, Thyroid disorders, hypercholesterolemia and its role in cardiovascular disease.	
LEARNING RESOURCES	
Text Books	1. Nelson D.L., Cox M.M., & Lehninger A.L., "Principles of Biochemistry", McMillan Learning, New York, USA, 2014 2. Voet D.J., Voet J.G. and Pratt C.W., "Principles of Biochemistry", 3rd Edition, John Wiley & Sons Inc., 2008. 3. Murray R.K., et al., "Harper's Illustrated Biochemistry". XXVIIth Edition, McGraw-Hill, 2006.
Reference Books	1. Berg J.M., Tymoczko, J.L. and Stryer, L., "Biochemistry",6th Edition, WH Freeman, 2006. 2. Salway J.G., "Metabolism at a Glance", 2nd Edition, Blackwell Science Ltd., 2000.
Reference videos	https://www.youtube.com/watch?v=QX6vKCWPqBM https://www.youtube.com/watch?v=0M-B2dOfcUo https://www.youtube.com/watch?v=4GFKdLy2fOE https://www.youtube.com/watch?v=9MNReWZQQbw https://www.youtube.com/watch?v=-SPRPkLoKp8
Reference NPTEL	https://archive.nptel.ac.in/courses/104/104/104104066/
Reference research/ review articles	1. Shao, X., Fredericks, S. A., Saylor, J. R., & Bostwick, J. B. (2020). A method for determining surface tension, viscosity, and elasticity of gels via ultrasonic levitation of gel drops. The Journal of the Acoustical Society of America, 147(4), 2488-2498. 2. Van Eker, D., Samanta, S. K., & Davis, A. P. (2020). Aqueous recognition of purine and pyrimidine bases by an anthracene-based macrocyclic receptor. Chemical Communications, 56(65), 9268-9271. 3. Paredes-Flores, M. A., Rahimi, N., & Mohiuddin, S. S. (2024). Biochemistry, glycogenolysis. In StatPearls [Internet]. StatPearls Publishing. 4. Long, T., Debler, E. W., & Li, X. (2022). Structural enzymology of cholesterol biosynthesis and storage. Current opinion in structural biology, 74, 102369. 5. Seyfried, T. N., Arismendi-Morillo, G., Mukherjee, P., & Chinopoulos, C. (2020). On the origin of ATP synthesis in cancer. Iscience, 23(11).

FOOD BIOTECHNOLOGY DOMAIN

Course Code	Course Title	L	T	P	C
10212BT131	PRINCIPLES OF FUNCTIONAL FOOD AND APPLICATIONS	3	0	0	3

Course Category	*Program Elective*
Preamble	*To know more about functional foods and its nutritional values, also the development of functional foods and its processing methods.*
Prerequisite Courses	*Nil*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Outline the types of nutraceutical and functional foods and its regulatory issues	K2
CO2	Relate deficiencies of essential nutrients to diseases.	K2
CO3	Build the steps in product developments of Nutraceuticals and functional foods	K3
CO4	Identify the interactions of environmental factors on processing and storage of foods	K3
CO5	Apply the methods to process functional foods into different forms	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Outline the types of nutraceutical and functional foods and its regulatory issues	M	H	M	L								H		M	
CO2	Relate deficiencies of essential nutrients to diseases.	M		M									H		M	
CO3	Build the steps in product developments of Nutraceuticals and functional foods	H		M		H							H	M		
CO4	Identify the interactions of environmental factors on processing and storage of foods		M			H	L	L	M				H			H

CO5	Apply the methods to process functional foods into different forms	M			H			L					H	M		

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO FUNCTIONAL FOODS**	**9 hours**

Introduction to functional foods, importance, history, definition, classification, list of functional foods active ingredients, health benefits, Recent development and advances in the areas of functional foods. Marketing and regulatory issues for functional foods.

UNIT II	**NUTRITIONAL VALUE OF FUNCTIONAL FOODS**	**9 hours**

Therapeutic nutrition & formulation of special dietary foods; Relation of food and diseases; Deficiencies of essential nutrients; Assessment of nutritional status & RDA; Effect of processing on nutrients.

UNIT III	**FORMULATION OF FUNCTIONAL FOODS**	**9 hours**

Steps in product developments of functional foods, formulation of functional foods containing nutraceuticals – stability and analytical issues. selections, optimal stability conditions of active ingredients/compounds used in the developments, selections of appropriate products for individual active compound or patient/consumer, health-benefitting level of active ingredients/compounds, developments of base formulae and formulae containing active ingredients/compounds as well

UNIT IV	**ROLE IN HEALTH AND DISEASES**	**9 hours**

Functional foods and immune competence; role and use in obesity and nervous system disorders, Functional foods and nutraceuticals with attributes to control cardiovascular diseases, cancer, ageing.

UNIT V	**PROCESSING OF FUNCTIONAL FOODS**	**9 hours**

Processing of Functional Foods in various forms of powders, beverages, snacks; stability consideration, limitation, precaution to retain bioactive compounds. Effects of processing, storage and interactions of various environmental factors on the potentials of such foods.

LEARNING RESOURCES

Text Books	1. Shi J.(Ed) 2006. Functional Food Ingredients and Nutraceuticals: Processing Technologies.. CRC. 2. Wildman, Robert “Handbook of Nutraceuticals and Functional Foods”. CRC, 2006.
Reference Books	Functional Foods by R. Chadwick,S. Henson,B. Moseley,G. 2. Methods of Analysis for Functional Foods and Nutraceuticals by W. Jeffrey Hurst

Reference videos	https://www.youtube.com/watch?v=svS6I09JORQ https://www.youtube.com/watch?v=C2WgjlotVMQ https://www.youtube.com/watch?v=qNTYqOt04rE https://www.youtube.com/watch?v=9G1wWUjkyz8 https://www.youtube.com/watch?v=0Ss_fguPoc4
Reference NPTEL	https://archive.nptel.ac.in/courses/126/105/126105015/
Reference research/ review articles	1. Díaz, L. D., Fernández-Ruiz, V., & Cámara, M. (2020). An international regulatory review of food health-related claims in functional food products labeling. Journal of Functional Foods, 68, 103896. 2. Gómez, I., Janardhanan, R., Ibañez, F. C., & Beriain, M. J. (2020). The effects of processing and preservation technologies on meat quality: Sensory and nutritional aspects. Foods, 9(10), 1416. 3. Alongi, M., & Anese, M. (2021). Re-thinking functional food development through a holistic approach. Journal of Functional Foods, 81, 104466. 4. Khalaf, A. T., Wei, Y., Alneamah, S. J. A., Al-Shawi, S. G., Kadir, S. Y. A., Zainol, J., & Liu, X. (2021). What is new in the preventive and therapeutic role of dairy products as nutraceuticals and functional foods?. BioMed research international, 2021(1), 8823222. 5. Perfilova, O. V., Akishin, D. V., Vinnitskaya, V. F., Danilin, S. I., & Olikainen, O. V. (2020, August). Use of vegetable and fruit powder in the production technology of functional food snacks. In IOP Conference Series: Earth and Environmental Science (Vol. 548, No. 8, p. 082071). IOP Publishing.

Course Code	Course Title	L	T	P	C
10212BT132	NUTRACEUTICALS	3	0	0	3

Course Category	*Program Elective*
Preamble	*Provides knowledge in newly emerging area of nutraceuticals with respect to the types, mechanisms of action, manufacture of selected nutraceuticals, product development, clinical testing and toxicity aspects.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Define history and basis of nutraceuticals in relation to various factors	K2
CO2	Understand concepts of nutritional assessment and indices	K2
CO3	Comprehend nutritional disorders and role of nutraceuticals in medicine	K3
CO4	Understand applications of metabolites in medicine and treatment	K3
CO5	Apply knowledge of nutraceutical production and formulation as functional foods	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Define history and basis of nutraceuticals in relation to various factors	M	L	M									H	L	M	
CO2	Understand concepts of nutritional assessment and indices	M	L	L	L								H		M	
CO3	Comprehend nutritional disorders and role of nutraceuticals in medicine	L	M	H		L							M	M	M	
CO4	Understand applications of metabolites in medicine and treatment	H	M	L			M		M				H	H		H

CO5	Apply knowledge of nutraceutical production and formulation as functional foods	M	L	H									H	M		

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION**	**9 hours**

History, definition, classification and source of nutraceuticals, basis of claims for a compound as a nutraceutical, benefits of nutraceuticals, role of nutraceuticals in Medicine, Human physiology, genetics, food technology, chemistry and nutrition, scope and availability involved in the industry, Indian and global scenario.

UNIT II	**NUTRITIONAL ANALYSIS**	**9 hours**

Food components based on nutritional value, nutritional assessment of carbohydrates, proteins and fats, recommended dietary intake, recommended daily allowance (RDA), acceptable dietary intake, nitrogen balance, protein efficiency ratio (PER), basics of energy balance - Basal Metabolic Rate (BMR), Body Mass Index (BMI) and Standard Dynamic Action (SDA) with special reference to nutraceutical industry

UNIT III	**DIETARY FOODS**	**9 hours**

Factors responsible for nutritional disorders: Malnutrition, undernutrition and anti-nutritional factors (cyanogens, lectins, enzyme inhibitors, phytoallexins and phytates), types of metabolic disorders, nutritional factors, nutraceuticals for prevention and treatment (diabetes mellitus, hypertension, hypercholesterolemia, etc), concept of antioxidants - use of antioxidants as dietary supplements in prevention and treatment of cancer, obesity and stress, role of nutraceuticals and functional foods in pediatrics, geriatrics, sports, pregnancy and lactation, functional food as remedies.

UNIT IV	**PLANT AND ANIMAL METABOLITES**	**9 hours**

Plant secondary metabolites, classification and sub-classification -alkaloids, phenols, Terpenoids. Animal metabolites - chitin, chitosan, glucosamine, chondroitin sulphate, polysaccharides of animal origin, uses and applications in preventive medicine and treatment, Concept of prebiotics and probiotics, synbiotics for maintaining good health, algae as a source of omega - 3 fatty acids, antioxidants and minerals - extraction and enrichment.

UNIT V	**INDUSTRIAL PRODUCTION AND FORMULATION OF NUTRACEUTICALS**	**9 hours**

Industrial production of nutraceuticals, formulation of functional foods containing nutraceuticals, manufacturing aspects of nutraceuticals (lycopene, isoflavonoids, prebiotics and

probiotics, glucosamine, phytosterols etc), preferences and globalization on selection of nutraceutical products, identification and estimation of health benefits of selected nutraceuticals, quality evaluation of foods containing nutraceuticals, packaging and labeling of functional foods, toxicology and bioavailability, use of animal models, pre-clinical and clinical trials involved.

LEARNING RESOURCES	
Text Books	
Reference Books	1. Handbook of nutraceuticals and functional foods by Robert E C. Wildman, CRC/Taylor&Francis 2. Handbook of nutraceuticals Vol I by Yahwant Vishnupant Pathak, CRC press.2009 3. Handbook of nutraceuticals Vol II by Yahwant Vishnupant Pathak, CRC press,2011 4. Handbook of Prebiotics, Glenn R. Gibson, Marcel Roberfroid, CRC press, 2008. 5. Swaminathan M., Essentials of Food and Nutrition, 2nd Ed, 1985, Ganesh and Co. 6. Dietary Supplements: Toxicology and Clinical Pharmacology. Humana Press. Gibson GR & William CM. 2000. 7. Dietary Supplements. 2nd Ed. Pharmaceutical Press. Campbell JE & Summers JL. 2004. 8. Bioprocesses and Biotechnology for Nutraceuticals. Chapman & Hall. Robert EC. 2006. 9. Handbook of Nutraceuticals and Functional Foods. 2nd Ed. Wildman.
Reference videos	https://www.youtube.com/watch?v=h8uV5I_N8w4 https://www.youtube.com/watch?v=ojhdTFmkY1c https://www.youtube.com/watch?v=Ua-dLw2nFs4 https://www.youtube.com/watch?v=_NNtgHmD5BU https://www.youtube.com/watch?v=K3L3DMkfyc8
Reference NPTEL	https://archive.nptel.ac.in/courses/126/105/126105015/
Reference research/ review articles	1. Nutrition in Health and Disease 17th Edition; Anderson, Dibble, Turkki, Mitchell, Rynbergen J.B. Lippincott Company, 1982 2. Dietary Supplements of Plant Origin, M. Maffei (Ed.), Taylor & Francis, 2003. 3. Bioprocesses and Biotechnology for Functional Foods and Nutraceuticals, Jean – Richard Neeser & J. Bruce German, Marcel Dekker, Inc., 2004. Nutraceuticals in health and disease prevention, Klaus Krämer, Peter-Paul Hoppe, Lester Packer

Course Code	Course Title	L	T	P	C
10212BT133	FOOD PRESERVATION, PACKAGING TECHNOLOGIES	3	0	0	3

Course Category	*Program Elective*
Preamble	*To provide an adequate knowledge of principles of food preservation and packaging*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Illustrates the different modes of food preservation	K2
CO2	Understand the fundamentals of food preservation through dehydration	K2
CO3	Identify the purpose and principles of food packaging	K2
CO4	Explain the nature of different materials used in food packaging	K2
CO5	Develop food packaging technologies for different foods	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Illustrates the different modes of food preservation	H	L			M							H	H	M	
CO2	Understand the fundamentals of food preservation through dehydration	L	H	L									H	H	L	
CO3	Identify the purpose and principles of food packaging	M											H	H		
CO4	Explain the nature of different materials used in food packaging	H	H	L		M							H	M	H	
CO5	Develop food packaging technologies for different foods	H		M			L						H		H	

H – High; M- Medium; L- Low

Course Content:

UNIT I	DIFFERENT MODES OF FOOD PRESERVATION	9 hours
Introduction of preservation, Preservation methods: thermal and other non-thermal methods, microbiological additives, and pulsed electric or magnetic fields. High temperature, low temperature, drying, radiation, chemical preservatives, bio-preservatives, hurdle technology, active packaging. Preservation by fermentation – Curing, Pickling and Smoking, Chilling and Freezing, Properties of frozen foods. Food preservation and handling including fresh fruits and vegetables, grains and pulses, fish, red meat, and milk.		
UNIT II	**FOOD PRESERVATION THROUGH DEHYDRATION**	**9 hours**
Water activity and moisture absorption isotherms, Psychometric chart, Dehydration and drying of foods, drying curve and drying time calculation, Enthalpy change during freezing, Plank's equation for freezing time, Cold storage and Refrigeration load, Refrigeration cycle, Cryogenic freezing and IQF Different types of dryers: Conductive, convective and combined, IMF foods, Osmotic dehydration. food preservatives of microbial origin.		
UNIT III	**ADVANCED TECHNIQUES OF PACKAGING**	**9 hours**
Packaging of foods, requirement, importance and scope. Factors affecting shelf life of food material during storage, spoilage agents with environmental factors. Control of the spoilage agents. Functions of packaging - packaging materials, risks associated with potential food contamination, Interpret packaging standards and regulations in food packaging materials. Aseptic packaging. Retort processing.Packaging systems, types: flexible and rigid; retail and bulk; levels of packaging; special solutions and packaging machines, technical packaging systems and data management packaging systems.Nutritional labeling on packages, CAS and MAP, shrink and cling packaging, vacuum and gas packaging; Factors affecting the choice of packaging materials, Disposal and recycle of packaging waste. Printing and labeling, Lamination.		
UNIT IV	**MATERIALS FOR FOOD PACKAGING**	**9 hours**
Different types of packaging materials, their key properties and applications. Different types of polymers used in food packaging and their barrier properties. Metal cans, manufacture of two piece and three-piece cans. Canning of food products, Classifications and structure of cans, corrosion, Lacquering. Manufacture of plastic packaging materials, profile extrusion, blown film/ sheet extrusion, blow molding, extrusion blow molding, injection blow molding, stretch blow molding, injection molding. Glass containers, types of glass used in food packaging. Paper and paper board packaging, paper and paper board manufacture process. Relative advantages and disadvantages of different packaging materials.		

UNIT V	TESTING METHODS FOR PACKAGING MATERIALS	9 hours
Testing methods for flexible materials, rigid materials and semi rigid materials; Tests for paper (thickness, bursting strength, breaking length, stiffness, tear resistance, folding endurance, ply bond test, surface oil absorption test, etc.), plastic film and laminates (thickness, tensile strength, gloss, haze, burning test to identify polymer, etc.), aluminium foil (thickness, pin holes, etc.), glass containers (visual defects, colour, dimensions, impact strength, etc.), metal containers (pressure test, product compatibility, etc.).		

LEARNING RESOURCES	
Text Books	1. Robertson, G. L. 2005. Food Packaging: Principles and Practice. Second Edition. Taylor and Francis Pub 2. Coles, R., McDowell, D., Kirwan, M .J. 2003. Food Packaging Technology. Blackwell Publishing Co. **3.** Gosby, N.T. 2001. Food Packaging Materials. Applied Science Publication
Reference Books	1. Mahadevia, M., Gowramma, R.V. 2007. Food Packaging Materials. Tata McGraw Hill 2. Robertson, G. L. 2001. Food Packaging and Shelf life: A Practical Guide. Narendra Publishing House. **3.** John, P.J. 2008. A Handbook on Food Packaging Narendra Publishing House
Reference videos	https://www.youtube.com/watch?v=NJBj0ArTcQA https://www.youtube.com/watch?v=b33hd8TO7ws https://www.youtube.com/watch?v=HCH_cVKJ5lA https://www.youtube.com/watch?v=ToHIfshAt3g https://www.youtube.com/watch?v=f3JTA0YN3Hk
Reference NPTEL	https://nptel.ac.in/courses/126105015
Reference research/ review articles	1. Xiong, Y. L. (2023). The storage and preservation of meat: I—Thermal technologies. In Lawrie's meat science (pp. 219-244). Woodhead publishing. 2. Figura, L. O., & Teixeira, A. A. (2023). Water activity. In Food Physics: Physical Properties-Measurement and Applications (pp. 1-57). Cham: Springer International Publishing. 3. Jagoda, S. U. M., Gamage, J. R., & Karunathilake, H. P. (2023). Environmentally sustainable plastic food packaging: A holistic life cycle thinking approach for design decisions. Journal of Cleaner Production, 400, 136680. 4. Agarwal, A., Shaida, B., Rastogi, M., & Singh, N. B. (2023). Food packaging materials with special reference to biopolymers-properties and applications. Chemistry Africa, 6(1), 117-144. 5. Chen, Z., Qiao, J., Yang, X., Sun, Y., & Sun, D. (2023). A review of grouting materials for pouring semi-flexible pavement: Materials, design and performance. Construction and Building Materials, 379, 131235.

Course Code	Course Title	L	T	P	C
10212BT134	MARINE BIOTECHNOLOGY AND AQUACULTURE	3	0	0	3

Course Category	*Program Elective*
Preamble	*To provide an adequate knowledge of the wealth and benefits of marine and aquaculture resources.*
Prerequisite Courses	*NIL*

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

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Outline the history, biochemicals, and food chain in the marine system.	K2
CO2	Illustrate about the organisms and its importance in sea water. comprehend the importance of marine organisms.	K2
CO3	Explain about the remediation and correction in the marine system. acquire to problems faced and the protective measures.	K2
CO4	Explain the marine pharmacology with the help of medicinal compounds produced from marine flora and fauna	K2
CO5	Utilize the knowledge in aquaculture technology for various applications	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Outline the history, biochemicals, and food chain in the marine system.	H											M	H	M	
CO2	Illustrate about the organisms and its importance in sea water.	H		H	M								M	H	H	
CO3	Explain about the remediation and correction in the marine system. acquire to problems faced and the protective measures.	H	M	H	M								M	H	H	

CO4	Explain the marine pharmacology with the help of medicinal compounds produced from marine flora and fauna	H	H	H	H	L							M	H	H	M
CO5	Utilize the knowledge in aquaculture technology for various applications	H		M	M	H							M	H	H	L

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO MARINE ENVIRONMENT**	**9 hours**

World oceans ans seas – ocean currents – physical and chemical properties of sea water – abiotic and biotic factors of the sea – ecological divisions of the sea – history of marine biology – bioecochemical cycles – food chain and food web.

UNIT II	**MARINE ENVIRONMENTAL BIOTECHNOLOGY**	**9 hours**

Phytoplanktons – zooplantons – nektons – benthos – marine mammals – marine algae – mangroves – coral reefs – deep sea animals and adaptation – intertidal zone – fauna and flora.

UNIT III	**MARINE PHARMACOLOGY**	**9 hours**

Marine pollution – biology indicators (marine micro, algae) – biodegradation & bioremediation – marine fouling and corrosion. Protection methods against fouling and corrosion. Red tides: causative factors and effects on the organisms of marine environment.

UNIT IV	**AQUACULTURE TECHNOLOGY**	**9 hours**

Medicinal compound from marine flora and fauna – marine toxins (tetrodotoxins, conotoxins, and ciguateratoxins), antiviral, antimicrobial agents, antioxidants, collagen, gelatin, heparin, chitosan, omega 3 fatty acids and carotinoids.

UNIT V	**COASTAL AQUACULTURE**	**9 hours**

Important of coastal aquaculture – marine fishery resources – common fishing crafts and gears – aquafarm design and construction.

LEARNING RESOURCES	
Text Books	1. FingermanM. and Nagabhushanam MaryR.,"Recent advances in marine biotechnology", volume 3 & 2, Frances Thomson.
Reference Books	1. Le Gal Y., Ulber, R, "Marine Biotechnology I: Advances in Biochemical Engineering/Biotechnology", Springer-Verlag Berlin Heidelberg, 2005. 2. Attaway D.H. and Zaborsky O.R., "Marine Biotechnology: Volume I, Pharmaceuticals and Bioactive Natural Products", New York: Plenum. 1993.
Reference videos	https://www.youtube.com/watch?v=AhkNDCe98U0 https://www.youtube.com/watch?v=nvSM9A-qW8w https://www.youtube.com/watch?v=yDBU1Dq5JTc https://www.youtube.com/watch?v=wVcIGaBZW1A https://www.youtube.com/watch?v=YGaFNZzjCXI
Reference NPTEL	https://archive.nptel.ac.in/courses/126/105/126105022/
Reference research/ review articles	1. Morrow, R., Fu, L. L., Rio, M. H., Ray, R., Prandi, P., Le Traon, P. Y., & Benveniste, J. (2023). Ocean circulation from space. Surveys in Geophysics, 44(5), 1243-1286. 2. Wang, L., Liu, J., Bao, Z., Ma, X., Shen, H., Chen, J., & Xie, P. (2024). Predictable shifts in diversity and ecosystem function in phytoplankton and zooplankton communities along thermocline stratification intensity continua. Science of the Total Environment, 912, 168981. 3. Chen, J., Li, P., Wang, X., & Yi, K. (2023). Above management: Scale development and empirical testing for public opinion monitoring of marine pollution. Marine Pollution Bulletin, 192, 114953. 4. Nugraha, A. S., Firli, L. N., Rani, D. M., Hidayatiningsih, A., Lestari, N. D., Wongso, H., ... & Keller, P. A. (2023). Indonesian marine and its medicinal contribution. Natural Products and Bioprospecting, 13(1), 38. 5. Wang, M., Mao, D., Xiao, X., Song, K., Jia, M., Ren, C., & Wang, Z. (2023). Interannual changes of coastal aquaculture ponds in China at 10-m spatial resolution during 2016–2021. Remote Sensing of Environment, 284, 113347.

Course Code	Course Title	L	T	P	C
10212BT135	FOOD SAFETY, QUALITY AND REGULATION	3	0	0	3

Course Category	*Program Elective*
Preamble	*To provide an adequate knowledge to learn food safety and quality auditing programme.*
Prerequisite Courses	*Nil*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Compute different type of food hazards, physical, chemical and biological in the industry and food service	K2
CO2	Acquaint knowledge on food safety surveillance	K2
CO3	Identify the quality attributes of food	K3
CO4	Develop Pre-Requisite program on food plant management system	K3
CO5	Compute awareness on regulatory and statutory bodies in India and the world	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Compute different type of food hazards, physical, chemical and biological in the industry and food service	H	M	H				M						H		
CO2	Acquaint knowledge on food safety surveillance	H		M											M	
CO3	Identify the quality attributes of food	H							L				M			H
CO4	Develop Pre-Requisite program on food plant management system	M		H			M						M			

CO5	Compute awareness on regulatory and statutory bodies in India and the world	M					L						M		H	M

H – High; M- Medium; L- Low

Course Content:

UNIT I	**FOOD SAFETY AND SECURITY**	**9 hours**

Introduction to food safety and security, Factors contributing to physical, chemical and biological contamination in food chain, prevention and control of food borne hazards, Regulation of food sanitation, personal hygiene-food handlers, cleaning compounds, sanitation methods, waste disposal strategy (solid and liquid waste) and pest control

UNIT II	**FOOD SAFETY SURVEILLANCE**	**9 hours**

Food Adulteration, Food Additives, Food Packaging & labeling. Sanitation in warehousing, storage, shipping, receiving, containers and packaging materials. Cleaning and Disinfection, ISO 22000 – Importance and Implementation. Requirements Specific to Food Testing – Physical and Chemical Parameters, Requirements Specific to Food Testing – Biological Parameters, General Topics: Related to Food Testing Laboratories.

UNIT III	**FOOD QUALITY SYSTEM**	**9 hours**

Various Quality attributes of food, Instrumental, chemical and microbial Quality control. Sensory evaluation of food and statistical analysis - Descriptive testing and Product Matching. Water quality and other utilities. Laboratory Quality Management System:Overview and Requirements of ISO 17025, Food Bioterrorism Acts. Food inspection and Food Law, Risk assessment – microbial risk assessment, dose response and exposure response modelling, risk management, implementation of food surveillance system to monitor food safety, risk communication

UNIT IV	**PRE-REQUISITE PROGRAM**	**9 hours**

Good Manufacturing Practices - Personal hygiene – occupational health and safety specification, Food Plant Sanitation Management - Plant facilities construction and maintenance - exterior of the building- interior of the building- equipments. Storage, transportation, traceability, recalling procedures, training.

UNIT V	**FOOD SAFETY REGULATIONS**	**9 hours**

Indian and global regulations: International Agencies in Food Regulation: Food Codex Alimentarius: Codex India – Role of Codex Contact point, National Codex contact point (NCCP), National Codex Committee of India – ToR, Functions, Shadow Committees etc. Various aspects and relation with domestic laws; FAO, WHO, WTO. FAO in India, Technical

Cooperation programmes, Bio-security in Food and Agriculture, World Health Organization (WHO), World Animal Health Organization (OIE), International Plant Protection Convention (IPPC).	
LEARNING RESOURCES	
Text Books	1. Handbook of food toxicology by S. S. Deshpande, 2002 2. The food safety information handbook by Cynthia A. Robert, 2009 3. Nutritional and safety aspects of food processing by Tannenbaum SR, Marcel Dekker Inc., New York 1979
Reference Books	1. Microbiological safety of Food by Hobbs BC, 1973
Reference videos	https://www.youtube.com/watch?v=0J2Qv_72Xzo https://www.youtube.com/watch?v=rkuInbWL_pI https://www.youtube.com/watch?v=yxlC-ffnfrY https://www.youtube.com/watch?v=ZvmMMDRQoyw https://www.youtube.com/watch?v=_mcsYYbhEhE
Reference NPTEL	https://nptel.ac.in/courses/126105336
Reference research/ review articles	1. Kiran, V., Harini, K., Thirumalai, A., Girigoswami, K., & Girigoswami, A. (2024). Nanotechnology's Role in Ensuring Food Safety and Security. Biocatalysis and Agricultural Biotechnology, 103220. 2. Glykas, M. (2024). Quality management implementation maturity assessment in the food industry: glykas quality compass assessment on ISO 22000. International Journal of Productivity and Quality Management, 41(3), 289-336. 3. Chen, L., Ning, F., Zhao, L., Ming, H., Zhang, J., Yu, W., ... & Luo, L. (2023). Quality assessment of royal jelly based on physicochemical properties and flavor profiles using HS-SPME-GC/MS combined with electronic nose and electronic tongue analyses. Food Chemistry, 403, 134392. 4. Overbosch, P., & Blanchard, S. (2023). Principles and systems for quality and food safety management. In Food Safety Management (pp. 497-512). Academic Press. 5. Choudhury, A., Singh, P. A., Bajwa, N., Dash, S., & Bisht, P. (2023). Pharmacovigilance of herbal medicines: Concerns and future prospects. Journal of Ethnopharmacology, 116383.

Course Code	Course Title	L	T	P	C
10212BT136	STORAGE ENGINEERING	3	0	0	3

Course Category	*Program Elective*
Preamble	*To acquire knowledge about the different storage techniques and storage design structures.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Outline the scope and importance of storage engineering.	K2
CO2	Illustrate the possible damages to storage and tell the factors responsible for the damages.	K2
CO3	Build the design of storage structures.	K3
CO4	Plan the methods and ways to store foods	K3
CO5	Make use of the regulations involved in storage	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Outline the scope and importance of storage engineering.	M		H									H	L		
CO2	Illustrate the possible damages to storage and tell the factors responsible for the damages.	H	M	H									H	L	H	
CO3	Build the design of storage structures.	M		H	M								H		M	
CO4	Plan the methods and ways to store foods	H	M	H									H	H	M	
CO5	Make use of the regulations involved in storage	M		H			M		H				H	H	H	M

H – High; M- Medium; L- Low

Course Content:		
UNIT I	**INTRODUCTION TO STORAGE ENGINEERING**	**9 hours**
Introduction, Scope and Importance of Food and Grain storage, Methods and factors for Safe and scientific storage, Site selection for storage facilities, Overview of Pre and post Storage operations; (cleaning, drying), Control measures to prevent spoilage during storage, Inspection and Quality control of stored foods.		
UNIT II	**DAMAGES TO STORAGE**	**9 hours**
Direct damages, Indirect damages during storage, Biotic and Abiotic Factors for spoilage in storage (moisture, temperature, humidity, respiration loss, heat of respiration, sprouting), destructive agents (rodents, birds, insects, etc.), Sources of infestation and control measures.		
UNIT III	**DESIGN OF STORAGE STRUCTURES**	**9 hours**
Introduction to food storage structures and facilities, Principles of Grain storage loads, pressure and capacities, Considerations in choice of storage structures, Functional and structural design of grain storage structures, Modern and large scale storage: Bulk storage, Warehouses; Silos (deep, shallow), Design aspects of Silos (Janseens equations).		
UNIT IV	**STORAGE OF FOODS**	**9 hours**
Factors involved in Storage of Perishables, Conditions for storage of perishable products, Principles of Controlled and modified atmospheric storage, control of temperature and relative humidity, Hypobaric storage, Cold storage, evaporative cooling storage, functional, structural and thermal design of cold stores.		
UNIT V	**REGULATIONS INVOLVED IN STORAGE**	**9 hours**
Regulations and Quality control of storage structures, National and International market regulations in Storage specifications, BIS specifications, Centralized and decentralized storage facilities, Overview of logistics and supply control from storage facilities.		
LEARNING RESOURCES		
Text Books	1. G. Boumans. 1985. Grain Handling and Storage. Elsevier Science Publishers, Amsterdam, The Netherlands. 2. C.W. Hall. 1980. Drying and Storage of Agricultural Crops. The AVI Publishing Company, Inc., Westport, Connecticut, USA. 3. Donald B. Brooker, F.W. Bakker-Arkema, Carl W. Hall. 1974. Drying and Storage of Grains and Oilseeds. The AVI Publishing Company, Inc., Westport, Connecticut, USA. 4. P.H. Pandey. 2014. Principles and Practices of Agricultural Structures and Environmental Control. Kalyani Publishers, Ludhiana. **5.** Myer Kutz. 2007. Handbook of Farm, Dairy, and Food Machinery. William Andrew, Inc., Norwich, NY, USA.	
Reference Books	1. A.M. Michael and T.P. Ojha. 2004. Principal of Agricultural Engineering, Vol. I. Jain Brothers, New Delhi.	

	2. L.W. Newbaver and H.B. Walker. 2003. Farm Buildings Design. Prentice-Hall Inc., New Jersey, USA. 3. Jayas D.S., White N.D.G., Muir, W.E. 1994. Stored Grain Ecosystems. Marcel Dekker, New York. **4.** J. Whitaker. 2002. Agricultural Buildings and Structures. Reston Publishing Home, Reston, Virgenia, USA.
Reference videos	https://www.youtube.com/watch?v=TNGno8H2Tzg https://www.youtube.com/watch?v=6jmSg4kiIuw https://www.youtube.com/watch?v=BggCZHQ77Uc https://www.youtube.com/watch?v=N4vSFEd1MY8 https://www.youtube.com/watch?v=CiEy9GmmFdM
Reference NPTEL	https://nptel.ac.in/courses/126105015
Reference research/ review articles	1. Navaid, H. B., Emadi, H., & Watson, M. (2023). A comprehensive literature review on the challenges associated with underground hydrogen storage. International Journal of Hydrogen Energy, 48(28), 10603-10635. 2. Taher, H., San Martino, S., Abadia, M. B., & Bartosik, R. E. (2023). Respiration of barley seeds (Hordeum vulgare L.) under different storage conditions. Journal of Stored Products Research, 104, 102178. 3. Kolli, V. S., Garg, S., & Shirkole, S. S. (2023). Silos and bins. In Transporting Operations of Food Materials Within Food Factories (pp. 61-93). Woodhead Publishing. 4. Abbas, H., Zhao, L., Gong, X., & Faiz, N. (2023). The perishable products case to achieve sustainable food quality and safety goals implementing on-field sustainable supply chain model. Socio-Economic Planning Sciences, 87, 101562. 5. Lin, C., Burggräf, P., Liu, L., Adlon, T., Mueller, K., Beyer, M., ... & Wang, F. (2023). Deep-Dive analysis of the latest Lithium-Ion battery safety testing standards and regulations in Germany and China. Renewable and Sustainable Energy Reviews, 173, 113077.

OPEN ELECTIVE COURSES

Course Code	Course Title	L	T	P	C
10213BT101	BIOCHIPS	3	0	0	3

Course Category	*Open Elective*
Preamble	*To know the essential concepts of biochips and microarray with major applications in medical field.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Understand the working principles of biochips and detection mechanism	K2
CO2	Develop Acquisition and analysis techniques with micro array for various applications.	K3
CO3	Identify the use of DNA biomolecules in computing and bimolecular device with nanoelectronics	K3
CO4	Develop the commercial and market strategies involved in biochips.	K3
CO5	Examine the biochips for molecular diagnostics, pharmaco genomics, drug discovery and epidemiology applications.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand the working principles of biochips and detection mechanism	H		H	H								H	H	M	
CO2	Develop Acquisition and analysis techniques with micro array for various applications.	H	H	M	M		M						H	H	H	
CO3	Identify the use of DNA biomolecules in computing and bimolecular device with nanoelectronics	H	H	M	L	L	H						M	M	M	
CO4	Develop the commercial and market strategies involved in biochips.	H	H	M	H	H	H	H					H	H	H	

CO5	Examine the biochips for molecular diagnostics, pharmaco genomics, drug discovery and epidemiology applications.	M	H	M	M	M	L	L	L				M	H	H	L

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION**	**9 hours**

Basics of Biochips; Types of Biochips - DNA Microarrays, Protein Microarrays, Oligonucleotide, cDNA and genomic microarrays, Integrated biochip system; microarray scanners./headers, microarray robotics; microfluidics systems, chips and mass spectrometry.

UNIT II	**CONSTRUCTION OF BIOCHIPS**	**9 hours**

Biochips assays, combination of microarray and biosensor technology, biochip versus gel-based methods, process flow for production and analysis of a chip, standardization of microarray analysis, bioinformatics and microarrays, evaluation of conventional microarray technology. Electrical detection methods for microarrays, SERS (Surface-Enhanced Raman spectroscopy)-based microarrays.

UNIT III	**GENOME SIGNAL PROCESSING AND DNA COMPUTING**	**9 hours**

Genome signal processing: Introduction, Mathematical models and Modeling DNA Microarray; DNA Computing: Introduction, Junctions, other shapes, Biochips and large scale structures; Strand algebras used in DNA computing.

UNIT IV	**COMMERCIAL ASPECTS OF BIOCHIPS**	**9 hours**

Markets for biochip technologies, commercial support for the development of biochips, government support for biochip development, business strategies and patent issues.

UNIT V	**APPLICATIONS OF BIOCHIPS**	**9 hours**

Application of microarray technology in drug discovery development and drug delivery, use of DNA chip technology for drug safety, use of microchips for drug delivery, use of biochips in health care,use of microarray in forensics, Limitations of biochip technology.

LEARNING RESOURCES	
Text Books	1. Isaac S. Kohane, Alvin Kho, Atul J. Butte., "Microarrays for an Integrative Genomics (Computational Molecular Biology)", 1st edition, MIT Press, 2002. 2. Helen C. Causton, John Quackenbush, Alvis Brazma., "Microarray Gene Expression Data Analysis: A Beginner's Guide", 1st edition, Wiley-Blackwell, 2003. 3. Sorin Draghici, "Data Analysis Tools for DNA Microarrays", Har/Cdr Re edition, Chapman & Hall/CRC, 2003. 4. DNA Computing: 15th International Meeting on DNA Computing, DNA 15, Fayetteville, AR, USA, June 8-11, 2009, Springer, 2009. 5. Grigorenko E., "DNA Arrays: Technology and Experimental Strategies", Vth Edition, CRC Press, 2002. **6.** Wan-Li Xing and Jing Cheng., "Biochips: Technology and Applications", Springer, 2003.
Reference Books	
Reference videos	https://www.youtube.com/watch?v=208pMhKoQeo https://www.youtube.com/watch?v=g8Qav3vIv9s https://www.youtube.com/watch?v=vefBhhjodpE https://www.youtube.com/watch?v=-EO5fmz0tts https://www.youtube.com/watch?v=HZ8f0F2RMuo
Reference NPTEL	https://nptel.ac.in/courses/112104029
Reference research/ review articles	1. Kuru, C. İ., Ulucan-Karnak, F., & Akgöl, S. (2023). Lab-on-a-chip sensors: recent trends and future applications. Fundamentals of Sensor Technology, 65-98. 2. Chen, X., Yao, C., & Li, Z. (2023). Microarray-based chemical sensors and biosensors: Fundamentals and food safety applications. TrAC Trends in Analytical Chemistry, 158, 116785. 3. Pantic, I., Paunovic, J., Cumic, J., Valjarevic, S., Petroianu, G. A., & Corridon, P. R. (2023). Artificial neural networks in contemporary toxicology research. Chemico-Biological Interactions, 369, 110269. 4. Meng, X., O'Hare, D., & Ladame, S. (2023). Surface immobilization strategies for the development of electrochemical nucleic acid sensors. Biosensors and Bioelectronics, 115440. 5. Akinnuwesi, B. A., Olayanju, K. A., Aribisala, B. S., Fashoto, S. G., Mbunge, E., Okpeku, M., & Owate, P. (2023). Application of support vector machine algorithm for early differential diagnosis of prostate cancer. Data Science and Management, 6(1), 1-12.

Course Code	Course Title	L	T	P	C
10213BT102	BIOSENSORS	3	0	0	3

Course Category	*Open Elective*
Preamble	*This course helps to understand the use of biomolecues as recognition elements for detection of a particular analyte and the use of biological elements such as proteins in place of silicon chips.*
Prerequisite Courses	*NIL*

Course Outcomes — *Upon successful completion of the course, students will be able to:*

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Explain the application of biomolecules in sensing applications.	K2
CO2	Understand principle behind the functions of the immune biosensors and immobilized enzymes.	K2
CO3	Apply the biochemical and electrochemical mechanism to develop biosensors and oligonucleotide sensitive electrodes.	K2
CO4	Make use of chromophores and fluorophore to construct enzyme based fiberoptic biosensors.	K3
CO5	Analyze the metals and minerals by using biosensors.	K4

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Explain the application of biomolecules in sensing applications.	H	H	H	H								H	H	M	L
CO2	Understand principle behind the functions of the immune biosensors and immobilized enzymes.	H	H	H	H		M	M					H	H	H	L
CO3	Apply the biochemical and electrochemical mechanism to develop biosensors and oligonucleotide sensitive electrodes.	H	H	H	H	H	H	M					M	M	M	H

CO4	Make use of chromophores and fluorophore to construct enzyme based fiberoptic biosensors.	H	H	M	H		H						H	H	H	
CO5	Apply the biosensor tools for agriculture, pharmaceuticals and drug industry applications	M	H	H	H	H	H	H	L				M	H	H	L

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO BIOSENSORS**	**9 hours**

Definitions, biological inspiration, types of sensors, target analytes, various recognition, Recognition event: Catalytic, Single and multiple enzyme, Bio Affinity: Labeled and Label free, whole cell sensing – bacteria, yeast, mammalian cell, Generation of Biosensor; Biomolecule Immobilization Techniques.

UNIT II	**BASIC DESIGN AND TRANSDUCER**	**9 hours**

Considerations calibration, dynamic Range, signal to noise, sensitivity, selectivity, Interference Recognition/Transduction membrane protein sensors: ion channels, Types of Transducer, Optical; Fiber Optic, FET, Impedance, Piezoelectric; Cantilever

UNIT III	**DETECTION METHODS**	**9 hours**

Fluorescence Spectroscopy, UV-Vis Absorption and Emission, Surface Plasmon Resonance, Magnetic labeling, Electrochemical Detection.

UNIT IV	**APPLICATIONS OF BIOSENSORS**	**9 hours**

Biosensors and diabetes management, Microfabricated biosensors and point-of-care diagnostics systems, Noninvasive biosensors in clinical analysis; Surface plasmon resonance and evanescent wave biosensors, Biosensor in cancer and HIV early diagnosis.

UNIT V	**APPLICATIONS OF NANOMATERIALS IN BIOSENSORS**	**9 hours**

Nano Materials in biosensors; Carbon based Nano Material, Metal oxide and nano particle, Quantum dots, Role of nano material in Signal Amplifications, Detection and Transducer Fabrication.

LEARNING RESOURCES

Text Books	
Reference Books	1. Jeong-Yeol Yoon, "Introduction to Biosensors: From Electric Circuits to Immunosensors",1st Edition, Springer-Verlag, New York.

	2. Mohammed Zourob, "Recognition Receptors in Biosensors", 1st Edition, Springer-Verlag, New York. 3. ZviLiron,"Novel Approaches in Biosensors and Rapid Diagnostic Assays",1st Edition, Springer US, 2001.
Reference videos	https://www.youtube.com/watch?v=9SF_8LP2xKM https://www.youtube.com/watch?v=4PvOLVzHV3g&list=PLkqcnysg6e-tdd24uyfDKlaC0vyFbkNdF https://www.youtube.com/watch?v=ER6YIeYjluY&list=PLkqcnysg6e-tdd24uyfDKlaC0vyFbkNdF&index=3 https://www.youtube.com/watch?v=IY0PswHQS9k https://www.youtube.com/watch?v=0-PvA1Sl4WE
Reference NPTEL	https://nptel.ac.in/courses/115107122
Reference research/ review articles	1. Barhoum, A., Altintas, Z., Devi, K. S., & Forster, R. J. (2023). Electrochemiluminescence biosensors for detection of cancer biomarkers in biofluids: Principles, opportunities, and challenges. Nano Today, 50, 101874. 2. Lu, J., Zhuang, X., Wei, H., Liu, R., Ji, W., Yu, P., ... & Mao, L. (2024). Enzymatic Galvanic Redox Potentiometry for In Vivo Biosensing. Analytical Chemistry. 3. Singh, A. K., Mittal, S., Das, M., Saharia, A., & Tiwari, M. (2023). Optical biosensors: A decade in review. Alexandria Engineering Journal, 67, 673-691. 4. Selvolini, G., & Marrazza, G. (2023). Sensor principles and basic designs. In Fundamentals of Sensor Technology (pp. 17-43). Woodhead Publishing. 5. Rubino, A., & Queirós, R. (2023). Electrochemical determination of heavy metal ions applying screen-printed electrodes based sensors. A review on water and environmental samples analysis. Talanta Open, 100203.

Course Code	Course Title	L	T	P	C
10213BT103	BIOMATERIALS ENGINEERING	3	0	0	3

Course Category	*Open Elective*
Preamble	*This Course will give a broad view towards various types of biomaterials, its properties, manufacturing methods and its applications.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Understand the physiochemical properties of Biomaterials	K2
CO2	Apply the Metallic and Ceramic biomaterials for various medical applications	K3
CO3	Make use of biopolymers for various industrial applications.	K3
CO4	Select the biomaterials according to the mechanisms and regularities of friction and wear.	K3
CO5	Develop and identify the degradation and Corrosion characteristics of biomaterials	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand the physio chemical properties of Biomaterials	M		M									H	H	M	
CO2	Apply the Metallic and Ceramic biomaterials for various medical applications	H	M	M									H	H	H	
CO3	Make use of biopolymers for various industrial applications.	H	M	M									H	H	H	L
CO4	Select the biomaterials according to the mechanisms and regularities of friction and wear.	H	H	H	M								H	H	M	L

CO5	Develop and identify the degradation and Corrosion characteristics of biomaterials	H	H	H	M			H					H	H	M	L

H – High; M- Medium; L- Low

Course Content:

UNIT I	**BIOMATERIALS**	**9 hours**

Introduction to Biomaterials, Physical and Chemical properties, performance, response to implants, blood compatibility, Nanoscale phenomena.

UNIT II	**METALLIC AND CERAMIC BIOMATERIALS**	**9 hours**

Different implants - Stainless steels, cobalt-based alloys, Titanium-based alloys, shape memory alloy, ceramic implant, nanostructured metallic implants, biodegradable or bioresorbable, bioactive ceramics, nanostructured bio ceramics.

UNIT III	**POLYMERIC BIOMATERIALS**	**9 hours**

Polymer as biomaterials, Polymerization, properties of polymers, biodegradable polymers, Introduction bio polymers: Collagen, Elastin and chitin, Medical Textiles.

UNIT IV	**FAILURE AND TRIBOLOGY OF BIOMATERIALS**	**9 hours**

Failure and Tribology of Biomaterials: Deformation Mechanics, Fracture Mechanics, Classification of Fracture, Brittle to Ductile Transition of Biomaterials, Toughness Analysis of Biomaterials.

UNIT V	**DEGRADATION AND CORROSION OF BIOMATERIALS**	**9 hours**

Degradation and Corrosion of Biomaterials: Surface Properties, Degradation of Biomaterials, Corrosion of Biomaterials, Methods of Corrosion Testing, Biocompatibility of Implants.

LEARNING RESOURCES

Text Books	1. Sujata V. Bhatt, "Biomaterials", Second Edition, Narosa Publishing House, 2005.
Reference Books	1. Sreeram Ramakrishna, Murugan Ramalingam, Sampath Kumar T.S., and Winston O. Soboyejo, "Biomaterials: A Nano Approach", CRC Press, 2010.
Reference videos	https://www.youtube.com/watch?v=-jw8osY5QJM https://www.youtube.com/watch?v=k_ftHmWEHm8 https://www.youtube.com/watch?v=BYW7IzqxdWQ https://www.youtube.com/watch?v=Oq7Q-Xf2jGg https://www.youtube.com/watch?v=iALmpZHTXx4

Reference NPTEL	https://nptel.ac.in/courses/102106057
Reference research/ review articles	1. Deng, J., & Gao, C. (2023). An introduction to scaffolds, biomaterial surfaces, and stem cells. In Polymeric Biomaterials for Tissue Regeneration: From Surface/Interface Design to 3D Constructs (pp. 1-38). Singapore: Springer Nature Singapore. 2. Que, Y., Zhang, Z., Zhang, Y., Li, X., Chen, L., Chen, P., ... & Chang, J. (2023). Silicate ions as soluble form of bioactive ceramics alleviate aortic aneurysm and dissection. Bioactive materials, 25, 716-731. 3. Pires, P. C., Mascarenhas-Melo, F., Pedrosa, K., Lopes, D., Lopes, J., Macário-Soares, A., ... & Paiva-Santos, A. C. (2023). Polymer-based biomaterials for pharmaceutical and biomedical applications: A focus on topical drug administration. European Polymer Journal, 187, 111868. 4. Bienz, S. P., Vaquette, C., Ioannidis, A., Hämmerle, C. H., Jung, R. E., Ivanovski, S., & Thoma, D. S. (2023). Tissue integration and biodegradation of soft tissue substitutes with and without compression: an experimental study in the rat. Clinical Oral Investigations, 27(1), 313-328. 5. Colaço, R., & Serro, A. P. (2024). Sterilization methods. In Hydrogels for Tissue Engineering and Regenerative Medicine (pp. 139-159). Academic Press.

Course Code	Course Title	L	T	P	C
10213BT104	BIO-INSPIRED DESIGN: PRINCIPLES AND PRACTICE	3	0	0	3

Course Category	*Open Elective*
Preamble	*This course introducesand explains the various principles and opportunitiesavailable in engineering designs.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Relate the nature based biological systems to engineering designs.	K2
CO2	Understand the structural and functional properties of bio composites	K2
CO3	Develop the biosensors and navigators from the working principle of natural biosystems	K3
CO4	Make use of natural design to design the engineering tools	K3
CO5	Utilize the biological concepts to identify various computational and industrial tools	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Relate the nature based biological systems to engineering designs.	H		M			L						H	M	H	L
CO2	Understand the structural and functional properties of bio composites	H		M			H						H	H	H	
CO3	Develop the biosensors and navigators from the working principle of natural biosystems	H	H	H	M		M						H	H	H	
CO4	Make use of natural design to design the engineering tools	H	M	H	H		M						H	H	H	H

CO5	Utilize the biological concepts to identify various computational and industrial tools	H	H	H		H	H						H	H	H	M

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO BIOLOGICAL SYSTEMS**	**9 hours**

Introduction to biological systems, Biological systems and interaction with environment, Design based adaptations in biological systems, Observation of Nature based design – principles and methods, Application of bio inspired design for engineers.

UNIT II	**BIOMIMETICS**	**9 hours**

Introduction to Biomimetics, Elements of Biological design as seen in nature, Functional rationale of bio inspired design, Studies on structural, functional properties of biological material (skeletal structure, muscular structure, exoskeletons, plants and tree structure – Tree trunks, Bamboo), Bio composites and Biomaterials.

UNIT III	**BIOLOGICAL SYSTEMS OF PERCEPTION AND NAVIGATION**	**9 hours**

Perception – spatial awareness and biological sensors in nature, Gait, movement and locomotion from Biology, Bio-optics, Bio-photonics, Navigational methods found in nature – bird migration, Energy conservation in organisms – hibernation, fat/nutrient storage, Communication networks in nature.

UNIT IV	**BIO- INSPIRED DESIGN FOR ENGINEERS**	**9 hours**

Introduction to Advanced concepts in Bio- inspired design for engineers, Symbiotic living structures and design, Nanostructures in nature – Gecko grip, Shark skin; Integrated network across large distances – termite mounds, root network, Mycelial mats.

UNIT V	**CASE STUDIES**	**9 hours**

Existing bio- inspired designs used by engineers, Case studies of aesthetic V/s functional designs from nature, Applications in robotics, Bio- inspired Computational techniques, Concepts of green building and Industrial ecology, activity on bio inspired design.

LEARNING RESOURCES

Text Books	1. Maria G. Trotta, "Bio-inspired Design Methodology", International Journal of Information Science 1(1), 2011.
Reference Books	1. Yoseph Bar-Cohen, "Biomimetics: Nature-Based Innovation", CRC Press, 2016. 2. Ashok K.G., Daniel A. McAdams, and Robert B. Stone, "Biologically inspired designs: computational methods and tools", Springer London, 2013.

	3. Lakhtakia A. and Martin-Palma R.J., "Engineered biomimicry", Elsevier, 2013. 4. Reich Y., "A critical review of General Design Theory", Research in Engineering Design, 7 (1) 1-18, 1995.
Reference videos	https://www.youtube.com/watch?v=vWSsNi5uFVY https://www.youtube.com/watch?v=wvAXzlHpSs8 https://www.youtube.com/watch?v=jmxiMZ67VZs https://www.youtube.com/watch?v=iMtXqTmfta0 https://www.youtube.com/watch?v=Ezd4AcC3uZ4
Reference NPTEL	**https://nptel.ac.in/courses/127106231**
Reference research/ review articles	1. Martinez, A., DeJong, J., Akin, I., Aleali, A., Arson, C., Atkinson, J., ... & Zheng, J. (2022). Bio-inspired geotechnical engineering: principles, current work, opportunities and challenges. Géotechnique, 72(8), 687-705. 2. Tang, T. C., An, B., Huang, Y., Vasikaran, S., Wang, Y., Jiang, X., ... & Zhong, C. (2021). Materials design by synthetic biology. Nature Reviews Materials, 6(4), 332-350. 3. Yue, X., Tao, T. H., & Jiang, J. (2022, January). Visualized Drug Release Silk Patch Using Thermal Nanoimprinting of Pdms Template. In 2022 IEEE 35th International Conference on Micro Electro Mechanical Systems Conference (MEMS) (pp. 21-24). IEEE. 4. Göçerler, H., Gachot, C., Grützmacher, P. G., & Eder, S. J. (2023). Skin as an interface: Understanding the synergy of dermatology, biomimetics and tribology. Tribology and Materials, 2(3), 128-153. 5. Molina, D., Poyatos, J., Ser, J. D., García, S., Hussain, A., & Herrera, F. (2020). Comprehensive taxonomies of nature-and bio-inspired optimization: Inspiration versus algorithmic behavior, critical analysis recommendations. Cognitive Computation, 12, 897-939.

Course Code	Course Title	L	T	P	C
10213BT105	ENGINEERING ADVANCES IN FOOD PRESERVATION	2	0	0	2

Course Category	*Open Elective*
Preamble	*This course will give a broad view towards fundamental knowledge of modern food preservation techniques and the equipment used.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Understand the principles of heat and mass transfer in food processing	K2
CO2	Implementing the proper canning technology in food preservation	K3
CO3	Apply different thermal technologies to preserve the foods	K3
CO4	Apply the chemicals and antibiotics to preserve the foods	K2
CO5	Design the proper food packaging materials for food transport	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand the principles of heat and mass transfer in food processing	H	H	M			M						H	H	H	
CO2	Implementing the proper canning technology in food preservation	H	M	M	M		H						H	M	H	H
CO3	Apply different thermal technologies to preserve the foods	H	H	M			H						H	H	H	M
CO4	Apply the chemicals and antibiotics to preserve the foods	H	H	H	H		H						M	M	H	

CO5	Design the proper food packaging materials for food transport	H	H	H	H		M						H	H	M	M

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO FOOD PRESERVATION**	**9 hours**

Introduction to food preservation – Objectives and modern techniques in food preservation. Transport phenomena with respect to foods; Factors affecting heat and mass transfer; Study of heat transfer and its application in the design of thermal processes and freezing. Pasteurization.

UNIT II	**CANNING TECHNOLOGY**	**9 hours**

Preservation principle of canning of food items, thermal processing foods, Newer methods of thermal processing; application of infra-red microwaves; ohmic heating; preservation by concentration and dehydration; osmotic methods. Design of modern Canning machines.

UNIT III	**DRYING AND REFRIGERATION TECHNOLOGY**	**9 hours**

Water activity of food and its significance in food preservation; dehydration and drying of food items; IMF; Low temperature preservation: cold storage, freezing. Design parameters of different types of dryers; freezing and cold storage. Freeze drying, IQF; Refrigeration load, design of freezers and cold storages machines.

UNIT IV	**NON-THERMAL TECHNOLOGY**	**9 hours**

Super Critical Technology for Preservation - Chemical preservatives, preservation by ionizing radiations, ultrasonics, high pressure, fermentation, curing, pickling, smoking, membrane technology. Modern Hurdle technology. Antibiotics, lactic acid bacteria.

UNIT V	**FOOD PACKAGING TECHNOLOGY**	**9 hours**

Basic packaging materials, types of packaging, packaging machine design, retort pouch packing, Preservation of foods by low temperatures Considerations relating to storage of foods at low temperature, controlled and modified atmosphere storage of foods; MAP.

LEARNING RESOURCES

Text Books	1. KyzlinkV., "Principles of Food Preservation (Developments in Food Science), Elsevier Press, 1990.
Reference Books	1. SivasankarB., "Food Processing and Preservation", Prentice Hall of India, 2002. 2. Singh M.K., "Food Preservation", Discovery Publishing, 2007.
Reference videos	https://www.youtube.com/watch?v=dJXsT6gJXgo&list=PLAY98libqFHowL3H-xItIeO3LJaFQnhdx https://www.youtube.com/watch?v=82GPTNOAR8U https://www.youtube.com/watch?v=b33hd8TO7ws

	https://www.youtube.com/watch?v=0RCsmoqRGBY&list=PLbRMhDVUMngdSyw7OUHJJNYPfo_p4Ysln&index=20 https://www.youtube.com/watch?v=VZ0ke71IXZE&list=PLAY98libqFHqk2qNGnFS8zmgBXh-ZNyBw
Reference NPTEL	https://nptel.ac.in/courses/126103017
Reference research/ review articles	1. Yu, T., Niu, L., & Iwahashi, H. (2020). High-pressure carbon dioxide used for pasteurization in food industry. Food Engineering Reviews, 12(3), 364-380. 2. Kutlu, N. (2022). Optimization of ohmic heating-assisted osmotic dehydration as a pretreatment for microwave drying of quince. Food Science and Technology International, 28(1), 60-71. 3. Noriega-Juárez, A. D., Rubio-Carrillo, J. D., de Lourdes García-Magaña, M., González-Aguilar, G. A., Meza-Espinoza, L., Chacón-López, M. A., ... & Montalvo-González, E. (2024). Comparison of individual quick freezing and traditional slow freezing on physicochemical, nutritional and antioxidant changes of four mango varieties harvested in two ripening stages. Food Chemistry Advances, 4, 100590. 4. Kaveh, S., Hashemi, S. M. B., Abedi, E., Amiri, M. J., & Conte, F. L. (2023). Bio-preservation of meat and fermented meat products by lactic acid bacteria strains and their antibacterial metabolites. Sustainability, 15(13), 10154. 5. Latos-Brozio, M., & Masek, A. (2020). The application of natural food colorants as indicator substances in intelligent biodegradable packaging materials. Food and Chemical Toxicology, 135, 110975.

Specialization
Food and Precision Agriculture

Course Code	Course Title	L	T	P	C
10212BT131	PRINCIPLES OF FUNCTIONAL FOOD AND APPLICATIONS	3	0	0	3

Course Category	*Program Elective*
Preamble	*To know more about functional foods and its nutritional values, also the development of functional foods and its processing methods.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Outline the types of nutraceutical and functional foods and its regulatory issues	K2
CO2	Relate deficiencies of essential nutrients to diseases.	K2
CO3	Build the steps in product developments of Nutraceuticals and functional foods	K3
CO4	Identify the interactions of environmental factors on processing and storage of foods	K3
CO5	Apply the methods to process functional foods into different forms	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Outline the types of nutraceutical and functional foods and its regulatory issues	M			L			L					H	H	M	
CO2	Relate deficiencies of essential nutrients to diseases.	M		L	L		L	L					H	H	M	
CO3	Build the steps in product developments of Nutraceuticals and functional foods	H		M		M	L	L					H	M	L	
CO4	Identify the interactions of environmental factors on processing and storage of foods	H	M	M	L				M				M	M	L	H

CO5	Apply the methods to process functional foods into different forms	M	L		L			L					M	M		

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO FUNCTIONAL FOODS**	**9 hours**

Introduction to functional foods, importance, history, definition, classification, list of functional foods active ingredients, health benefits, Recent development and advances in the areas of functional foods. Marketing and regulatory issues for functional foods.

UNIT II	**NUTRITIONAL VALUE OF FUNCTIONAL FOODS**	**9 hours**

Therapeutic nutrition & formulation of special dietary foods; Relation of food and diseases; Deficiencies of essential nutrients; Assessment of nutritional status & RDA; Effect of processing on nutrients.

UNIT III	**FORMULATION OF FUNCTIONAL FOODS**	**9 hours**

Steps in product developments of functional foods, formulation of functional foods containing nutraceuticals – stability and analytical issues. selections, optimal stability conditions of active ingredients/compounds used in the developments, selections of appropriate products for individual active compound or patient/consumer, health-benefitting level of active ingredients/compounds, developments of base formulae and formulae containing active ingredients/compounds as well

UNIT IV	**ROLE IN HEALTH AND DISEASES**	**9 hours**

Functional foods and immune competence; role and use in obesity and nervous system disorders, Functional foods and nutraceuticals with attributes to control cardiovascular diseases, cancer, ageing.

UNIT V	**PROCESSING OF FUNCTIONAL FOODS**	**9 hours**

Processing of Functional Foods in various forms of powders, beverages, snacks; stability consideration, limitation, precaution to retain bioactive compounds. Effects of processing, storage and interactions of various environmental factors on the potentials of such foods.

LEARNING RESOURCES

Text Books	1. Shi J.(Ed) 2006. Functional Food Ingredients and Nutraceuticals: Processing Technologies.. CRC. **2.** Wildman, Robert "Handbook of Nutraceuticals and Functional Foods". CRC, 2006.
Reference Books	Functional Foods by R. Chadwick,S. Henson,B. Moseley,G. 2. Methods of Analysis for Functional Foods and Nutraceuticals by W. Jeffrey Hurst

Reference NPTEL	**https://archive.nptel.ac.in/courses/126/105/126105015/**
Reference research/ review articles	1. Díaz, L. D., Fernández-Ruiz, V., & Cámara, M. (2020). An international regulatory review of food health-related claims in functional food products labeling. Journal of Functional Foods, 68, 103896. 2. Gómez, I., Janardhanan, R., Ibañez, F. C., & Beriain, M. J. (2020). The effects of processing and preservation technologies on meat quality: Sensory and nutritional aspects. Foods, 9(10), 1416. 3. Alongi, M., & Anese, M. (2021). Re-thinking functional food development through a holistic approach. Journal of Functional Foods, 81, 104466. 4. Khalaf, A. T., Wei, Y., Alneamah, S. J. A., Al-Shawi, S. G., Kadir, S. Y. A., Zainol, J., & Liu, X. (2021). What is new in the preventive and therapeutic role of dairy products as nutraceuticals and functional foods?. BioMed research international, 2021(1), 8823222. 5. Perfilova, O. V., Akishin, D. V., Vinnitskaya, V. F., Danilin, S. I., & Olikainen, O. V. (2020, August). Use of vegetable and fruit powder in the production technology of functional food snacks. In IOP Conference Series: Earth and Environmental Science (Vol. 548, No. 8, p. 082071). IOP Publishing.

Course Code	Course Title	L	T	P	C
10212BT132	NUTRACEUTICALS	3	0	0	3

Course Category	*Program Elective*
Preamble	*Provides knowledge in newly emerging area of nutraceuticals with respect to the types, mechanisms of action, manufacture of selected nutraceuticals, product development, clinical testing and toxicity aspects.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Define history and basis of nutraceuticals in relation to various factors	K2
CO2	Understand concepts of nutritional assessment and indices	K2
CO3	Comprehend nutritional disorders and role of nutraceuticals in medicine	K2
CO4	Develop the product with metabolites for various in medicinal and treatment purpose	K3
CO5	Apply knowledge of nutraceutical production and formulation as functional foods	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Define history and basis of nutraceuticals in relation to various factors	M	L	M									H	L	M	
CO2	Understand concepts of nutritional assessment and indices	M	L	L	L								H		M	
CO3	Comprehend nutritional disorders and role of nutraceuticals in medicine	L	M	H		L							M	M	M	
CO4	Develop the product with metabolites for various in medicinal and treatment purpose	H	M	L			M		M				H	H		H

CO5	Apply knowledge of nutraceutical production and formulation as functional foods	M	L	H									H	M		

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION**	**9 hours**

History, definition, classification and source of nutraceuticals, basis of claims for a compound as a nutraceutical, benefits of nutraceuticals, role of nutraceuticals in Medicine, Human physiology, genetics, food technology, chemistry and nutrition, scope and availability involved in the industry, Indian and global scenario.

UNIT II	**NUTRITIONAL ANALYSIS**	**9 hours**

Food components based on nutritional value, nutritional assessment of carbohydrates, proteins and fats, recommended dietary intake, recommended daily allowance (RDA), acceptable dietary intake, nitrogen balance, protein efficiency ratio (PER), basics of energy balance - Basal Metabolic Rate (BMR), Body Mass Index (BMI) and Standard Dynamic Action (SDA) with special reference to nutraceutical industry

UNIT III	**DIETARY FOODS**	**9 hours**

Factors responsible for nutritional disorders: Malnutrition, undernutrition and anti-nutritional factors (cyanogens, lectins, enzyme inhibitors, phytoallexins and phytates), types of metabolic disorders, nutritional factors, nutraceuticals for prevention and treatment (diabetes mellitus, hypertension, hypercholesterolemia, etc), concept of antioxidants - use of antioxidants as dietary supplements in prevention and treatment of cancer, obesity and stress, role of nutraceuticals and functional foods in pediatrics, geriatrics, sports, pregnancy and lactation, functional food as remedies.

UNIT IV	**PLANT AND ANIMAL METABOLITES**	**9 hours**

Plant secondary metabolites, classification and sub-classification -alkaloids, phenols, Terpenoids. Animal metabolites - chitin, chitosan, glucosamine, chondroitin sulphate, polysaccharides of animal origin, uses and applications in preventive medicine and treatment, Concept of prebiotics and probiotics, synbiotics for maintaining good health, algae as a source of omega - 3 fatty acids, antioxidants and minerals - extraction and enrichment.

UNIT V	**INDUSTRIAL PRODUCTION AND FORMUALTION OF NUTRACEUTICALS**	**9 hours**

Industrial production of nutraceuticals, formulation of functional foods containing nutraceuticals, manufacturing aspects of nutraceuticals (lycopene, isoflavonoids, prebiotics and

probiotics, glucosamine, phytosterols etc), preferences and globalization on selection of nutraceutical products, identification and estimation of health benefits of selected nutraceuticals, quality evaluation of foods containing nutraceuticals, packaging and labeling of functional foods, toxicology and bioavailability, use of animal models, pre-clinical and clinical trials involved.

LEARNING RESOURCES	
Text Books	
Reference Books	1. Handbook of nutraceuticals and functional foods by Robert E C. Wildman, CRC/Taylor&Francis 2. Handbook of nutraceuticals Vol I by Yahwant Vishnupant Pathak, CRC press.2009 3. Handbook of nutraceuticals Vol II by Yahwant Vishnupant Pathak, CRC press,2011 4. Handbook of Prebiotics, Glenn R. Gibson, Marcel Roberfroid, CRC press, 2008. 5. Swaminathan M., Essentials of Food and Nutrition, 2nd Ed, 1985, Ganesh and Co. 6. Dietary Supplements: Toxicology and Clinical Pharmacology. Humana Press. Gibson GR & William CM. 2000. 7. Dietary Supplements. 2nd Ed. Pharmaceutical Press. Campbell JE & Summers JL. 2004. 8. Bioprocesses and Biotechnology for Nutraceuticals. Chapman & Hall. Robert EC. 2006. 9. Handbook of Nutraceuticals and Functional Foods. 2nd Ed. Wildman. 10. Nutrition in Health and Disease 17th Edition; Anderson, Dibble, Turkki, Mitchell, Rynbergen J.B. Lippincott Company, 1982 11. Dietary Supplements of Plant Origin, M. Maffei (Ed.), Taylor & Francis, 2003. 12. Bioprocesses and Biotechnology for Functional Foods and Nutraceuticals, Jean – Richard Neeser & J. Bruce German, Marcel Dekker, Inc., 2004. 13. Nutraceuticals in health and disease prevention, Klaus Krämer, Peter-Paul Hoppe, Lester Packer 14. Nutraceutical beverages Chemistry, Nutrition and health Effects, Shahidi and Weerasinghe (Ed.), American Chemical Society, 2004. **15.** Functional Foods: Principles and Technology, M. Guo, CRC press, 2009.
Reference videos	https://www.youtube.com/watch?v=h8uV5I_N8w4 https://www.youtube.com/watch?v=ojhdTFmkY1c https://www.youtube.com/watch?v=Ua-dLw2nFs4 https://www.youtube.com/watch?v=_NNtgHmD5BU https://www.youtube.com/watch?v=K3L3DMkfyc8
Reference NPTEL	https://archive.nptel.ac.in/courses/126/105/126105015/

Reference research/ review articles	1. Kaur, M., Bhatia, S., Gupta, U., Decker, E., Tak, Y., Bali, M., ... & Bala, S. (2023). Microalgal bioactive metabolites as promising implements in nutraceuticals and pharmaceuticals: inspiring therapy for health benefits. Phytochemistry Reviews, 22(4), 903-933. 2. Chauhan, A. S., Patel, A. K., Nimker, V., Singhania, R. R., Chen, C. W., Patel, A. K., ... & Dong, C. D. (2024). Biorefining of essential polyunsaturated fatty acids from microbial sources: current updates and prospects. Systems Microbiology and Biomanufacturing, 4(2), 425-447. 3. Duraiswamy, A., Sneha A, N. M., Jebakani K, S., Selvaraj, S., Pramitha J, L., Selvaraj, R., ... & Kumar P, R. (2023). Genetic manipulation of anti-nutritional factors in major crops for a sustainable diet in future. Frontiers in plant science, 13, 1070398. 4. Roy, S., & Dhaneshwar, S. (2023). Role of prebiotics, probiotics, and synbiotics in management of inflammatory bowel disease: Current perspectives. World Journal of Gastroenterology, 29(14), 2078. 5. Udayan, A., Pandey, A. K., Sirohi, R., Sreekumar, N., Sang, B. I., Sim, S. J., ... & Pandey, A. (2023). Production of microalgae with high lipid content and their potential as sources of nutraceuticals. Phytochemistry Reviews, 22(4), 833-860**.**

Course Code	Course Title	L	T	P	C
10212BT133	FOOD PRESERVATION, PACKAGING TECHNOLOGIES	3	0	0	3

Course Category	*Program Elective*
Preamble	*To provide an adequate knowledge of principles of food preservation and packaging*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Illustrates the different modes of food preservation	K2
CO2	Understand the fundamentals of food preservation through dehydration	K2
CO3	Identify the purpose and principles of food packaging	K2
CO4	Explain the nature of different materials used in food packaging	K2
CO5	Develop food packaging technologies for different foods	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Illustrates the different modes of food preservation	H	L			M							H	H	M	
CO2	Understand the fundamentals of food preservation through dehydration	L	H	L									H	H	L	
CO3	Identify the purpose and principles of food packaging	M											H	H		
CO4	Explain the nature of different materials used in food packaging	H	H	L		M							H	M	H	
CO5	Develop food packaging technologies for different foods	H		M			L						H		H	

H – High; M- Medium; L- Low

Course Content:		
UNIT I	**DIFFERENT MODES OF FOOD PRESERVATION**	**9 hours**
Introduction of preservation, Preservation methods: thermal and other non-thermal methods, microbiological additives, and pulsed electric or magnetic fields. High temperature, low temperature, drying, radiation, chemical preservatives, bio-preservatives, hurdle technology, active packaging. Preservation by fermentation – Curing, Pickling and Smoking, Chilling and Freezing, Properties of frozen foods. Food preservation and handling including fresh fruits and vegetables, grains and pulses, fish, red meat, and milk.		
UNIT II	**FOOD PRESERVATION THROUGH DEHYDRATION**	**9 hours**
Water activity and moisture absorption isotherms, Psychometric chart, Dehydration and drying of foods, drying curve and drying time calculation, Enthalpy change during freezing, Plank's equation for freezing time, Cold storage and Refrigeration load, Refrigeration cycle, Cryogenic freezing and IQF Different types of dryers: Conductive, convective and combined, IMF foods, Osmotic dehydration. food preservatives of microbial origin.		
UNIT III	**ADVANCED TECHNIQUES OF PACKAGING**	**9 hours**
Packaging of foods, requirement, importance and scope. Factors affecting shelf life of food material during storage, spoilage agents with environmental factors. Control of the spoilage agents. Functions of packaging - packaging materials, risks associated with potential food contamination, Interpret packaging standards and regulations in food packaging materials. Aseptic packaging. Retort processing.Packaging systems, types: flexible and rigid; retail and bulk; levels of packaging; special solutions and packaging machines, technical packaging systems and data management packaging systems.Nutritional labeling on packages, CAS and MAP, shrink and cling packaging, vacuum and gas packaging; Factors affecting the choice of packaging materials, Disposal and recycle of packaging waste. Printing and labeling, Lamination.		
UNIT IV	**MATERIALS FOR FOOD PACKAGING**	**9 hours**
Different types of packaging materials, their key properties and applications. Different types of polymers used in food packaging and their barrier properties. Metal cans, manufacture of two piece and three-piece cans. Canning of food products, Classifications and structure of cans, corrosion, Lacquering. Manufacture of plastic packaging materials, profile extrusion, blown film/ sheet extrusion, blow molding, extrusion blow molding, injection blow molding, stretch blow molding, injection molding. Glass containers, types of glass used in food packaging. Paper and paper board packaging, paper and paper board manufacture process. Relative advantages and disadvantages of different packaging materials.		

UNIT V	TESTING METHODS FOR PACKAGING MATERIALS	9 hours
Testing methods for flexible materials, rigid materials and semi rigid materials; Tests for paper (thickness, bursting strength, breaking length, stiffness, tear resistance, folding endurance, ply bond test, surface oil absorption test, etc.), plastic film and laminates (thickness, tensile strength, gloss, haze, burning test to identify polymer, etc.), aluminium foil (thickness, pin holes, etc.), glass containers (visual defects, colour, dimensions, impact strength, etc.), metal containers (pressure test, product compatibility, etc.).		
LEARNING RESOURCES		
Text Books	1. Robertson, G. L. 2005. Food Packaging: Principles and Practice. Second Edition. Taylor and Francis Pub 2. Coles, R., McDowell, D., Kirwan, M .J. 2003. Food Packaging Technology. Blackwell Publishing Co. **3.** Gosby, N.T. 2001. Food Packaging Materials. Applied Science Publication	
Reference Books	1. Mahadevia, M., Gowramma, R.V. 2007. Food Packaging Materials. Tata McGraw Hill 2. Robertson, G. L. 2001. Food Packaging and Shelf life: A Practical Guide. Narendra Publishing House. 3. John, P.J. 2008. A Handbook on Food Packaging Narendra Publishing House	
Reference videos	https://www.youtube.com/watch?v=NJBj0ArTcQA https://www.youtube.com/watch?v=b33hd8TO7ws https://www.youtube.com/watch?v=HCH_cVKJ5lA https://www.youtube.com/watch?v=ToHIfshAt3g https://www.youtube.com/watch?v=f3JTA0YN3Hk	
Reference NPTEL	https://nptel.ac.in/courses/126105015	

Course Code	Course Title	L	T	P	C
10212BT135	FOOD SAFETY, QUALITY AND REGULATION	3	0	0	3

Course Category	*Program Elective*
Preamble	*To provide an adequate knowledge to learn food safety and quality auditing programme.*
Prerequisite Courses	*NIL*

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

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Compute different type of food hazards, physical, chemical and biological in the industry and food service	K2
CO2	Acquaint knowledge on food safety surveillance	K2
CO3	Identify the quality attributes of food	K3
CO4	Develop Pre-Requisite program on food plant management system	K3
CO5	Compute awareness on regulatory and statutory bodies in India and the world	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Compute different type of food hazards, physical, chemical and biological in the industry and food service	H	M	H				M						H		
CO2	Acquaint knowledge on food safety surveillance	H		M											M	
CO3	Identify the quality attributes of food	H							L				M			H
CO4	Develop Pre-Requisite program on food plant management system	M		H			M						M			
CO5	Compute awareness on regulatory and statutory bodies in India and the world	M					L						M		H	M

H – High; M- Medium; L- Low

Course Content:		
UNIT I	**FOOD SAFETY AND SECURITY**	**9 hours**
Introduction to food safety and security, Factors contributing to physical, chemical and biological contamination in food chain, prevention and control of food borne hazards, Regulation of food sanitation, personal hygiene-food handlers, cleaning compounds, sanitation methods, waste disposal strategy (solid and liquid waste) and pest control		
UNIT II	**FOOD SAFETY SURVEILLANCE**	**9 hours**
Food Adulteration, Food Additives, Food Packaging & labeling. Sanitation in warehousing, storage, shipping, receiving, containers and packaging materials. Cleaning and Disinfection, ISO 22000 – Importance and Implementation. Requirements Specific to Food Testing – Physical and Chemical Parameters, Requirements Specific to Food Testing – Biological Parameters, General Topics: Related to Food Testing Laboratories.		
UNIT III	**FOOD QUALITY SYSTEM**	**9 hours**
Various Quality attributes of food, Instrumental, chemical and microbial Quality control. Sensory evaluation of food and statistical analysis - Descriptive testing and Product Matching. Water quality and other utilities. Laboratory Quality Management System:Overview and Requirements of ISO 17025, Food Bioterrorism Acts. Food inspection and Food Law, Risk assessment – microbial risk assessment, dose response and exposure response modelling, risk management, implementation of food surveillance system to monitor food safety, risk communication		
UNIT IV	**PRE-REQUISITE PROGRAM**	**9 hours**
Good Manufacturing Practices - Personal hygiene – occupational health and safety specification, Food Plant Sanitation Management - Plant facilities construction and maintenance - exterior of the building- interior of the building- equipments. Storage, transportation, traceability, recalling procedures, training.		
UNIT V	**FOOD SAFETY REGULATIONS**	**9 hours**
Indian and global regulations: International Agencies in Food Regulation: Food Codex Alimentarius: Codex India – Role of Codex Contact point, National Codex contact point (NCCP), National Codex Committee of India – ToR, Functions, Shadow Committees etc. Various aspects and relation with domestic laws; FAO, WHO, WTO. FAO in India, Technical Cooperation programmes, Bio-security in Food and Agriculture, World Health Organization (WHO), World Animal Health Organization (OIE), International Plant Protection Convention (IPPC).		

LEARNING RESOURCES	
Text Books	1. Handbook of food toxicology by S. S. Deshpande, 2002 2. The food safety information handbook by Cynthia A. Robert, 2009 3. Nutritional and safety aspects of food processing by Tannenbaum SR, Marcel Dekker Inc., New York 1979
Reference Books	1. Microbiological safety of Food by Hobbs BC, 1973
Reference videos	https://www.youtube.com/watch?v=0J2Qv_72Xzo https://www.youtube.com/watch?v=rkuInbWL_pI https://www.youtube.com/watch?v=yxlC-ffnfrY https://www.youtube.com/watch?v=ZvmMMDRQoyw https://www.youtube.com/watch?v=_mcsYYbhEhE
Reference NPTEL	https://nptel.ac.in/courses/126105336

Course Code	Course Title	L	T	P	C
10212BT130	PRECISION AGRICULTURAL BIOTECHNOLOGY	3	0	0	3

Course Category	*Program Elective*
Preamble	*Provide an in-depth exploration of the principles, technologies, and applications of precision agriculture.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Understand basic concepts, history and basic practices of Precision agriculture	K2
CO2	Identify the soil and soil interactions for farming	K3
CO3	Utilize Geoinformatics tools for Precision Agriculture applications	K3
CO4	Develop electronics and imagery tools for agricultural development	K3
CO5	Model the Greenhouse with latest technologies and strategies	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand basic concepts, history and basic practices of Precision agriculture	H	H										H	H	L	
CO2	Identify the soil and soil interactions for farming	H	H	M	H	M	L						H	L	H	
CO3	Utilize Geoinformatics tools for Precision Agriculture applications	H	M	L	L	M	M						H	M	M	
CO4	Develop electronics and imagery tools for agricultural development	H	M	M	H	L	L						H	M	M	
CO5	Model the Greenhouse with latest technologies and strategies	H	H	M	M	H	M						H	M	L	

H – High; M- Medium; L- Low

Course Content:		
UNIT I	**PRECISION AGRICULTURE**	**9 hours**
Precision agriculture: concepts and techniques; their issues and concerns for Indian agriculture; Historic Perspectives of Precision Agriculture. Laser leveling, mechanized direct seed sowing; seedling and sapling transplanting, mapping of soils and plant attributes, site specific input application, weed management, insect pests and disease management, Good Agricultural Practices in precision farming, yield mapping in horticultural crops. Peat moss and mixtures, rock wool and other inert media for soilless culture, nutrient film technique (NFT)/ hydroponics.		
UNIT II	**CULTIVATION TECHNIQUES**	**9 hours**
Growing media, soil culture, Selection Criteria for soil media, soil pasteurization. Soil Variability and Soil Mapping - Factors affecting soil variability, Digital soil data and sources, Correlating soil data to other crop production data. Proximate Sensors: measure soil parameters - N status and soil pH. Crop discrimination and Yield monitoring, soil mapping; fertilizer recommendation using geospatial technologies		
UNIT III	**GEOINFORAMTICS**	**9 hours**
Geoinformatics- definition, concepts, tool and techniques; their use in Precision Agriculture. Spatial data and their management in GIS; Geodesy and its basic principles; Image processing and interpretation; Global positioning system (GPS), components and its functions; System Simulation- Concepts and principles, Introduction to crop Simulation. STCR approach for precision agriculture; Agricultural GIS software programs. Mobile GIS/GPS software programs. Principles and applications of mapping data in precision agriculture, GIS, GPS, sensors, drones, data acquisition and management. Yield Maps. Applications of Big Data in Precision Agriculture. Variable Rate Technology (VRT) - Grid Sampling, VRT Seeding, Planter Unit Controllers, Variable Hybrid/Variety Planting, VRT Pesticides, Spray Boom and Nozzle Control, Automatic Boom Leveling.		
UNIT IV	**SENSORS**	**9 hours**
Electronic systems and Signal processing: Communications data network for tractors and machinery for agriculture applications. Remote sensing basics- Applications in agriculture, correlating imagery to other crop production data, Remote sensing data sources. Sensors- Sensing Platforms—Satellite, UAV, Aerial, Proximal, The Electromagnetic Spectrum, Active vs. Passive Remote Sensing, Spectral, Spatial, and Temporal Resolution, Soil Sensors, Crop Sensors, Weather Sensors		
UNIT V	**GREEN HOUSE TECHNOLOGY**	**9 hours**
Green house technology - Introduction, Types of Green Houses; Plant response to Greenhouse environment, planning and design of greenhouses, Design criteria of green house for cooling		

and heating purposes. Green house equipments, materials of construction for traditional and low-cost greenhouses. Design and construction of green houses., Greenhouse heating – necessity, components, methods, design of heating system. Root media –types – soil and soil less media, composition, estimation, preparation and disinfection, bed preparation. Irrigation requirement, fertilizer management, cultivation, harvesting and post harvest techniques; Typical applications. Problems/constraints of greenhouse cultivation and future strategies.

LEARNING RESOURCES	
Text Books	1. Singh Brahma and Balraj Singh. 2014. Advances in protected cultivation, New India Publishing Company. · 2. Sharma P. 2007. Precision Farming. Daya Publishing House New Delhi.· 3. Ghosh Arupratan, Green house Technology, the future concept of Horticulture, Kalyani Publishers, Ludhiana. ·
Reference Books	**1.**Tiwari G.N., Green house Technology for Controlled Environment, Narosa Pub. House Pvt. Ltd., New Delhi.
Reference videos	https://www.youtube.com/watch?v=WhAfZhFxHTs https://www.youtube.com/watch?v=yEejDAwu4RE https://www.youtube.com/watch?v=6ct7uDKHEj8 https://www.youtube.com/watch?v=Tl1YkbdcEgU https://www.youtube.com/watch?v=8APpeti82hw
Reference NPTEL	https://onlinecourses.nptel.ac.in/noc24_bt30/preview
Reference research/ review articles	1. Ahmad, U., & Sharma, L. (2023). A review of best management practices for potato crop using precision agricultural technologies. Smart Agricultural Technology, 100220. 2. Mwangi, R. W., Mustafa, M., Kappel, N., Csambalik, L., & Szabó, A. (2024). Practical applications of spent mushroom compost in cultivation and disease control of selected vegetables species. Journal of Material Cycles and Waste Management, 1-16. 3. Saranya, T., Deisy, C., Sridevi, S., & Anbananthen, K. S. M. (2023). A comparative study of deep learning and Internet of Things for precision agriculture. Engineering Applications of Artificial Intelligence, 122, 106034. 4. El-Hageen, H. M., Alatwi, A. M., & Zaki Rashed, A. N. (2024). High-speed signal processing and wide band optical semiconductor amplifier in the optical communication systems. Journal of Optical Communications, 44(s1), s1277-s1284. 5. Al-Naemi, S., & Al-Otoom, A. (2023). Smart sustainable greenhouses utilizing microcontroller and IOT in the GCC countries; energy requirements & economical analyses study for a concept model in the state of Qatar. Results in Engineering, 17, 100889.

Course Code	Course Title	L	T	P	C
10212BT104	AGRICULTURAL BIOTECHNOLOGY	3	0	0	3

Course Category	*Program Elective*
Preamble	*To comprehend the knowledge and applications of biotechnology in agriculture field.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Understand the basic concepts of normal and hybrid plant cells development for agricultural applications.	K2
CO2	Apply the various genetic engineering tools and methods to improve the growth and production of plant.	K2
CO3	Solve plant growth promotion related problems in agricultural field with organic products with microbes and biomass.	K2
CO4	Apply proper plan for rare species conservation and degradation of materials by plants	K2
CO5	Make use of ethical knowledge of GM for agricultural development	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand the basic concepts of normal and hybrid plant cells development for agri cultural applications.	H		L	M			L					H	H	M	
CO2	Apply the various genetic engineering tools and methods to improve the growth and production of plant.	H	H	M	M	M	H	M	M				H	H	M	L
CO3	Solve plant growth promotion related problems in agricultural field with organic products with microbes and biomass.	H		L	M		H	H	H				H	H	H	H

CO4	Apply proper plan for rare species conser-vation and degradation of materials by plants	H	H	L	H		H	M	H				H	H	M	H
CO5	Make use of ethical knowledge of GM for agricultural development	H	M	H	M		H	H	M				H	H	M	M

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION**	**9 hours**

Basic concepts of Agriculture, Role of Genetic engineering for increasing crop productivity, Agricultural Applications of Genetic Engineering, : shoot - tip - cultures, shoot - tip - grafting, viricidal compound, Protoplast isolation: culture and fusion, selection of hybrid cells and regeneration of hybrid plants, somatic hybridization, Introducing genes into pro-and eukaryotes using gene transfer methods, DNA mediated and Agrobacterium mediated transfers, microinjection, electroporation, somatic cell hybridization.

UNIT II	**GENETIC ENGINEERING TECHNOLOGIES IN AGRICULTURE**	**9 hours**

Techniques for the insertion of genes into plant cells, Ti plasmid and vectors, (i) Transgenic plants (ii) Gene cloning, Restriction Fragment Length Polymorphisms, Transposons, and Insertional mutagenesis. Molecular Farming: Plants As factories for biopharmaceuticals, Transgenic value added specialty crops, Use of antisense RNA and other technologies, Developing stress tolerant varieties, vaccine and antibody producing plants. Terminator technology, Introduction of male sterility through genetic engineering. Genetic engineering in improving nitrogen fixation in plants.

UNIT III	**BIOFERTILIZERS AND ORGANIC FARMING**	**9 hours**

Biofertilizer: Mass cultivation of microbial inoculants, green manuring, algalization, Azolla. Microbial products and plant health: PGPR (plant growth promoting Rhizobacteria), significance of mycorrhizae, toxin producing microbes (antibiotics, aflatoxin, and others), microbial herbicides, Organic Farming: Introduction and sustainable use of natural and bioresources, Organic standards and certification of organic produce and products, Biological control, Global initiatives and future prospects.

UNIT IV	**BIODIVERSITY AND ENVIRONMENTAL PRESERVATION**	**9 hours**

Preservation of rare plant species germplasm collection and conservation, Soil Reclamation: Phytoremediation

UNIT V	ISSUES IN AGRICULTURE AND FOOD SECURITY	9 hours
World Food Security: Causes of food insecurity, social economic issues, ensuring food security, BIS regulations, GM food, GM Crops – Ethical challenges.		
LEARNING RESOURCES		
Text Books		
Reference Books	1. Arie Altman, "Agricultural Biotechnology', Marcel Dekker, Inc., 2001. 2. Henry R.J., "Practical applications of Plant Molecular Biology", Chapman & Hall London, UK,1997. 3. Chrispeels M.J. and Sadava D.E., "Plants, Genes and Crop Biotechnology", 2nd Edition, American Society of Plant Biologists, Jones and Bartlett Publishers, USA, 2003. 4. Lindsey K, Jones M.G.K., "Plant biotechnology In Agriculture", Prentice hall, 1990. 5. Bhojwani S.S. and Razdan M.K., "Plant Tissue culture Theory and Practice", Elsevier Science, Netherlands, 2004.	
Reference videos	https://www.youtube.com/watch?v=ICv9o3dexrc https://www.youtube.com/watch?v=Un_LA9s9y-E https://www.youtube.com/watch?v=2wStx02R_qg https://www.youtube.com/watch?v=dtKThKBq454 https://www.youtube.com/watch?v=tLMW96vkduI https://www.youtube.com/watch?v=iyT0wTEPOO8	
Reference NPTEL	https://onlinecourses.nptel.ac.in/noc24_ag08/preview	
Reference research/ review articles	1. Ahmad, U., & Sharma, L. (2023). A review of best management practices for potato crop using precision agricultural technologies. Smart Agricultural Technology, 100220. 2. Mwangi, R. W., Mustafa, M., Kappel, N., Csambalik, L., & Szabó, A. (2024). Practical applications of spent mushroom compost in cultivation and disease control of selected vegetables species. Journal of Material Cycles and Waste Management, 1-16. 3. Saranya, T., Deisy, C., Sridevi, S., & Anbananthen, K. S. M. (2023). A comparative study of deep learning and Internet of Things for precision agriculture. Engineering Applications of Artificial Intelligence, 122, 106034. 4. El-Hageen, H. M., Alatwi, A. M., & Zaki Rashed, A. N. (2024). High-speed signal processing and wide band optical semiconductor amplifier in the optical communication systems. Journal of Optical Communications, 44(s1), s1277-s1284. 5. Al-Naemi, S., & Al-Otoom, A. (2023). Smart sustainable greenhouses utilizing microcontroller and IOT in the GCC countries; energy requirements & economical analyses study for a concept model in the state of Qatar. Results in Engineering, 17, 100889.	

Specialization
Regenerative Medicine, Health Diagnosis and Disease Control

Course Code	Course Title	L	T	P	C
10212BT117	BIOPHARMACEUTICAL TECHNOLOGY	3	0	0	3

Course Category	*Program Elective*
Preamble	*To understand drug development process for the preparation of medicine as per norms.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Understand the various types of therapeutic agents used in pharmaceutical industry, their use and regulatory aspects.	K2
CO2	Elucidate the drug metabolism involving the physico-chemical properties and pharmacokinetics of drugs.	K2
CO3	Demonstrate the different types of reaction process involved in bulk drug manufacture.	K2
CO4	Apply the analytical methods in drug manufacture and packing techniques.	K3
CO5	Identify the various pharmaceutical products, current medicines and their applications in therapeutic and diagnostic fields.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand the various types of therapeutic agents used in pharma ceutical industry, their use and regulatory aspects.	M		M									M	H	M	
CO2	Elucidate the drug metabolism involving the physico-chemical properties and pharma cokinetics of drugs.	H	H	H	H	H							H	H	H	

CO3	Demonstrate the different types of reaction process involved in bulk drug manufacture.	H	H	H	H	H							H	H	H	H
CO4	Apply the analytical methods in drug manufacture and packing techniques.	H	H	H	H	H							H	H	H	H
CO5	Identify the various pharmaceutical products, current medicines and their applications in therapeutic and diagnostic fields.	H	H	H	H	H		M	H				H	H	H	H

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION**	**9 hours**

Development of Drug and Pharmaceutical Industry, types of therapeutic agents and their uses; economics and regulatory aspects.

UNIT II	**DRUG METABOLISM AND PHARMACOKINETICS**	**9 hours**

Drug metabolism – physico chemical principles, radioactivity – pharmacokinetics-action of drugs on human bodies.

UNIT III	**MANUFACTURE OF DRUGS, PROCESS AND APPLICATIONS**	**9 hours**

Bulk drug manufacturers, Type of reactions in bulk drug manufacture and processes. Special requirement for bulk drug manufacture.

UNIT IV	**MANUFACTURING PRINCIPLES**	**9 hours**

Compressed table, wet granulation-dry granulation or slugging-direct compression-tablet presses, coating of tablets,capsules, sustained action dosage forms-parental solution-oral liquids-injections-ointment-topical applications,Preservation, analytical methods and test for various drug and pharmaceuticals, packing-packing techniques, quality Management,GMP.

UNIT V	**PHARMACEUTICAL PRODUCTS**	**9 hours**

Therapeutic categories such as vitamins, laxatives, analgesics, non-steroidal contraceptives, Antibiotics, biological, Hormones.

LEARNING RESOURCES	
Text Books	1. Finkel Richard, *et al*., "Lippincott's Illustrated Reviews: Pharmacology", 4th Edition, Wolters Kluwer / Lippincott Williams & Wilkins, 2009. 2. Shayne Cox Gad,"Pharmaceutical Manufacturing Handbook", John Wiley &Sons, Inc., 2008. 3. Bernd Meibohm,"Pharmacokinetics and Pharmacodynamics of biotech drugs", Wiley-VCH, 2006.
Reference Books	1. Leon Lachman,"Theory and Practice of Industrial Pharmacy", 3rdEdition, Lea and Febiger, 1986. 2. Remington,"Pharmaceutical Sciences", 17thEdition, Mark Publishing & co, 1985.
Reference videos	https://www.youtube.com/watch?v=FPLzzuwZyMo https://www.youtube.com/watch?v=qvucMHUVZA4 https://www.youtube.com/watch?v=u0ulEC-shAI https://www.youtube.com/watch?v=bGwR_7BqXfA https://www.youtube.com/watch?v=ElTMeiMgsG8
Reference NPTEL	https://archive.nptel.ac.in/courses/102/107/102107028/
Reference research/ review articles	1. Sharma, D., Patel, P., & Shah, M. (2023). A comprehensive study on Industry 4.0 in the pharmaceutical industry for sustainable development. Environmental Science and Pollution Research, 30(39), 90088-90098. 2. Yadav, U., & Bhatted, S. K. (2023). A comparative analysis of Vamana and Shamana Chikitsa in prediabetes management: A randomized clinical trial. Journal of Ayurveda and Integrative Medicine, 14(5), 100764. 3. Panchal, K., Katke, S., Dash, S. K., Gaur, A., Shinde, A., Saha, N., ... & Chaurasiya, A. (2023). An expanding horizon of complex injectable products: Development and regulatory considerations. Drug Delivery and Translational Research, 13(2), 433-472. 4. Gozdzialski, L., Wallace, B., & Hore, D. (2023). Point-of-care community drug checking technologies: an insider look at the scientific principles and practical considerations. Harm Reduction Journal, 20(1), 39. 5. Kiruba, J., Justin Thenmozhi, A., Jayalakshmi, M., & Arockia Jeya Yasmi Prabha, E. (2023). Role of Vitamins in Alzheimer's Disease. In Nutraceuticals for Alzheimer's Disease: A Promising Therapeutic Approach (pp. 27-42). Singapore: Springer Nature Singapore.

Course Code	Course Title	L	T	P	C
10212BT125	HERBAL AND PHYTOCHEMICAL ENGINEERING	3	0	0	3

Course Category	*Program Elective*
Preamble	*To study and understand various basic concepts on Secondary metabolites from the plant resources and its isolation characterization techniques.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Summarize the different types of alkaloids and its isolation methods	K2
CO2	Utilize and categorize the different types alkaloids based its structural and functional properties	K3
CO3	Utilize and categorize the different types Steroids based its structural and functional properties	K3
CO4	Develop the drugs by using medicinal compounds of marine and plant sources	K3
CO5	Make use of chromatography techniques and analytical calculations to for phytocompound estimations.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Summarize the different types of alkaloids and its isolation methods	H	H	H	L				L	M			M	H	H	H
CO2	Utilize and categorize the different types alkaloids based its structural and functional properties	L	L	M					L				M	H	H	H
CO3	Utilize and categorize the different types Steroids based its structural and functional properties	H	H	H		M			M			M	M	H	L	L

CO4	Develop the drugs by using medicinal compounds of marine and plant sources	M	L	H					L				M	M	M	M
CO5	Make use of chromatography techniques and analytical calculations to for phytocompound estimations.	M		H		H		M		L		M			M	M

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO PHYTOCHEMISTRY**	**9 hours**

Introduction to alkaloids, classification, physical, chemical and general methods for isolation of alkaloids –Phenyl alkyl amine alkaloids.

UNIT II	**SYNTHESIS OF HERBAL- PHYTO CONSTITUENTS –I**	**9 hours**

Alkaloids: Ephedrine, Quinine, Strychynine, Piperine, Berberine, Taxol, Vinca alkoloids, Glycosides: Digitoxin, Glycyrrhizin, Sennosides, Bacosides, Quercitin.

UNIT III	**SYNTHESIS OF HERBAL- PHYTO CONSTITUENTS –II**	**9 hours**

Steroids: Hecogenin, guggulosterone and withanolides- Coumarin: Umbelliferone - Terpenoids: Cucurbitacins.

UNIT IV	**NATURAL PRODUCTS AS MEDICINE**	**9 hours**

Marine Drugs, cardiovascular, cytotoxic or anticancer, antimicrobials, anti-inflammatory & marine toxins;Antibiotics, definition, classification, natural sources and therapeutic indications.

UNIT V	**ANALYTICAL METHODS IN PHYTOCHEMISTRY**	**9 hours**

Chromatography techniques- Paper-Thin Layer- GC- GCMS-UV-IR-HPLC-HPTLC – NMR.

LEARNING RESOURCES

Text Books	1. Harbone J.B., "Phytochemical Method-- A guide to modern techniques of plant analysis", Third edition ,Chapman and Hall, 2005. 2. Trease and Evans, 'Pharmacognosy",16th Edition, Elsevier, New York, 2009. 3. Dewick P.M., "Medicinal Natural products – a biosynthetic approach", John Wiley & Sons, 2009.
Reference Books	1. Sarker S. D., Latif Z. and Gray A.I., "Methods in Biotechnology -Natural Product Isolation", Second Edition, Humana Press, 2006. 2. Bruneton J, "Pharmacognosy& Phytochemistry of Medicinal Plants", Interceptt Ltd., New York. 3. Jarald E.E. and Jarald S.E., "Textbook of Pharmacognosy and Phytochemistry", CBS Publishers & Distributors, New Delhi, 2009.

	4. Jean Bruneton, "Pharmacognosy, Phytochemistry, Medicinal plants", English edition,Levoisier Publishing, Paris, 1995.
Reference videos	https://www.youtube.com/watch?v=aLfabuFo7qo https://www.youtube.com/watch?v=6ZCnbCrYlJo https://www.youtube.com/watch?v=nVEopYV7dK4 https://www.youtube.com/watch?v=3wvwtv4sAPA https://www.youtube.com/watch?v=ByJ6lzD2Vbg
Reference NPTEL	https://nptel.ac.in/courses/102105342
Reference research/ review articles	1. Faisal, S., Badshah, S. L., Kubra, B., Emwas, A. H., & Jaremko, M. (2023). Alkaloids as potential antivirals. A comprehensive review. Natural Products and Bioprospecting, 13(1), 4. 2. Liu, W., Tang, X., Fan, C., He, G., Wang, X., Liang, X., & Bao, X. (2023). Chemical constituents, pharmacological action, antitumor application, and toxicity of strychnine semen from Strychnons pierriana AW Hill.: a review. Journal of Ethnopharmacology, 116748. 3. Bai, B., Liu, C., Zhang, C., He, X., Wang, H., Peng, W., & Zheng, C. (2023). Trichoderma species from plant and soil: An excellent resource for biosynthesis of terpenoids with versatile bioactivities. Journal of advanced research, 49, 81-102. 4. Hu, D., Jin, Y., Hou, X., Zhu, Y., Chen, D., Tai, J., ... & Lu, Y. (2023). Application of marine natural products against Alzheimer's disease: past, present and future. Marine Drugs, 21(1), 43. 5. Demyanovich, R. J. (2024). High energy dissipation rates from the impingement of free paper-thin sheets of liquids: Determination of the volume of the energy dissipation zone. Chemical Engineering Science, 294, 120128.

Course Code	Course Title	L	T	P	C
10212BT115	CANCER BIOLOGY	3	0	0	3

Course Category	*Program Elective*
Preamble	*To create a clear and thorough understanding on Cancer Biology from the fundamental principles to the most recent advances in its detection, tracking and therapy.*
Prerequisite Courses	*10211BT102 – Cell Biology* *10211BT104 – Molecular Biology: Concepts and Techniques*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Illustrate and diagnosis the regulations of cell cycle checkpoints in cancer cells	K2
CO2	Comprehend the various types of Carcinogenic materials and its regulatory mechanisms	K2
CO3	Explain different stages of cancers based on its molecular level understanding	K3
CO4	Identify the cause of cancer stimulation at Metastasis stage and its regulatory proteins	K3
CO5	Choose the proper therapy for different types of cancer according to their markers and proteins	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Illustrate and diagnosis the regulations of cell cycle checkpoints in cancer cells	H	M										H	H	M	
CO2	Comprehend the various types of Carcinogenic materials and its regulatory mechanisms	H		M	M	L						H	H	H	H	
CO3	Explain different stages of cancers based on its molecular level understanding	H	M	H	L							H	M	H	H	

CO4	Identify the cause of cancer stimulation at Metastasis stage and its regulatory proteins	H	H	M	H	H						H	M	H	H	M
CO5	Choose the proper therapy for different types of cancer according to their markers and proteins	H	H	M	H	L							M	H	H	L

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO CANCER BIOLOGY**	**9 hours**

Nomenclature, Historical perspective, regulation of cell cycle, check points, Basic mechanism of cancer, Signal molecules, signal transduction, mutations that cause changes in signal molecules, Modulation of cell cycle, receptors, oncogenesis, diagnostic tools for screening and early detection. Different forms of cancer.

UNIT II	**PRINCIPLES OF CARCINOGENESIS**	**9 hours**

Theory of Carcinogenesis, Metabolism of carcinogenesis, Physical and Chemical Carcinogenesis, Radiation carcinogenesis, ionizing and non-ionization radiation effects, CYP450 reductase mechanism, Retroviruses-RSV life cycle and role in cancer, Identification of carcinogens with long term and short term bioassays, other methods.

UNIT III	**MOLECULAR BASIS OF CANCER BIOLOGY**	**9 hours**

Principles of molecular cell biology of cancer - Differentiation, local invasion, Metastasis; Pathways of spread, Progression of Tumor, Signal targets and cancer, Identification, activation and detection of Oncogenes, activation of kinases, growth factors related to transformation,Telomerases

UNIT IV	**CANCER METASTASIS, ONCOGENES, ONCOPROTEINS**	**9 hours**

Introduction to Metastasis and cascade, Invasion-three step theory, Heterogeneity of metastatic phenotype, Proteinases and tumor cell invasion, Introduction to oncogenes and oncoproteins, tumor suppression genes - p53 genes, activation, evasion of apoptosis, DNA repair defects and instability of genes in cancer cells, chromosomal changes, gene amplification, molecular profile of cancer cells.

UNIT V	**CANCER THERAPY**	**9 hours**

Introduction and different types of cancer therapy, Chemotherapy, radiation therapy,Tumor markers, molecular tools for early detection of cancer, prediction of aggressiveness of cancer, advances in cancer detection, use of signal targets towards therapy of cancer, Gene therapy

LEARNING RESOURCES	
Text Books	
Reference Books	1. Weinberg R.A., "The Biology of Cancer", Garland Science, 2007. 2. Ian F.Tannock, Richard P. Hill, Robert G. Bristow and Lea Harrington,"The Basic Sciences of Oncology, 4th Edition, McGraw-Hill, 2005. 3. PelengarisS. and Khan M.,"The Molecular Biology of Cancer", Wiley Blackwell Publishing, USA, 2006. 4. Margaret A. Knowles and Peter T. Selvo, "An introduction to cellular and molecular biology of cancer", Oxford Medical publication,1991.
Reference videos	https://www.youtube.com/watch?v=46Xh7OFkkCE https://www.youtube.com/watch?v=NO0eKiIUcBg https://www.youtube.com/watch?v=8fwmSnkdY8Q https://www.youtube.com/watch?v=bdWRZd19swg https://www.youtube.com/watch?v=-6j0e_lZC6o
Reference NPTEL	https://nptel.ac.in/courses/102106025
Reference research/ review articles	1. Huang, Z., Xie, N., Illes, P., Di Virgilio, F., Ulrich, H., Semyanov, A., ... & Tang, Y. (2021). From purines to purinergic signalling: molecular functions and human diseases. Signal transduction and targeted therapy, 6(1), 162. 2. Stading, R., Gastelum, G., Chu, C., Jiang, W., & Moorthy, B. (2021, November). Molecular mechanisms of pulmonary carcinogenesis by polycyclic aromatic hydrocarbons (PAHs): Implications for human lung cancer. In Seminars in cancer biology (Vol. 76, pp. 3-16). Academic Press. 3. Schulz, W. A. (2023). Molecular biology of human cancers. Springer Nature Switzerland AG. 4. Schiller, J. T., & Lowy, D. R. (2021). An introduction to virus infections and human cancer. Viruses and human cancer: from basic science to clinical prevention, 1-11. 5. Gavas, S., Quazi, S., & Karpiński, T. M. (2021). Nanoparticles for cancer therapy: current progress and challenges. Nanoscale research letters, 16(1), 173.

Course Code	Course Title	L	T	P	C
10212BT118	**STEM CELL TECHNOLOGY**	**3**	**0**	**0**	**3**

Course Category	*Program Elective*
Preamble	*To study the unique properties of stem cell with its classification and to understand its application in the treatment of diseases.*
Prerequisite Courses	*10211BT`116- Immunology*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Outline the properties, classification and preservation of stem cell	K2
CO2	Comprehend the source and characterization of human embryonic stem cell.	K2
CO3	Identify and study about the properties of different types of adult stem cell.	K2
CO4	Make use of the hematopoietic stem cells for bone repair with tissue engineering tools	K3
CO5	Identify the solution for various diseases by using stem cell technology.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Outline the properties, classification and preservation of stem cell	H		H									M	H	M	
CO2	Comprehend the source and characterization of human embryonic stem cell.	H											H	H	M	
CO3	Identify and study about the properties of different types of adult stem cell.	H											H	H	M	
CO4	Make use of the hematopoietic stem cells for bone repair with tissue engineering tools	H	M	H	H	H	M		H				H	H	H	M

CO5	Identify the solution for various diseases by using stem cell technology.	H	H	H	H	H	M	H	H				H	H	H	L

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO STEM CELLS**	**9 hours**

Scope of Stem Cells -Unique properties of stem cells – differentiation, maturation, proliferation, pluripotency, self – maintenance and self – renewal –classification- problems in measuring stem cells – preservation protocols.

UNIT II	**HUMAN EMBRYONIC STEM CELL**	**9 hours**

Stem cells and their developmental potential. In vitro fertilization-culturing of embryos-blastocyst-inner cell mass-isolation and growing ES cells in lab Identification and characterization of human ES cells-Cloning and controlled differentiation of human embryonic stem cells. Applications of Embryonic stem cells. Ethical issues and regulations.

UNIT III	**HUMAN ADULT STEM CELL**	**9 hours**

Somatic stem cells-test for identification of adult stem cells- adult stem cell differentiation-trans differentiation-plasticity-different types of adult stem cells-liver stem cells-skeletal muscle stem cells-bone marrow derived stem cells.

UNIT IV	**STEM CELLS IN TISSUE ENGINEERING**	**9 hours**

Haematopoietic Stem Cells-Growth factors and the regulation of haematopoietic stem cells-clinical applications of haematopoietic stem cells. Mesenchymal stem cells and their role in bone tissue engineering-bone repair. Stem cell based gene therapy and benefits to human.

UNIT V	**APPLICATIONS OF STEM CELL**	**9 hours**

Therapeutic applications-Parkinsons disease, Cancer stem cell – Neural stem cell for central nervous system repair – Spinal cord injury – use of ESC to treat heart disease – Burns and skin ulcers – Orthopaedic applications of stem cell - Insulin-producing Cells Derived from Stem Cells: A Potential Treatment for Diabetes.

LEARNING RESOURCES

Text Books	1. Potten C.S., "Stem Cells," Elsevier, 1996. 2. Robert Lanza, "Essentials of Stem Cell Biology," Academic Press, 2009.
Reference Books	1. AriffBongso, EngHin Lee, "Stem Cells: From Bench to Bedside," World Scientific, 2011. 2. Daniel R. Marshak, "Stem cell biology," Cold Spring Harbor Laboratory Press, 2001. 3. Peter Quesenberry, "Stem cell biology and Gene Therapy," Wiley-Liss, 1998.

Reference videos	https://www.youtube.com/watch?v=evH0I7Coc54 https://www.youtube.com/watch?v=gxAVnoarveE https://www.youtube.com/watch?v=fp5H3SslskQ https://www.youtube.com/watch?v=ca3H2vemYXo https://www.youtube.com/watch?v=o7dDKMOMYWk
Reference NPTEL	**https://nptel.ac.in/courses/102106036**
Reference research/ review articles	1. Das, M., & Sloan, A. J. (2023). Stem cell sources from human biological waste material: a role for the umbilical cord and dental pulp stem cells for regenerative medicine. Human Cell, 36(4), 1312-1325. 2. Abel, A., & Sozen, B. (2023). Shifting early embryology paradigms: Applications of stem cell-based embryo models in bioengineering. Current Opinion in Genetics & Development, 81, 102069. 3. Tkemaladze, J. (2023). Reduction, proliferation, and differentiation defects of stem cells over time: a consequence of selective accumulation of old centrioles in the stem cells?. Molecular Biology Reports, 50(3), 2751-2761. 4. Plakhova, N., Panagopoulos, V., Vandyke, K., Zannettino, A. C., & Mrozik, K. M. (2023). Mesenchymal stromal cell senescence in haematological malignancies. Cancer and Metastasis Reviews, 42(1), 277-296. 5. Wu, B., Shi, X., Jiang, M., & Liu, H. (2023). Cross-talk between cancer stem cells and immune cells: potential therapeutic targets in the tumor immune microenvironment. Molecular Cancer, 22(1), 38.

Course Code	Course Title	L	T	P	C
10212BT126	MEDICAL GENOMICS AND PROTEOMICS	3	0	0	3

Course Category	*Program Elective*
Preamble	*To know more about the techniques involved in the genomics and proteomics for medical applications.*
Prerequisite Courses	*10211BT108 - Molecular Biology: Concepts and Techniques* *10211BT112 – Genetic Engineering*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Summarize the basic structure and organization of genomes of prokaryotes and eukaryotes.	K2
CO2	Illustrate the physical mapping techniques.	K2
CO3	Develop the knowledge on various techniques in genomics.	K3
CO4	Construct the importance of techniques involved in proteomic analysis.	K3
CO5	Apply the knowledge of proteomics for protein profiling.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Summarize the basic structure and organization of genomes of prokaryotes and eukaryotes.	L											H	L	L	
CO2	Illustrate the physical mapping techniques.	L											H	L		M
CO3	Develop the knowledge on various techniques in genomics.	M	L	L	L								M	M		
CO4	Construct the importance of techniques involved in proteomic analysis.	M	L	L	L								H	M		

CO5	Apply the knowledge of proteomics for protein profiling.	M	L	L	L								H	M		

H – High; M- Medium; L- Low

Course Content:

UNIT I	**OVERVIEW OF GENOMES OF BACTERIA, ARCHAEA ANDEUKARYOTA**	**9 hours**

Genome organization of prokaryotes and eukaryotes, Gene structure of Bacteria, Archaea and Eukaryotes, Human genome project, Introduction to functional and comparative genomics.

UNIT II	**PHYSICAL MAPPING TECHNIQUES**	**9 hours**

Cytogenetic mapping, Radiation hybrid mapping, Fish-STS mapping, SNP mapping, Optical mapping. Top down and bottom up approach, Linking and jumping of clones, Gap closure, Pooling strategies, Automation in Genome sequencing-Next Generation Sequencing.

UNIT III	**FUNCTIONAL GENOMICS**	**9 hours**

Gene finding, Annotation of genome – experimental and computational approach. ORF and functional prediction, Subtractive DNA library screening, Differential display and representational difference analysis, SAGE.

UNIT IV	**PROTEOMICS TECHNIQUES**	**9 hours**

Protein level estimation-Edman protein microsequencing, Protein cleavage, 2D gel electrophoresis, metabolic labelling. Detection of proteins on SDS gels. Mass spectrometry principles of MALDITOF, Fourier Transform Ion Cyclotron Resonance Mass Spectrometer, Orbitrap Mass Analyzer, Tandem MS, Peptide mass fingerprinting.

UNIT V	**PROTEIN PROFILING**	**9 hours**

Post translational modification, Protein-protein interactions, Glycoprotein analysis, Phosphoprotein analysis.

LEARNING RESOURCES

Text Books	1. Twyman R.M. and PrimroseS.B., "Principle of Genome Analysis and Genomics", Wiley Blackwell Publications, 2007. 2. Brown T.A., "Introduction to Genetic: A molecular Approach", Garland Science, Taylor and Francis, 2012.
Reference Books	1. Liebler, "Introduction to Proteomics", Humana Press, 2002 **2.** Veenstra T.W. andTates III Jr, "Proteomics for Biological Discovery", Wiley Publications, 2006.
Reference videos	https://www.youtube.com/watch?v=mg6tXQaiBaI https://www.youtube.com/watch?v=KXn533DTrsM https://www.youtube.com/watch?v=D-Ljd5Uex0s https://www.youtube.com/watch?v=k2ie0sWZKkc

	https://www.youtube.com/watch?v=5h3JGVlwR_8
Reference NPTEL	**https://nptel.ac.in/courses/102101072**
Reference research/ review articles	1. Shine, M., Gordon, J., Schärfen, L., Zigackova, D., Herzel, L., & Neugebauer, K. M. (2024). Co-transcriptional gene regulation in eukaryotes and prokaryotes. Nature Reviews Molecular Cell Biology, 1-21. 2. Puebla-Aparicio, M., Ascencio-Elizondo, C., Vieira, M., Amorim, M. C. P., Duarte, R., & Fonseca, P. J. (2024). Characterization of the fish acoustic communities in a Mozambican tropical coral reef. Marine Ecology Progress Series, 727, 143-158. 3. Lang, B. F., Beck, N., Prince, S., Sarrasin, M., Rioux, P., & Burger, G. (2023). Mitochondrial genome annotation with MFannot: a critical analysis of gene identification and gene model prediction. Frontiers in Plant Science, 14, 1222186. 4. Gosset-Erard, C., Aubriet, F., Leize-Wagner, E., François, Y. N., & Chaimbault, P. (2023). Hyphenation of Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR MS) with separation methods: The art of compromises and the possible-A review. Talanta, 257, 124324. 5. Lee, J. M., Hammarén, H. M., Savitski, M. M., & Baek, S. H. (2023). Control of protein stability by post-translational modifications. Nature Communications, 14(1), 201.

Course Code	Course Title	L	T	P	C
10212BT116	MOLECULAR PATHOGENESIS	3	0	0	3

Course Category	*Program Elective*
Preamble	*To introduce the molecular basis and factors behind pathogenesis and the various strategies designed to study, diagnose and treat pathogenesis.*
Prerequisite Courses	*10211BT101 – Microbiology* *10211BT116 - Immunology and Immunotechnology*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Explain the historical background of molecular pathogenesis and basic mechanisms.	K2
CO2	Comprehend the interactions mechanism of pathogens toward host organism and resistance development.	K2
CO3	Identify the molecular mechanisms of various Enteric pathogens for disease causing in human.	K3
CO4	Make use of molecular level experiments to understand host pathogen interactions	K3
CO5	Develop the diagnosis and prevention tools for various pathogenic infections.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Explain the historical background of molecular pathogenesis and basic mechanisms.	H	M										H	H	M	
CO2	Comprehend the interactions mechanism of pathogens toward host organism and resistance development.	H	H										H	H	H	
CO3	Identify the molecular mechanisms of various Enteric pathogens for disease causing in human.	H	M		L								H	H	H	

CO4	Make use of molecular level experiments to understand host pathogen interactions	H	H	M	H	H							H	H	H	M
CO5	Develop the diagnosis and prevention tools for various pathogenic infections.	H	H	M	H	L	H						H	H	H	L

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO MOLECULAR PATHOGENESIS**	**9 hours**

Historical background, Introduction to infectious diseases, Concepts of virulence, pathogenicity, commensalism, symbiosis, opportunism, parasitism; Significance of the discovery of Microscope in pathogenesis, Significant contributions of Louis Pasteur, Robert Koch postulates, Microbial toxins - discovery, assays, underlying mechanisms of bacterial colonization and infection.

UNIT II	**HOST DEFENSE AGAINST PATHOGENS, STRATEGIES**	**9 hours**

Basic components and nature of pathogenesis, Host defense mechanisms - Skin, Mucosa, Cilia, Secretions, Physical movements, limitation of free iron, antimicrobial compounds, mechanism of killing by humoral and cellular defense mechanisms, resistance development in pathogens, Pathogenic adaptations.

UNIT III	**MECHANISM IN MOLECULAR PATHOGENESIS**	**9 hours**

Underlying mechanisms of Molecular pathogenesis, Role of Molecular genetics and gene regulation in virulence of pathogens, Influence of lifestyle factors on virulence, Clinical features and molecular mechanism of pathogenesis: Enteric pathogens- Enteropathogenic (EPEC), Enteroinvasive (EIEC), Enteroaggressive *E.coli* (EAEC),Shigella, Salmonella, Dermatophytes, Candidiasis, Plasmodium - Life cycle, Malaria, different stages of Influenza virus.

UNIT IV	**EXPERIMENTAL STUDIES ON HOST PATHOGEN INTERACTIONS**	**9 hours**

Assays for Virulence, Principles of Adherence, Invasion, Cytopathic effects; Tests in identifying virulence factors, attenuated mutants, Molecular characterization of virulence factors, Signal transduction and host responses.

UNIT V	**PATHOGEN DIAGNOSIS AND CONTROL METHODS**	**9 hours**

Classical methods- Serotyping, Diagnosis using Virulence factors, Immuno, DNA based techniques, Precipitation, Agglutination, ELISA, RIA, PCR, Blotting techniques - Southern and

Western blotting, Bioinformatics/whole genome analysis for pathogen diagnosis, Vaccines - Types, applications, advantages and disadvantages, Cocktail vaccines, New therapeutic strategies based on recent findings on molecular pathogenesis of pathogens.	
LEARNING RESOURCES	
Text Books	
Reference Books	1. Iglewski B.H. and Clark V.L., "Molecular basis of Bacterial Pathogenesis", Academic Press, 1990. 2. Eduardo A. Groisman, "Principles of Bacterial Pathogenesis", Academic Press, 2001. 3. Peter Williams, Julian Ketley and George Salmond, "Methods in Microbiology: Bacterial Pathogenesis", Academic Press, 1998. 4. Brenda B. Wilson, Abigail A. Salyers, Dixie D. Witt and Malcolm E. Winkler, "Bacterial Pathogenesis", 3rdEdition, ASM press, 2011.
Reference videos	https://www.youtube.com/watch?v=_2vTa4P6Tbg https://www.youtube.com/watch?v=X6wrFMvK804 https://www.youtube.com/watch?v=oaqwrJ-SZGE https://www.youtube.com/watch?v=XvlY0zvKbm4 https://www.youtube.com/watch?v=SwNXNFBIGKc
Reference NPTEL	https://nptel.ac.in/courses/102106025
Reference research/ review articles	1. Milgroom, M. G. (2023). The Germ Theory Paradigm. In Biology of Infectious Disease: From Molecules to Ecosystems (pp. 9-22). Cham: Springer International Publishing. 2. Iannacone, M., & Guidotti, L. G. (2022). Immunobiology and pathogenesis of hepatitis B virus infection. Nature Reviews Immunology, 22(1), 19-32. 3. Alfinete, N. W., Bolukaoto, J. Y., Heine, L., Potgieter, N., & Barnard, T. G. (2022). Virulence and phylogenetic analysis of enteric pathogenic Escherichia coli isolated from children with diarrhoea in South Africa. International Journal of Infectious Diseases, 114, 226-232. 4. Ahmadi, M., Ranjbar, R., Behzadi, P., & Mohammadian, T. (2022). Virulence factors, antibiotic resistance patterns, and molecular types of clinical isolates of Klebsiella Pneumoniae. Expert Review of Anti-infective Therapy, 20(3), 463-472. 5. Sanya, D. R. A., Onésime, D., Vizzarro, G., & Jacquier, N. (2023). Recent advances in therapeutic targets identification and development of treatment strategies towards Pseudomonas aeruginosa infections. BMC microbiology, 23(1), 86.

Minors
In
Bioprocess Control and Devices

Course Code	Course Title	L	T	P	C
10213BT107	BIOPROCESS CONTROL COMPONENTS	3	0	0	3

Course Category	*Open Elective*
Preamble	*The courses introduces various process variables and control measures in bioprocess*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Understand Process variables and their application in Bioreactors	K2
CO2	Understand Different online and offline analysis, biosensors and electrical components	K2
CO3	Relate between different processes and strategies of fermentation process control	K2
CO4	Understand the variables of incubation control	K2
CO5	Apply the principles of digital process control and use of computers in bioprocess control.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand Process variables and their application in Bioreactors	L	L	M									H	H		
CO2	Understand Different online and offline analysis, biosensors and electrical components	H	M			H	H						H	L	M	
CO3	Relate between different processes and strategies of fermentation process control	H	M	L	L	M	M	L					H	M	H	
CO4	Understand the variables of incubation control	M	L	L	L	M	L						H	M	H	

CO5	Apply the principles of digital process control and use of computers in bioprocess control.	M	L	H	H	H	M						H	M		

H – High; M- Medium; L- Low

Course Content:

UNIT I	**MEASUREMENTS IN BIOCHEMICAL PROCESS**	**9 hours**

Biochemical process variables and their measurements; Control principles and their application in bioreactors; Theory of electrode processes and their applications; Measurement and control of pH, temperature, dissolved oxygen, aeration and agitation, redox potential, foam. Online data analysis for measurement of important physico-chemical and biochemical parameters.

UNIT II	**BIOSENSORS**	**9 hours**

Methods of on-line and off-line biomass estimation. Flow injection analysis for measurement of substrates, products, and other metabolites-Data analysis-state and parameter estimation techniques for biochemical processes-biosensors in bioprocess monitoring, biosensors based on thermal effects, optical effects, potentiometric biosensors, amperometric biosensors, enzyme electrodes, transducers, electrochemical probes.

UNIT III	**FERMENTATION CONTROL SYSTEMS**	**9 hours**

Control of fermentation; requirement of control, nature of control, control loop strategy, typical fermentation sensors, control action, types of control, feedback and feed forward control loop, different types of controllers,P,PI,PD and PID.

UNIT IV	**FERMENTATION PARAMETERS**	**9 hours**

Controller characteristics and tuning, ultimate gain method, cascade control system-fermentation control system objectives-fermenter control specification, control of incubation, specification for incubation control, advanced incubation control-fermentation profile-other advanced fermentation control.

UNIT V	**DIGITAL PROCESS CONTROL AND ANN**	**9 hours**

Fundamentals of digital process control; Use of computer in control and optimization of microbiological processes. Artificial neural networking and use in prediction of bioprocess and control.

LEARNING RESOURCES	
Text Books	
Reference Books	1. Shuler M. L. and Kargi F, Bio-process Engineering, 2nd Edition, Prentice Hall of India, New Delhi, 2002. 2. Bailey J.E and Ollis D.F, Biochemical Engineering Fundamentals, 2nd Ed., McGraw-Hill Publishing Co. 3. Yang, V.C and Ngo T.T, Biosensors and Their Applications, Kluwer Academic/Plenum Publishers, 2000. 4. Stephanopoulose G. Chemical Process Control, An introduction to theory and practice, Prentice Hall of India, New Delhi, 1993. 5. Seborg E and Edgar J.F and Mellichamp, Process Dynamics and Control, John Wiley.
Reference videos	https://www.youtube.com/watch?v=7uIIq_Ofzgw https://www.youtube.com/watch?v=hdaVgptDQA https://www.youtube.com/watch?v=ndoXG0NfiYc https://www.youtube.com/watch?v=yjAdp2aO7XM https://www.youtube.com/watch?v=uBY9YTYd5SU
Reference NPTEL	https://nptel.ac.in/courses/102106053
Reference research/ review articles	1. Jerkiewicz, G. (2020). Standard and reversible hydrogen electrodes: Theory, design, operation, and applications. ACS Catalysis, 10(15), 8409-8417. 2. Ding, J., & Qin, W. (2020). Recent advances in potentiometric biosensors. TrAC Trends in Analytical Chemistry, 124, 115803. 3. Schachinger, F., Chang, H., Scheiblbrandner, S., & Ludwig, R. (2021). Amperometric biosensors based on direct electron transfer enzymes. Molecules, 26(15), 4525. 4. Krieger-Weber, S., Heras, J. M., & Suarez, C. (2020). Lactobacillus plantarum, a new biological tool to control malolactic fermentation: A review and an outlook. Beverages, 6(2), 23. 5. Sklar, B. (2021). Digital communications: fundamentals and applications. Pearson.

Course Code	Course Title	L	T	P	C
10213BT108	ADVANCED ANALYTICAL AND INSTRUMENTATION BIOPROCESS APPLICATIONS	3	0	0	3

Course Category	Open Elective
Preamble	The course introduces the learner to basic and advanced criteria involved for analytical and instrumentation in bioprocess/bioreactor applications.
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Differentiate the variables and basic criteria for design of bioreactor	K2
CO2	Understand different modes of Bioreactor operation	K2
CO3	Solve Oxygen transfer in bioreactors in relation to transfer coefficients	K3
CO4	Analyze Oxygen transfer in bioreactors in relation to power requirements	K4
CO5	Examine scale up and scale down criteria in fermenter	K4

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Differentiate the variables and basic criteria for design of bioreactor	L											H	L		
CO2	Understand different modes of Bioreactor operation	M	L	M	L		H						H	M	L	
CO3	Solve Oxygen transfer in bioreactors in relation to transfer coefficients	M	M	L	L								L	M		
CO4	Analyze Oxygen transfer in bioreactors in relation to power requirements	M	H	H	M								L	H		

CO5	Examine scale up and scale down criteria in fermenter	H	H	H	H	H	H						M	H	M	

H – High; M- Medium; L- Low

Course Content:

UNIT I	**BIOPROCESS INSTRUMENTATION**	**9 hours**

Bioprocess Instrumentation: Temperature, pH, Level, Flow, Pressure, DO sensors. Response of First order systems: Transfer Function, Transient Response, Forcing Functions and Responses Basic criteria for design of bioreactor

UNIT II	**BIOREACTORS**	**9 hours**

Modes of operation of bioreactors: Batch operation (enzymatic and microbial), Continuous stirred tank On-line analysis of process parameters; Introduction to biosensors;

UNIT III	**OXYGEN TRANSFER IN BIOREACTOR-I**	**9 hours**

Oxygen transfer in bioreactors-I: Oxygen transfer to cells – transfer resistances – mass transfer coefficients – determination of oxygen transfer coefficients

UNIT IV	**OXYGEN TRANSFER IN BIOREACTOR-II**	**9 hours**

Oxygen transfer in bioreactors – II: Power requirement for mixing in aerated and non-aerated tanks, agitated and non-agitated tanks for Newtonian and non-Newtonian liquid. Mixing time in agitated reactor

UNIT V	**SCALE -UP PROCESS**	**9 hours**

Scale – Up: Reactor scale up – Scale up criteria – Scale down

LEARNING RESOURCES

Text Books	
Reference Books	1. Michael L. Shuler, FikretKargi, Matthew DeLisa (2017). Bioprocess Engineering, 3rd Edition, Prentice Hall International Series. **2.** Pauline M Doran (2013) Bioprocess Engineering Principles. 2nd Edition. Academic Press
Reference videos	https://www.youtube.com/watch?v=azdVSr7DBlg https://www.youtube.com/watch?v=mUDXupn2Dhk https://www.youtube.com/watch?v=SUVeiqRQYBg https://www.youtube.com/watch?v=vsrwzr2ZaoY https://www.youtube.com/watch?v=h4z979NFmWA
Reference NPTEL	**https://archive.nptel.ac.in/courses/102/107/102107028/**
Reference research/ review articles	1. Pásztory, Z. (2021). An overview of factors influencing thermal conductivity of building insulation materials. Journal of Building Engineering, 44, 102604.

	2. Battiston, F., Amico, E., Barrat, A., Bianconi, G., Ferraz de Arruda, G., Franceschiello, B., ... & Petri, G. (2021). The physics of higher-order interactions in complex systems. Nature Physics, 17(10), 1093-1098. 3. Boughton, C. K., & Hovorka, R. (2021). New closed-loop insulin systems. Diabetologia, 64, 1007-1015. 4. Shen, Y., Borowski, J. E., Hardy, M. A., Sarpong, R., Doyle, A. G., & Cernak, T. (2021). Automation and computer-assisted planning for chemical synthesis. Nature Reviews Methods Primers, 1(1), 1-23. 5. Farhan Hashosh, A., & Basirzadeh, H. (2024). Routh stability criterion and Lyapunov-Routh method in control theory. International Journal of Nonlinear Analysis and Applications, 15(5), 111-120.

Course Code	Course Title	L	T	P	C
10213BT109	BIOSENSORS	3	0	0	3

Course Category	*Open Elective*
Preamble	*This course helps to understand the use of biomolecues as recognition elements for detection of a particular analyte and the use of biological elements such as proteins in place of silicon chips.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Explain the application of biomolecules in sensing applications.	K2
CO2	Understand principle behind the functions of the immune biosensors and immobilized enzymes.	K2
CO3	Apply the biochemical and electrochemical mechanism to develop biosensors and oligonucleotide sensitive electrodes.	K2
CO4	Make use of chromophores and fluorophore to construct enzyme based fiberoptic biosensors.	K3
CO5	Analyze the metals and minerals by using biosensors.	K4

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Explain the application of biomolecules in sensing applications.	H	H	H	H								H	H	M	L
CO2	Understand principle behind the functions of Transducer biosensors.	H	H	H	H		M	M					H	H	H	L
CO3	Apply the biochemical and electrochemical mechanism to detect the elements in biosensors.	H	H	H	H	H	H	M					M	M	M	H
CO4	Make use of biosensors for various medicinal applications.	H	H	M	H		H						H	H	H	

CO5	Analyze the metals and minerals by using Nanomaterial's based biosensors.	M	H	H	H	H	H	H	L				M	H	H	L

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO BIOSENSORS**	**9 hours**

Definitions, biological inspiration, types of sensors, target analytes, various recognition, Recognition event: Catalytic, Single and multiple enzyme, Bio Affinity: Labeled and Label free, whole cell sensing – bacteria, yeast, mammalian cell, Generation of Biosensor; Biomolecule Immobilization Techniques.

UNIT II	**BASIC DESIGN AND TRANSDUCER**	**9 hours**

Considerations calibration, dynamic Range, signal to noise, sensitivity, selectivity, Interference Recognition/Transduction membrane protein sensors: ion channels, Types of Transducer, Optical; Fiber Optic, FET, Impedance, Piezoelectric; Cantilever

UNIT III	**DETECTION METHODS**	**9 hours**

Fluorescence Spectroscopy, UV-Vis Absorption and Emission, Surface Plasmon Resonance, Magnetic labeling, Electrochemical Detection.

UNIT IV	**APPLICATIONS OF BIOSENSORS**	**9 hours**

Biosensors and diabetes management, Microfabricated biosensors and point-of-care diagnostics systems, Noninvasive biosensors in clinical analysis; Surface plasmon resonance and evanescent wave biosensors, Biosensor in cancer and HIV early diagnosis.

UNIT V	**APPLICATIONS OF NANOMATERIALS IN BIOSENSORS**	**9 hours**

Nano Materials in biosensors; Carbon based Nano Material, Metal oxide and nano particle, Quantum dots, Role of nano material in Signal Amplifications, Detection and Transducer Fabrication.

LEARNING RESOURCES

Text Books	
Reference Books	1. Jeong-Yeol Yoon, "Introduction to Biosensors: From Electric Circuits to Immunosensors",1st Edition, Springer-Verlag, New York. 2. Mohammed Zourob, "Recognition Receptors in Biosensors", 1st Edition, Springer-Verlag, New York. 3. ZviLiron,"Novel Approaches in Biosensors and Rapid Diagnostic Assays",1st Edition, Springer US, 2001.
Reference videos	https://www.youtube.com/watch?v=9SF_8LP2xKM

	https://www.youtube.com/watch?v=4PvOLVzHV3g&list=PLkqcnysg6e-tdd24uyfDKlaC0vyFbkNdF https://www.youtube.com/watch?v=ER6YIeYjluY&list=PLkqcnysg6e-tdd24uyfDKlaC0vyFbkNdF&index=3 https://www.youtube.com/watch?v=IY0PswHQS9k https://www.youtube.com/watch?v=0-PvA1Sl4WE
Reference NPTEL	https://nptel.ac.in/courses/115107122
Reference research/ review articles	1. Barhoum, A., Altintas, Z., Devi, K. S., & Forster, R. J. (2023). Electrochemiluminescence biosensors for detection of cancer biomarkers in biofluids: Principles, opportunities, and challenges. Nano Today, 50, 101874. 2. Lu, J., Zhuang, X., Wei, H., Liu, R., Ji, W., Yu, P., ... & Mao, L. (2024). Enzymatic Galvanic Redox Potentiometry for In Vivo Biosensing. Analytical Chemistry. 3. Singh, A. K., Mittal, S., Das, M., Saharia, A., & Tiwari, M. (2023). Optical biosensors: A decade in review. Alexandria Engineering Journal, 67, 673-691. 4. Selvolini, G., & Marrazza, G. (2023). Sensor principles and basic designs. In Fundamentals of Sensor Technology (pp. 17-43). Woodhead Publishing. 5. Rubino, A., & Queirós, R. (2023). Electrochemical determination of heavy metal ions applying screen-printed electrodes based sensors. A review on water and environmental samples analysis. Talanta Open, 100203.

Course Code	Course Title	L	T	P	C
10213BT110	BIOCHIPS	3	0	0	3

Course Category	*Open Elective*
Preamble	*To know the essential concepts of biochips and microarray with major applications in medical field.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Understand the working principles of biochips and detection mechanism	K2
CO2	Develop Acquisition and analysis techniques with micro array for various applications.	K2
CO3	Utilize different predictive models of gene regulation and statistical frame work for gene expression data analysis.	K3
CO4	Analyse the DNA biomolecules in computing and bimolecular device with nanoelectronics	K4
CO5	Examine the biochips for molecular diagnostics, pharmaco genomics, drug discovery and epidemiology applications.	K4

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand the working principles of biochips and detection mechanism	H		H	H								H	H	M	
CO2	Develop Acquisition and analysis techniques with micro array for various applications.	H	H	M	M		M						H	H	H	
CO3	Utilize different predictive models of gene regulation and statistical frame work for gene expression data analysis.	H	H	M	L	L	H						M	M	M	

CO4	Analyse the Mathematical models and Modeling in DNA microarray	H	H	M	H	H	H	H					H	H	H	
CO5	Examine the biochips for molecular diagnostics, pharmaco genomics, drug discovery and epidemiology applications.	M	H	M	M	M	L	L	L				M	H	H	L

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION**	**9 hours**

Basics of Biochips; Types of Biochips - DNA Microarrays, Protein Microarrays, Oligonucleotide, cDNA and genomic microarrays, Integrated biochip system; microarray scanners./headers, microarray robotics; microfluidics systems, chips and mass spectrometry.

UNIT II	**CONSTRUCTION OF BIOCHIPS**	**9 hours**

Biochips assays, combination of microarray and biosensor technology, biochip versus gel-based methods, process flow for production and analysis of a chip, standardization of microarray analysis, bioinformatics and microarrays, evaluation of conventional microarray technology. Electrical detection methods for microarrays, SERS (Surface-Enhanced Raman spectroscopy)-based microarrays.

UNIT III	**GENOME SIGNAL PROCESSING AND DNA COMPUTING**	**9 hours**

Genome signal processing: Introduction, Mathematical models and Modeling DNA Microarray; DNA Computing: Introduction, Junctions, other shapes, Biochips and large scale structures; Strand algebras used in DNA computing.

UNIT IV	**COMMERCIAL ASPECTS OF BIOCHIPS**	**9 hours**

Markets for biochip technologies, commercial support for the development of biochips, government support for biochip development, business strategies and patent issues.

UNIT V	**APPLICATIONS OF BIOCHIPS**	**9 hours**

Application of microarray technology in drug discovery development and drug delivery, use of DNA chip technology for drug safety, use of microchips for drug delivery, use of biochips in health care,use of microarray in forensics, Limitations of biochip technology.

LEARNING RESOURCES	
Text Books	
Reference Books	1. Isaac S. Kohane, Alvin Kho, Atul J. Butte., "Microarrays for an Integrative Genomics (Computational Molecular Biology)", 1st edition, MIT Press, 2002. 2. Helen C. Causton, John Quackenbush, Alvis Brazma., "Microarray Gene Expression Data Analysis: A Beginner's Guide", 1st edition, Wiley-Blackwell, 2003. 3. Sorin Draghici, "Data Analysis Tools for DNA Microarrays", Har/Cdr Re edition, Chapman & Hall/CRC, 2003. 4. DNA Computing: 15th International Meeting on DNA Computing, DNA 15, Fayetteville, AR, USA, June 8-11, 2009, Springer, 2009. 5. Grigorenko E., "DNA Arrays: Technology and Experimental Strategies", Vth Edition, CRC Press, 2002. 6. Wan-Li Xing and Jing Cheng., "Biochips: Technology and Applications", Springer, 2003.
Reference videos	https://www.youtube.com/watch?v=208pMhKoQeo https://www.youtube.com/watch?v=g8Qav3vIv9s https://www.youtube.com/watch?v=vefBhhjodpE https://www.youtube.com/watch?v=-EO5fmz0tts https://www.youtube.com/watch?v=HZ8f0F2RMuo
Reference NPTEL	https://nptel.ac.in/courses/112104029
Reference research/ review articles	1. Gmuender, H. (2024). Perspectives and challenges for DNA microarrays in drug discovery and development. Biotechniques, 32(1). 2. Zhang, D., Pu, H., Huang, L., & Sun, D. W. (2021). Advances in flexible surface-enhanced Raman scattering (SERS) substrates for nondestructive food detection: Fundamentals and recent applications. Trends in Food Science & Technology, 109, 690-701. 3. Fruncillo, S., Su, X., Liu, H., & Wong, L. S. (2021). Lithographic processes for the scalable fabrication of micro-and nanostructures for biochips and biosensors. ACS sensors, 6(6), 2002-2024. 4. Azizipour, N., Avazpour, R., Rosenzweig, D. H., Sawan, M., & Ajji, A. (2020). Evolution of biochip technology: A review from lab-on-a-chip to organ-on-a-chip. Micromachines, 11(6), 599. 5. Azizipour, N., Avazpour, R., Rosenzweig, D. H., Sawan, M., & Ajji, A. (2020). Evolution of biochip technology: A review from lab-on-a-chip to organ-on-a-chip. Micromachines, 11(6), 599.

Course Code	Course Title	L	T	P	C
10213BT120	BIOMATERIALS	3	0	0	3

Course Category	*Open Elective*
Preamble	*This Course will give a broad view towards various types of biomaterials, its properties, manufacturing methods and its applications.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Understand the physiochemical properties of Biomaterials	K2
CO2	Apply the Metallic and Ceramic biomaterials for various medical applications	K3
CO3	Make use of biopolymers for various industrial applications.	K3
CO4	Select the biomaterials according to the mechanisms and regularities of friction and wear.	K3
CO5	Develop and identify the degradation and Corrosion characteristics of biomaterials	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand the physio chemical properties of Biomaterials	M		M									H	H	M	
CO2	Apply the Metallic and Ceramic biomaterials for various medical applications	H	M	M									H	H	H	
CO3	Make use of biopolymers for various industrial applications.	H	M	M									H	H	H	L
CO4	Select the biomaterials according to the mechanisms and regularities of friction and wear.	H	H	H	M								H	H	M	L

CO5	Develop and identify the degradation and Corrosion characteristics of biomaterials	H	H	H	M			H					H	H	M	L

H – High; M- Medium; L- Low

Course Content:

UNIT I	**BIOMATERIALS**	**9 hours**

Introduction to Biomaterials, Physical and Chemical properties, performance, response to implants, blood compatibility, Nanoscale phenomena.

UNIT II	**METALLIC AND CERAMIC BIOMATERIALS**	**9 hours**

Different implants - Stainless steels, cobalt-based alloys, Titanium-based alloys, shape memory alloy, ceramic implant, nanostructured metallic implants, biodegradable or bioresorbable, bioactive ceramics, nanostructured bio ceramics.

UNIT III	**POLYMERIC BIOMATERIALS**	**9 hours**

Polymer as biomaterials, Polymerization, properties of polymers, biodegradable polymers, Introduction bio polymers: Collagen, Elastin and chitin, Medical Textiles.

UNIT IV	**FAILURE AND TRIBOLOGY OF BIOMATERIALS**	**9 hours**

Failure and Tribology of Biomaterials: Deformation Mechanics, Fracture Mechanics, Classification of Fracture, Brittle to Ductile Transition of Biomaterials, Toughness Analysis of Biomaterials.

UNIT V	**DEGRADATION AND CORROSION OF BIOMATERIALS**	**9 hours**

Degradation and Corrosion of Biomaterials: Surface Properties, Degradation of Biomaterials, Corrosion of Biomaterials, Methods of Corrosion Testing, Biocompatibility of Implants.

LEARNING RESOURCES

Text Books	
Reference Books	1. Sujata V. Bhatt, "Biomaterials", Second Edition, Narosa Publishing House, 2005. 2. Sreeram Ramakrishna, Murugan Ramalingam, Sampath Kumar T.S., and Winston O. Soboyejo, "Biomaterials: A Nano Approach", CRC Press, 2010.
Reference videos	https://www.youtube.com/watch?v=XqFSlG6WKO0 https://www.youtube.com/watch?v=k_ftHmWEHm8 https://www.youtube.com/watch?v=QBDsAR2Dw6g https://www.youtube.com/watch?v=og4BLTXJv-o https://www.youtube.com/watch?v=wxaPXGcC-SU
Reference NPTEL	https://nptel.ac.in/courses/113104009

Reference research/ review articles	1. Marin, E., Boschetto, F., & Pezzotti, G. (2020). Biomaterials and biocompatibility: An historical overview. Journal of Biomedical Materials Research Part A, 108(8), 1617-1633. 2. Gritsch, L., Perrin, E., Chenal, J. M., Fredholm, Y., Maçon, A. L., Chevalier, J., & Boccaccini, A. R. (2021). Combining bioresorbable polyesters and bioactive glasses: Orthopedic applications of composite implants and bone tissue engineering scaffolds. Applied Materials Today, 22, 100923. 3. Samir, A., Ashour, F. H., Hakim, A. A., & Bassyouni, M. (2022). Recent advances in biodegradable polymers for sustainable applications. Npj Materials Degradation, 6(1), 68. 4. Monn, M. A., Vijaykumar, K., Kochiyama, S., & Kesari, H. (2020). Lamellar architectures in stiff biomaterials may not always be templates for enhancing toughness in composites. Nature Communications, 11(1), 373. 5. Kumar, A., & Pandey, P. M. (2020). Development of Mg based biomaterial with improved mechanical and degradation properties using powder metallurgy. Journal of Magnesium and Alloys, 8(3), 883-898.

Honors in Bioengineering

Course Code	Course Title	L	T	P	C
10212BT137	INSTRUMENTATION AND PROCESS CONTROL	3	0	0	3

Course Category	*Open Elective*
Preamble	*The course enables the learner to learn about various Instrumentation and Process control*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Understand the principles and classification of bioprocess variables	K2
CO2	Apply Laplace transformation to solve various process calculations	K3
CO3	Make use of closed loop and other components in process control for fermenter design	K3
CO4	Build to different types of control systems for industrial applications	K3
CO5	Distinguish different standard criteria for control and stability of reactor systems	K4

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand the prin ciples and classification of bioprocess variables	L			H	H							H	L	H	
CO2	Apply Laplace transformation to solve various process calculations	M	H	M	H		H						H	M	L	
CO3	Make use of closed loop and other components in process control for fermenter design	M	M	H	M		M						L	M		L
CO4	Build to different types of control systems for industrial applications	M	H	H	M	H							L	H		H

CO5	Distinguish different standard criteria for control and stability of reactor systems	H	H	H	H	H							M	H	M	M

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION**	**9 hours**

Principles of measurements and classification of process instruments, measurement of temperature, pressure, fluid flow, liquid weight and weight flow rate, viscosity, pH, concentration, electrical and thermal conductivity, humidity of gases.

UNIT II	**MATHEMATICAL MODELING AND CONTROL SYSTEMS**	**9 hours**

Laplace transformation, application to solve ODEs. Open-loop systems, first order systems and their transient response for standard input functions, first order systems in series, linearization and its application in process control, second order systems and their dynamics; transportation lag.

UNIT III	**CLOSED-LOOP CONTROL SYSTEMS**	**9 hours**

Closed loop control systems, development of block diagram for feed-back control systems servo and regulatory problems, transfer function for controllers and final control element, principles of pneumatic and electronic controllers, transient response of closed-loop control systems and their stability

UNIT IV	**ADVANCED CONTROL SYSTEMS**	**9 hours**

Introduction to advanced control systems, cascade control, feed forward control, Smith predictor controller, control of distillation towers and heat exchangers, introduction to computer control of chemical processes

UNIT V	**ADVANCED PROCESS CONTROL AND STABILITY ANALYSIS**	**9 hours**

Stability criteria- Routh's stability criteria - Root locus diagram - Frequency response analysis - Gain margin - Phase margin and cross over frequency - Bode plot - Polar plot and Nyquist plot. Process reaction curve - Cohen-Coon method - IMC tuning - Ziegler Nichols method. Introduction to multivariable control - Computer applications in process control - Advanced control strategies - Cascade control - Ratio control - Feed-Forward control - Inferential control - Adaptive control - Control of Reactor - Distillation towers - Heat Exchangers

LEARNING RESOURCES

Text Books	**1.** Coughanowr C. R., Koppel L. M., Process System Analysis and Control, 3rd ed., McGraw Hill, New Delhi, 2013.

Reference Books	1. Seborg D. E., Edgar, T. F., Mellichamp D. A., Process Dynamics and Control, 3 rd ed.,Wiley India, New Delhi, 2013. 2. Stephanopoulos G., Chemical Process Control, 1 st ed., Pearson Education India, New Delhi, 2015.
Reference videos	https://www.youtube.com/watch?v=azdVSr7DBlg https://www.youtube.com/watch?v=mUDXupn2Dhk https://www.youtube.com/watch?v=SUVeiqRQYBg https://www.youtube.com/watch?v=vsrwzr2ZaoY https://www.youtube.com/watch?v=h4z979NFmWA
Reference NPTEL	https://nptel.ac.in/courses/103103037
Reference research/ review articles	1. Pásztory, Z. (2021). An overview of factors influencing thermal conductivity of building insulation materials. Journal of Building Engineering, 44, 102604. 2. Battiston, F., Amico, E., Barrat, A., Bianconi, G., Ferraz de Arruda, G., Franceschiello, B., ... & Petri, G. (2021). The physics of higher-order interactions in complex systems. Nature Physics, 17(10), 1093-1098. 3. Boughton, C. K., & Hovorka, R. (2021). New closed-loop insulin systems. Diabetologia, 64, 1007-1015. 4. Shen, Y., Borowski, J. E., Hardy, M. A., Sarpong, R., Doyle, A. G., & Cernak, T. (2021). Automation and computer-assisted planning for chemical synthesis. Nature Reviews Methods Primers, 1(1), 1-23. 5. Farhan Hashosh, A., & Basirzadeh, H. (2024). Routh stability criterion and Lyapunov-Routh method in control theory. International Journal of Nonlinear Analysis and Applications, 15(5), 111-120**.**

Course Code	Course Title	L	T	P	C
10212BT138	BIOMOLECULAR MODELLING	3	0	0	3

Course Category	*Open Elective*
Preamble	
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Understand basic applications of molecular modelling, graphics and energy concepts.	K2
CO2	Outline the computational mechanics, Hartree Fock equations	K2
CO3	Understand fundamental principles governing molecular mechanics	K2
CO4	Relate molecular simulation dynamics and its applications to process control	K2
CO5	Apply Cheminformatics and learn structure-based drug design	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand basic applications of molecular modelling, graphics and energy concepts.	L			M	L	M						H	L		
CO2	Outline the computational mechanics, Hartree Fock equations	M	L	M	L								H	M	L	L
CO3	Understand fundamental principles governing molecular mechanics	M	M	L	L		H						H	M		
CO4	Relate molecular simulation dynamics and its applications to process control	M	H	H	M	H	H						H	H		

CO5	Apply Cheminformatics and learn structure-based drug design	H	H	H	H	H	H						M	H	M	

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO MOLECULAR MODELING**	**9 hours**

Introduction to concept of molecular modeling, molecular structure and internal energy, applications of molecular graphics, coordinate systems, potential energy surfaces, discussion of local and global energy minima.

UNIT II	**INTRODUCTION TO THE COMPUTATIONAL QUANTUM MECHANICS**	**9 hours**

Introduction to the computational quantum mechanics; one electron atom, ply electronic atoms and molecules, Hartree Fock equations; calculating molecular properties using ab initio and semi empirical methods.

UNIT III	**MOLECULAR MECHANICS**	**9 hours**

Molecular Mechanics – Introduction, The Morse Potential, The Harmonic Oscillator Model for Molecules, Comparison of Morse and Harmonic Potential, Two atoms connected by a bond, Poly atomic Molecules, Energy due to Stretch, Bend, Stretch-Bend, Torsional strain, van der Waals and Dipole-Diploe interactions. Types of Potentials: Lennard-Jones, Truncated Lennard-jones, Exponential-6, Ionic and Polar potentials. Types of Force Fields: AMBER, CHARMM, Merck Molecular Force Field, Consistent Force Field, MM2, MM3 and MM4 force fields.

UNIT IV	**MOLECULAR DYNAMICS SIMULATION**	**9 hours**

Molecular Dynamics Simulation – Introduction, Radial distribution functions, Pair Correlation function, Newtonian dynamics, Integrators- Leapfrog and Verlet algorithm, Potential truncation and shifted-force potentials, Implicit and explicit Solvation models, Periodic boundary conditions, Temperature and pressure control in molecular dynamics simulations

UNIT V	**INTRODUCTION TO CHEMINFORMATICS AND MOLECULAR DOCKING**	**9 hours**

Introduction to cheminformatics, Macromolecular modeling, design of ligands for known macro molecular target sites, Drug- receptor interaction, classical SAR /QSAR studies and their implications to the 3 D modeler, 2-D and 3-D database searching, pharmacophore identification and novel drug design, molecular docking, Structure-based drug design for all classes of targets.

LEARNING RESOURCES

Text Books	

Reference Books	1. Seborg D. E., Edgar, T. F., Mellichamp D. A., Process Dynamics and Control, 3 rd ed.,Wiley India, New Delhi, 2013. 2. Stephanopoulos G., Chemical Process Control, 1 st ed., Pearson Education India, New Delhi, 2015. 3. Coughanowr C. R., Koppel L. M., Process System Analysis and Control, 3rd ed., McGraw Hill, New Delhi, 2013.
Reference videos	https://www.youtube.com/watch?v=dJg6Wc-4Ri0 https://www.youtube.com/watch?v=U3PFAoeT4eI https://www.youtube.com/watch?v=I57cyNqMYqc https://www.youtube.com/watch?v=g55QvpAev0I https://www.youtube.com/watch?v=XYkDL8Dl-2Q
Reference NPTEL	https://nptel.ac.in/courses/103103036
Reference research/ review articles	1. Manzhos, S., & Carrington Jr, T. (2020). Neural network potential energy surfaces for small molecules and reactions. Chemical Reviews, 121(16), 10187-10217. 2. Lafleche, L., & Saffirio, C. (2023). Strong semiclassical limits from Hartree and Hartree–Fock to Vlasov–Poisson equations. Analysis & PDE, 16(4), 891-926. 3. Qin, M., Zeng, Z., Wu, Q., Yan, H., Liu, M., Wu, Y., ... & Xie, J. (2023). Dipole–dipole interactions for inhibiting solvent co-intercalation into a graphite anode to extend the horizon of electrolyte design. Energy & environmental science, 16(2), 546-556. 4. Carle, C., Hochbruck, M., & Sturm, A. (2020). On leapfrog-Chebyshev schemes. SIAM Journal on Numerical Analysis, 58(4), 2404-2433. 5. Francoeur, P. G., Masuda, T., Sunseri, J., Jia, A., Iovanisci, R. B., Snyder, I., & Koes, D. R. (2020). Three-dimensional convolutional neural networks and a cross-docked data set for structure-based drug design. Journal of chemical information and modeling, 60(9), 4200-4215.

Course Code	Course Title	L	T	P	C
10212BT139	BIOMECHANICS	3	0	0	3

Course Category	*Open Elective*
Preamble	*Provide an in-depth exploration of the theoretical foundations, computational methods, and practical applications of biomolecular modeling.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Describe basic concepts of Kinematics in relation to human physiology	K2
CO2	Explain different mechanics involved in various physiological processes and movements	K2
CO3	Relate human movement mechanics with laws of motion	K2
CO4	Develop model with different concepts of fluid mechanics and basic laws governing rheology	K2
CO5	Select and study the body fluids and concepts of viscosity	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Describe basic concepts of Kinematics in relation to human physiology	L			M	L	M						H	L		
CO2	Explain different mechanics involved in various physiological processes and movements	M	L	M	L								H	M	L	H
CO3	Relate human movement mechanics with laws of motion	M	M	L	L		H						H	M		
CO4	Develop model with different concepts of fluid mechanics and basic laws governing rheology	M	H	H	M	H	H						H	H		H

CO5	Select and study the body fluids and concepts of viscosity	H	H	H	H	H	H						M	H	M	H

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO BIOMECHANICS**	**9 hours**

Biomechanics – Basic Concepts: Kinematics – Descriptions of Motion, Kinetics – Introduction to Forces – Introduction to Statics and Dynamics - Bio-fluid mechanics: Viscosity, classification of fluids, blood rheology, fundamental method for measuring viscosity, rheology of blood in microvessels, mechanical model of cardiovascular system, relationship among blood velocity, blood pressure and blood vessel diameter in the vascular tree.

UNIT II	**CONNECTIVE TISSUE MECHANICS**	**9 hours**

Mechanics of breathing, physical aspects of alveoli, diffusion, airway resistance. Connective tissue mechanics: structure and biomechanical properties of collagen, tendon, ligament & cartilage; composition, structure and biomechanical properties of bone, bone fracture and failure mechanics, skeletal muscle tissue properties and functions, Normal posture, deviations from normal posture; Effects of age, occupation, habit, disease on posture.

UNIT III	**HUMAN MOVEMENT MECHANICS**	**9 hours**

Human movement mechanics: linear kinematics- kinematic parameters, fundamental concepts of gait, projectile motion, linear kinematics of walking & running, angular kinematics- types of angles, lower extremity joint angles, angular motion relationships, relationship between linear and angular motion, angle-angle diagrams, linear kinetics- laws of motion

UNIT IV	**INTRODUCTION TO FLUID MECHANICS**	**9 hours**

Introduction to fluid mechanics: Newton and non-Newton fluids; Laminar and turbulent flow, Viscosity, elasticity, viscoelasticity; Basic laws governing rheology

UNIT V	**BODY FLUIDS**	**9 hours**

Body fluids: blood, plasma, CSF, protoplasm, lymph, synovial fluid, sweat, urine. Aqueous humor, visceral fluids, cystic fluid; Viscosity: definition, factors affecting viscosity of various body fluids; influence of varied viscosity in causing organ/ system dysfunction

LEARNING RESOURCES

Text Books	1. Cynthia Norkins, "Joint Structure and Function: A Comprehensive Analysis", 2019, 6thEdition, F. A. Davis Company, USA
Reference Books	1. Susan J Hall, "Basic Biomechanics", 8 th Edition, 2019, Mc Graw Hill, USA 2. Y C Fung, "Biomechanics – Mechanical Properties of Living Tissue" 2nd Edition, 1993, Reprinted in 2016, Springer, USA

Reference videos	https://www.youtube.com/watch?v=LnM74brIZPE https://www.youtube.com/watch?v=cMrUhjrV9ks https://www.youtube.com/watch?v=YFf41uGO1wU https://www.youtube.com/watch?v=lJM4GuUd3Hk https://www.youtube.com/watch?v=9NYs3Y-IjGw
Reference NPTEL	https://archive.nptel.ac.in/courses/102/106/102106098/
Reference research/ review articles	1. Liu, R., Qian, D., Chen, Y., Zou, J., Zheng, S., Bai, B., ... & Chen, Y. (2024). Investigation of normal knees kinematics in walking and running at different speeds using a portable motion analysis system. Sports Biomechanics, 23(4), 417-430. 2. Sorushanova, A., Skoufos, I., Tzora, A., Mullen, A. M., & Zeugolis, D. I. (2021). The influence of animal species, gender and tissue on the structural, biophysical, biochemical and biological properties of collagen sponges. Journal of Materials Science: Materials in Medicine, 32, 1-12. 3. Green, W. H. (2020). Moving from postdictive to predictive kinetics in reaction engineering. 4. Alharbi, K. A. M., Ullah, A., Fatima, N., Khan, R., Sohail, M., Khan, S., ... & Ali, F. (2022). Impact of viscous dissipation and coriolis effects in heat and mass transfer analysis of the 3D non-Newtonian fluid flow. Case Studies in Thermal Engineering, 37, 102289. 5. Rus, G., Faris, I. H., Torres, J., Callejas, A., & Melchor, J. (2020). Why are viscosity and nonlinearity bound to make an impact in clinical elastographic diagnosis. Sensors, 20(8), 2379.

Course Code	Course Title	L	T	P	C
10212BT140	BIONANOTECHNOLOGY	3	0	0	3

Course Category	*Open Elective*
Preamble	*This course delves into the intricate world of nanoscale structures and biological systems, materials science, and environmental sustainability.*
Prerequisite Courses	*NIL*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Illustrate the basics of nanotechnology and its synthesis process.	K2
CO2	Demonstrate the techniques used in nanotechnology.	K2
CO3	Extend the importance of nano in biotechnology.	K2
CO4	Outline the applications of nano devices in medical field.	K2
CO5	Build the strong knowledge about drug delivery process with the help of nano particles.	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Illustrate the basics of nanotechnology and its synthesis process.	H	L	M	M								H	H	H	
CO2	Demonstrate the techniques used in nanotechnology.	H	M	H	H								H	H	H	
CO3	Extend the importance of nano in biotechnology.	H	H	H	H		H	H					H	H	H	L
CO4	Outline the applications of nano devices in medical field.	H	H	M			H	L					M	M	H	L
CO5	Build the strong knowledge about drug delivery process with the help of nano particles.	H	H	M	M			L					H	H	H	

H – High; M- Medium; L- Low

Course Content:		
UNIT I	**BASICS OF NANOTECHNOLOGY**	**9 hours**
A Brief History and development of Nanotechnology, Definition of nanotechnology, Nanobiotechnology v/s Bionanotechnology, Bottom-Up versus Top-Down approaches; Methods of synthesis of nanoparticles or fabrication, Surface property relationship.		
UNIT II	**METHODS IN NANOTECHNOLOGY**	**9 hours**
Types of Nanomaterials, Characterization techniques by SEM, TEM, Atomic force microscopy, Dynamic light scattering (DLS), XRD. Surface Plasmon resonance (SPR), Raman shift, FTIR.		
UNIT III	**STRUCTURAL AND FUNCTIONAL ASPECTS OF NANOTECHNOLOGY**	**9 hours**
Lipid Bilayers, liposomes, Neosomes, Polysacharides, Peptides, Nucleic acids, DNA scaffolds, Enzymes, Biomolecular motors: linear, rotary mortors, Immunotoxins, Membrane transporters and pumps; S-layer proteins: structure, chemistry and assembly; engineered Nanopores.		
UNIT IV	**CLINICAL APPLICATIONS OF NANODEVICES**	**9 hours**
Artificial neurons. Real-time nanosensors- Synthetic retinyl chips based on bacteriorhodopsins. High throughput DNA sequencing with nanocarbon tubules, Nanoparticles for Bioanalytical Applications; Applications in cancer biology.		
UNIT V	**NANOPARTICLES IN DRUG DELIVERY**	**9 hours**
Delivery of Nanoparticles: Brain Delivery, Ocular Drug Delivery, Gene Delivery Systems and Carriers in Cancer Therapy; Natural polymers in tissue engineering applications, Degradable polymers for tissue engineering, Controlled release strategies in tissue engineering and Nanotoxicology.		
LEARNING RESOURCES		
Text Books	1. David S Goodsell, "Bionanotechnology", John Wiley & Sons, 2004. 2. Christof M. Niemeyer, Chad A. Mirkin, "Nanobiotechnology: Concepts, Applications and Perspectives", 1stEdition, Wiley-VCH, 2006. 3. Charles P. Poole Jr. and Frank J. Owens, "Introduction to Nanotechnology", A Wiley-Interscience publication, India, 2003.	
Reference Books	1. Bernd Rehm, "Microbial bionanotechnology: Biological Self-Assembly Systems and Biopolymer-Based Nanostructures", Taylor and Francis, 2006. 2. SalataO.V.,"Applications of nanoparticles in biology & medicine", Journal of nanobiotechnology, 2004. 3. Vladimir P Torchilin, "Nanoparticulates Drug Carriers", Imperial College Press, 2006.	
Reference videos	https://youtu.be/DAOFpgocfrg https://youtu.be/a0G7iyz4McM https://youtu.be/J5pWH1r3pgU	

	https://youtu.be/psJ5J0daSsk https://youtu.be/wYnCYq93c9s
Reference NPTEL	https://archive.nptel.ac.in/courses/118/107/118107015/
Reference research/ review articles	1. Harish, V., Ansari, M. M., Tewari, D., Gaur, M., Yadav, A. B., García-Betancourt, M. L., ... & Barhoum, A. (2022). Nanoparticle and nanostructure synthesis and controlled growth methods. Nanomaterials, 12(18), 3226. 2. Patil, R. M., Deshpande, P. P., Aalhate, M., Gananadhamu, S., & Singh, P. K. (2022). An Update on Sophisticated and Advanced Analytical Tools for Surface Characterization of Nanoparticles. Surfaces and Interfaces, 33, 102165. https://doi.org/10.1016/j.surfin.2022.102165. 3. Lu, D., Wu, P., Yang, W., Wang, Y., Yang, J., Zhang, G., Wang, C., Yang, L., Zhu, L., & Sun, Z. (2023). Recent advances in lipid nanovesicles for targeted treatment of spinal cord injury. Frontiers in Bioengineering and Biotechnology, 11. https://doi.org/10.3389/fbioe.2023.1261288 4. Ohshiro, T. (2021). Nanodevices for Biological and Medical Applications: Development of Single-Molecule Electrical Measurement Method. Applied Sciences, 12(3), 1539. https://doi.org/10.3390/app12031539 5. Mundekkad, D., & Cho, W. C. (2022). Nanoparticles in Clinical Translation for Cancer Therapy. International Journal of Molecular Sciences, 23(3). https://doi.org/10.3390/ijms23031685

Course Code	Course Title	L	T	P	C
10212BT141	**BIOCHEMICAL ENGINEERING**	3	0	0	3

Course Category	*Open Elective*
Preamble	*It provides a comprehensive overview of biochemical engineering principles, including bioreactor design, enzyme kinetics, fermentation technology, and downstream processing.*
Prerequisite Courses	*10211BT106-Chemical Reaction Engineering*

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

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Relate different types of microorganisms and factors governing their growth	K2
CO2	Outline about Enzyme kinetics in relation to immobilization and industrial applications	K2
CO3	Classify between kinetics in different types of fermenter design	K2
CO4	Identify different methodologies of fermenter operating conditions	K3
CO5	Develop product recovery and downstream processes for design and analysis of bioreactors	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Relate different types of microorganisms and factors governing their growth	L		H	H								H	H	M	
CO2	Outline about Enzyme kinetics in relation to immobilization and industrial applications	H	L	M	L	H	L						H	M	L	H
CO3	Classify between kinetics in different types of fermenter design	H	H	L	L	M	L						H	M	H	
CO4	Identify different methodologies of fermenter operating conditions	M	H	H	M	H	L						L	H	L	H

CO5	Develop product recovery and downstream processes for design and analysis of bioreactors	H	H	H	H		L						M	H	M	H

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO BIOSCIENCE**	**9 hours**

Introduction to Bioscience: Types of Microorganisms: Structure and function of microbial cells. Fundamentals of microbial growth, batch and continuous culture. Isolation and purification of Enzymes from cells. Cell Growth Measurement

UNIT II	**ENZYME KINETICS**	**9 hours**

Enzyme kinetics: Simple enzyme kinetics, Enzyme reactor with simple kinetics. Inhibition of enzyme reactions. Other influences on enzyme activity. Immobilization of enzymes. Effect of mass transfer in immobilised enzyme particle systems. Industrial applications of enzymes.

UNIT III	**CELL KINETICS AND FERMENTER DESIGN**	**9 hours**

Cell kinetics and fermenter design: Growth cycle for batch cultivation, Stirred-tank fermenter, Multiple fermenters connected in series. Cell recycling. Structured Model.

UNIT IV	**OPERATION AND CONTROL OF BIOREACTORS**	**9 hours**

Stoichiometry of microbial growth and product formation, Medium formulation, operating conditions of suspended and immobilized cells in bioreactors-Batch, fed batch; operation and control of bioreactors.

UNIT V	**DESIGN AND ANALYSIS OF BIOREACTORS**	**9 hours**

Product recovery: Filtration, sedimentation, centrifugation, cell disruption, extraction, crystallization, drying, Design and analysis of bioreactors.

LEARNING RESOURCES

Text Books	1. Biochemical engineering fundamentals by J.E.Bailey and D.F.Ollis, 2nd ed, 1986, McGraw Hill. 2. Bioprocess Engineering by Michael L. Shuler and FikretKargi, 2nd edition, Pearson education. 3. Biochemical engineering by James M.Lee – Prentice-Hall-1992.
Reference Books	1. Trevan, Boffey, Goulding and Stanbury," Biotechnology", Tata McGraw Hill Publishing Co., New Delhi, 1987. 3. Bioprocess engineering principles, Pauline M. Doran, Academic Press. 2. Biochemical Engineering, H.W. Blanch and D.S. Clark, Marcel Dekker, 1997
Reference videos	https://www.youtube.com/watch?v=9JW63U2mzqo https://www.youtube.com/watch?v=CotD9m8Wm78

	https://www.youtube.com/watch?v=8AhDxAQaDOA https://www.youtube.com/watch?v=mUDXupn2Dhk&t=2s https://www.youtube.com/watch?v=VKpthcW1llU
Reference NPTEL	https://archive.nptel.ac.in/courses/103/105/103105054/
Reference research/ review articles	1. Corrêa, P. S., Morais Júnior, W. G., Martins, A. A., Caetano, N. S., & Mata, T. M. (2020). Microalgae biomolecules: Extraction, separation and purification methods. Processes, 9(1), 10. 2. Ashkan, Z., Hemmati, R., Homaei, A., Dinari, A., Jamlidoost, M., & Tashakor, A. (2021). Immobilization of enzymes on nanoinorganic support materials: An update. International Journal of Biological Macromolecules, 168, 708-721. 3. Malairuang, K., Krajang, M., Sukna, J., Rattanapradit, K., & Chamsart, S. (2020). 4. High cell density cultivation of Saccharomyces cerevisiae with intensive multiple sequential batches together with a novel technique of fed-batch at cell level (FBC). Processes, 8(10), 1321. 5. Cui, Y., Zhang, Y., Duan, C., Wang, X., Zhang, X., Ju, W., ... & Fang, L. (2020). Ecoenzymatic stoichiometry reveals microbial phosphorus limitation decreases the nitrogen cycling potential of soils in semi-arid agricultural ecosystems. Soil and Tillage Research, 197, 104463. 6. Meldrum, F. C., & O'Shaughnessy, C. (2020). Crystallization in confinement. Advanced Materials, 32(31), 2001068.

Course Code	Course Title	L	T	P	C
10212BT142	OMICS TECHNOLOGIES	3	0	0	3

Course Category	*Open Elective*
Preamble	*Students will gain a deep understanding of the experimental techniques, data analysis methods, and biological insights derived from these powerful tools.*
Prerequisite Courses	*10211BT105-Genetic Engineering* *10211BT104-Molecular Biology: Concepts and Techniques*

Course Outcomes	*Upon successful completion of the course, students will be able to:*	
CO Nos.	**Course Outcomes**	**Knowledge Level (Based on revised Bloom's Taxonomy)**
CO1	Understand Genomics and Concepts of Gene libraries	K2
CO2	Demonstrate knowledge in Transcriptomics and applications in data analysis	K2
CO3	Utilize the Proteomics and protein-protein interaction knowledge	K3
CO4	Make use of knowledge in Metabolomics and lipidomics	K3
CO5	Apply the applications of OMICS and data management in different fields of biotechnology	K3

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand Genomics and Concepts of Gene libraries	L		M		H							H	L		
CO2	Demonstrate knowledge in Transcriptomics and applications in data analysis	L	L	M		H							H	L	H	H
CO3	Utilize the Proteomics and protein-protein interaction knowledge		L	M		H							H	M		
CO4	Make use of knowledge in Metabolomics and lipidomics	L	L	M	M	H							M	M	H	H

CO5	Apply the applications of OMICS and data management in different fields of biotechnology	L	L	M	M	H							H	M	H	H

H – High; M- Medium; L- Low

Course Content:

UNIT I	**INTRODUCTION TO GENOME STRUCTURE**	**9 hours**

Genomics: Introduction to Genome Structure; Genome sequencing - Whole genome and NGS; Genome mapping; Overview of methodologies for detecting genetic variations: SNVs, small insertions and deletions (indels), copy number variants (CNVs) or rearrangements; Gene Library construction strategies

UNIT II	**TRANSCRIPTOMICS**	**9 hours**

Transcriptomics: RNA sequencing & analysis of transcriptomic data, Reference genome sequence; Concepts and principles of gene annotation; Gene expression profiling & quantification; Differential expression analysis; Introduction to Statistical transcriptomic data analysis.

UNIT III	**PROTEOMICS**	**9 hours**

Proteomics: Mass spectrometry – ionization methods (MALDI, electrospray), mass analysers, fragmentation, intact protein analysis, protease digestion; tandem mass spectrometry; Introduction to quantitative & Differential proteomics; Bioinformatics-based tools for analysis of proteomics data & Protein-protein interaction.

UNIT IV	**METABOLOMICS**	**9 hours**

Metabolomics: Metabolomics-an overview, Analytical techniques for metabolomics; Mass spectrometry in metabolomics. Targeted Vs Untargeted metabolomics; Metabolic pathway analysis; Metabolomics data analysis – case studies; Introduction to lipidomics and its workflow.

UNIT V	**OMICS AND BIG DATA MANAGEMENT**	**9 hours**

OMICS and Big Data management: Data acquisition, cleaning, distribution, and best practices; Visualization and design principles of big data; Biological databases for big data management; Computational techniques in data integration; Omics projects worldwide; Application of Omics in different fields of biotechnology.

LEARNING RESOURCES

Text Books	1. Principles of Genome Analysis and Genomics (3rd Ed.) by Primrose, S.B. and Twyman, R.M., Blackwell Publishing Company, Oxford, UK. 2003

	2. Introduction to Proteomics – Tools for the new biology (1st Ed.) by Liebler, D.C., Humana Press Inc., New Jersey, USA. 2002
Reference Books	1. Barh D, Azevedo V, Omics Technologies and Bio-engineering: Towards Improving Quality of Life, Academic Press 2. Pevsner J, Bioinformatics and Functional Genomics, Wiley-Blackwell,ISBN: 978-81-265-3834-8 3. Primrose, S.B. and Twyman. "Principles of Genome Analysis and Genomics". 7th Edition,Blakwell Publishing, 2006
Reference videos	https://www.youtube.com/watch?v=2JUu1WqidC4 https://www.youtube.com/watch?v=uIl0i7HWZdQ https://www.youtube.com/watch?v=vnW9kH0agcE https://www.youtube.com/watch?v=0cuTCimrSoM https://www.youtube.com/watch?v=bAyrObl7TYE
Reference NPTEL	https://nptel.ac.in/courses/102101072
Reference research/ review articles	1. Naseri, G., & Koffas, M. A. (2020). Application of combinatorial optimization strategies in synthetic biology. Nature communications, 11(1), 2446. 2. Moses, L., & Pachter, L. (2022). Museum of spatial transcriptomics. Nature methods, 19(5), 534-546. 3. Morato, N. M., & Cooks, R. G. (2023). Desorption electrospray ionization mass spectrometry: 20 years. Accounts of chemical research, 56(18), 2526-2536. 4. Perez De Souza, L., Alseekh, S., Brotman, Y., & Fernie, A. R. (2020). Network-based strategies in metabolomics data analysis and interpretation: from molecular networking to biological interpretation. Expert Review of Proteomics, 17(4), 243-255. 5. Koppad, S., Gkoutos, G. V., & Acharjee, A. (2021). Cloud computing enabled big multi-omics data analytics. Bioinformatics and biology insights, 15, 11779322211035921.

COURSE CODE	Community Service Project	L	T	P	C
10214BT501		0	0	4	2

Course Category: Independent Learning

1. Preamble

This course imparts the knowledge to familiarize with scientific literature, to assimilate, synthesize and integrate information for solving the problem in a group.

2. Prerequisite

Program Core and Electives

3. Links to other courses:

Minor Project I-10214BT601

4. Course Outcomes

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

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Identify a problem in real life through proper survey	K3
CO2	Select the project methodology to solve those problems	K5
CO3	Solve the problem and interpret the results as a Team	K6

5. Correlation of COs with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	L	H	L	H	L	H	H	L	H	H	L	L	H	H	H
CO2	M	H	H	H	H	M	M	M	H	L	M	L	H	H	H
CO3	H	H	H	H	M	M	L	M	H	L	H	M	H	H	H

H- High; M-Medium; L-Low

6. Course Description

Students should conduct literature survey/visit industry/analyze current trends and identify the problem for Project and finalize in consultation with Guide. Students should use multiple literatures and understand the problem. The community service project may address societal problems/issues related to the Programme.

COURSE CODE	MINOR PROJECT I	L	T	P	C
10214BT601		0	0	4	2

Course Category: Independent Learning

1. Preamble

This course imparts the knowledge to familiarize with scientific literature, to assimilate, synthesize and integrate information for solving the problem in a group.

2. Prerequisite

Program Core and Electives

3. Links to other courses:

Minor Project II-10214BT602

4. Course Outcomes

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

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Select the problem statement through literature survey / field work	K3
CO2	Analyze and problem solving methodology and remunerate social, ethical, economic and business aspects	K4
CO3	Select the process/ protocol/ tools to fine the solution to solve the problems	K5
CO4	Perform an experiment as a team/individual and discuss the results	K6
CO5	Practice engineering report preparation and life long learning	K6

5. Correlation of COs with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	H	H	L	H	L	M	-	-	H	L	-	-	H	L	-
CO2	H	H	H	M	M	M	L	H	H	-	M	M	H	-	M
CO3	M	M	H	L	H	M	L	M	H	-	H	H	M	M	L
CO4	M	M	M	H	H	M	L	H	M	H	M	H	M	H	H
CO5	M	L	L	L	M	M	L	M	H	H	H	H	M	M	-

H- High; M-Medium; L-Low

6. Course Description

Students should conduct literature survey/visit industry/analyze current trends and identify the problem for Project and finalize in consultation with Guide. Students should use multiple literatures and understand the problem. The minor project may address societal problems/issues related to the Programme.

COURSE CODE	MINOR PROJECT II	L	T	P	C
10214BT602		0	0	4	2

Course Category: Independent Learning

1. Preamble

This course imparts the knowledge to familiarize with scientific literature, to assimilate, synthesize and integrate information for solving the problem in a group.

2. Prerequisite

Program Core and Electives

3. Links to other courses:

Major Project – 10214BT701

4. Course Outcomes

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

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Select the problem statement through literature survey / field work	K3
CO2	Analyze and problem solving methodology and remunerate social, ethical, economic and business aspects	K4
CO3	Select the process/ protocol/ tools to fine the solution to solve the problems	K5
CO4	Perform an experiment as a team/ individual and discuss the results	K6
CO5	Practice engineering report preparation and life long learning	K6

5. Correlation of COs with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	H	H	L	H	L	M	-	-	H	L	-	-	H	L	-
CO2	H	H	H	M	M	M	L	H	H	-	M	M	H	-	M
CO3	M	M	H	L	H	M	L	M	H	-	H	H	M	M	L
CO4	M	M	M	H	H	M	L	H	M	H	M	H	M	H	H
CO5	M	L	L	L	M	M	L	M	H	H	H	H	M	M	-

H- High; M-Medium; L-Low

6. Course Description

Students should conduct literature survey/visit industry/analyze current trends and identify the problem for Project and finalize in consultation with Guide. Students should use multiple literatures and understand the problem. The minor project may address societal problems/issues related to the Programme.

COURSE CODE	MAJOR PROJECT	L	T	P	C
10214BT701		0	0	18	9

Course outcomes and K levels for the self-learning course - Major Project:

Course Category: Independent Learning

1. Preamble

This course imparts the knowledge to implement the principles of engineering learnt by them in practical applications with innovative ideas and thus enable them to have a practical exposure.

2. *Prerequisite*

Program Core and Electives

3. Links to other courses:

Nil

4. *Course Outcomes*

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

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Identify problem through literature survey / field work	K3
CO2	Select the problem solving methodology based on practical aspects	K5
CO3	Plan the sequence of experiments and equipment require for analysis	K6
CO4	Perform experiment as per the scientific ethics and discuss the results	K6
CO5	Prepare project report and practice lifelong learning from the major findings	K6

5. *Correlation of COs with Programme Outcomes*

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	H	H	L	H	L	M	-	-	H	L	-	-	H	L	-
CO2	H	H	H	M	M	M	L	H	H	-	M	M	H	-	M
CO3	M	M	H	L	H	M	L	M	H	-	H	H	M	M	L
CO4	M	M	M	H	H	M	L	H	M	H	M	H	M	H	H
CO5	M	L	L	L	M	M	L	M	H	H	H	H	M	M	-

H- High; M-Medium; L-Low

6. *Course Description*

Students should conduct literature survey/visit industry/analyze current trends and identify the problem for Project and finalize in consultation with Guide. Students should use multiple literatures and understand the problem. Students should attempt solution to the problem by experimental/simulation methods. The solution to be validated with proper justification and report to be compiled in standard format.