COURSE STRUCTURE & CURRICULUM

(AS PER NATIONAL EDUCATION POLICY- 2020)

For

B. Tech. Programme

In

BIOTECHNOLOGY

Department of Biotechnology
Motilal Nehru National Institute of Technology Allahabad
Prayagraj -211004 (UP)

VISION AND MISSION OF THE INSTITUTE

Vision

To attain a distinct identity for the Institute through technology innovation, knowledge creation and dissemination for the benefit of the society.

Mission

To nurture an eco system for continuous enhancement of value based teaching and learning process in the emerging areas of technology.
To train quality human and knowledge resources in the service of society.
To develop sustainable products and technologies.

Objectives of undergraduate programs of the institute *(adapted from UG ordinances)*

The objectives of the Undergraduate Programme at the Motilal Nehru National Institute of Technology Allahabad (MNNIT Allahabad) are:

- To provide the highest level of education in technology and science and to produce competent, creative and imaginative engineers and scientists.
- To promote a spirit of free and objective enquiry in different fields of knowledge.
- To make a significant contribution towards the development of skilled technical manpower, and
- To create an intellectual reservoir to meet the growing demands of the nation.

The undergraduate programmes are designed to achieve these objectives and to inculcate in the student concepts and intellectual skills, courage and integrity, awareness and sensitivity towards the needs and aspirations of the society.

VISION AND MISSION OF THE DEPARTMENT

Department Vision

The biotechnology program vision is to provide quality teaching with a strong core science concepts and an application-oriented undergraduate and post-graduate education along with solid foundation in the rapidly expanding fields of biotechnology that enable them to produce high quality professionals. Our goal is to provide students with a sound knowledge and understanding of current theories, concepts and laboratory practices in biotechnology

Department Mission:

To generate high quality engineering professionals by offering UG (B.Tech.) and PG (M.Tech. and Ph.D.) programmes in Biotechnology and to develop a premier biotechnology teaching and research department to cater the needs and challenges of the region and the country.

Mapping of the Departmental Vision and Mission with the Institute Vision and Mission

Mapping institutional vision with Departmental vision statement

	Institutional Vision			
Department Vision	Establishing unique identity	Knowledge creation	Knowledge acquisition	Knowledge dissemination for benefit of society
Provide quality teaching with a strong core science concept	✓	✓	✓	✓
Application oriented UG and PG education	✓	✓	✓	✓
Generation of high quality engineering professionals	✓	✓	✓	✓
Imparting practical knowledge	✓	✓	✓	✓
To cater the needs and challenges of the region and country	✓	✓	✓	✓

Mapping institutional mission with Departmental mission

		Institute mission	
Department mission	To generate high quality human and knowledge resource	Make valuable contribution in technology for social and economic development	Make organised effort for continuous enhancement of academic process, infrastructure and ambience
Generate high quality professionals	✓	✓	✓
To develop a premier biotechnology teaching and research department	✓	✓	✓
Cater the needs and challenges of region and country	✓	✓	✓

About the Department

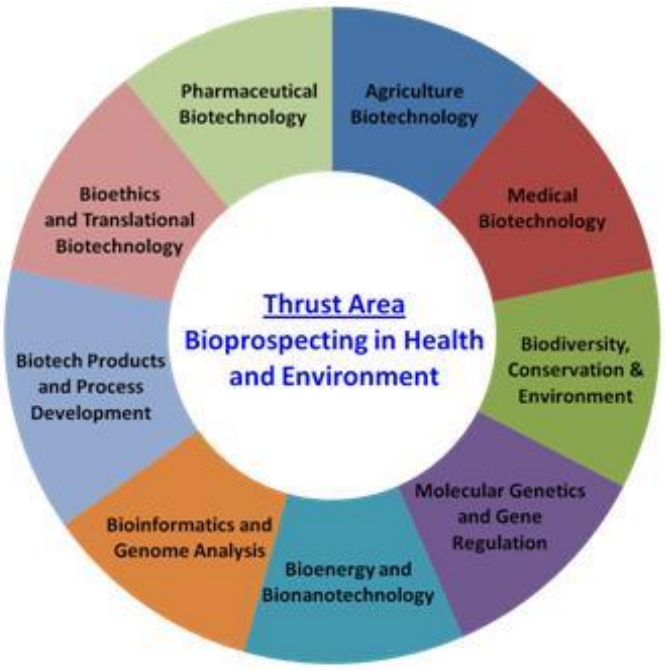
Biotechnology at MNNIT Allahabad was established as a new academic unit under Applied Mechanics in 2006, with the objective of integrating life sciences with engineering and to develop cutting-edge technology through research, training and technological innovation. Initially as a part of the Department of Applied Mechanics, an administratively independent Department of Biotechnology was established in the April, 2012. Since its inception, the department has witnessed a consistent rise in the students demand for the subject. Keeping a beat to the global demands for researchers in this field, a full-fledged post graduate degree course (M. Tech) in Biotechnology was introduced in the year 2010. The department has also started a PhD program in biotechnology since 2009.

The department is well equipped with the all-necessary instruments and number of research facilities. The department has a young, enthusiastic and well qualified faculty actively involved in research and teaching. The teachers are available to the students for academic as well as personal counselling. The department has been encouraging the students to independently think as well as implement research ideas. Presently, B. Tech, M. Tech (Biotechnology) and PhD program is being run under Biotechnology with the involvement of thirteen faculty members.

During this short span of time, the discipline has grown in every sphere. The faculty has been able to generate the external funding from various government agencies viz., DST, DBT, UGC, MNRE etc. and published papers in national/ International journals of repute. The department has been able to generate externally funded research grants of more than 4 crores recently. The faculty is frequently visiting various academic institutes/ research laboratories both in India and abroad. In addition, national & International conference supported by various government agencies was also organized regularly. The infrastructure in terms of equipment and other aspects has also grown significantly. All the Bachelor students in Biotechnology have passed, are either placed in good companies or pursuing their higher studies (MS and PhD program) in India or abroad. In addition, students of the department have been successful in prestigious GRE, CSIR-UGC (NET), GATE examinations.

The department aims to establish advanced research laboratories in all the identified areas. Apart from fundamental research, the goals of the department are also targeted to meet the demands of the biotechnology based industries.

Departmental Thrust Area



Proposed model curriculum for B. Tech. (Biotechnology)
(Based on NEP 2020)

Programme Educational Objectives (PEOs):

PEO1. Generate adequate human resources for employment opportunities in the critically important and dynamic biotechnology industry in t context of a socio-economic and sustainable society.

PEO2. Impart an uniquely combinatorial theoretical and practical knowledge in biotechnology with cutting-edge biotechnology research a teaching.

PEO3. Develop trained manpower with strong knowledge and ethics to undertake and execute sponsored and collaborative research programm and consultancies to promote long term academia industrial collaboration as well as for generating resources.

Program outcomes

PO1. To inculcate strong foundation in the basic fundamentals of engineering and sciences.

PO2. Apply the knowledge of basic, emerging and scientific advancements in the field of Biotechnology for problem solving fulfilling societal, environmental and ethical functional constraints

PO3. Identify and define biotechnological problems, and offer potential solutions by conducting experiments, investigating, analyzing and interpreting data to arrive at substantial inferences and conclusions, with comprehensive oral and written expression of technical and scientific literature.

PO4. Give reasoning and assess societal, industrial, health, and cultural issues with competency in professional biotechnological practices.

PO5. Have awareness regarding environmental protection and biodiversity conservation and their responsibilities and duties towards it, both as a biotechnologist and as an individual.

PO6. Apply the subject related technical knowledge for biotechnology related innovations and develop entrepreneurial outcomes for the benefit of mankind and human use and manifest the understanding of production and manufacture of different bio-related products.

PO7. Demonstration of application of principles of biology/ biotechnology in inter/ multidisciplinary projects and attainment of the ability to translate the acquired knowledge and core competence among his/her professionals, clients and society.

Program specific outcomes

PSO 1. Acquire an in-depth understanding of fundamental concepts of Biotechnology and capability to apply the gained knowledge in their professional development and to fulfil the emerging industrial demands of the country.

PSO 2. Develop scientific aptitude and strong oral and written communication skills, specifically with respect to scientific and technical report writing.

PSO 3. Have the knowledge of all the facets of biotechnology and its multidisciplinary applications and ability to implement it for the benefit of humanity.

PSO 4. Demonstrate high ethical, cultural and societal values with distinctive leadership traits and pursuit of life-long learning.

GENERAL COURSE STRUCTURE & THEME

Definition of credit

1 Hr. Lecture (L) per week	1 Credit
1 Hr. Tutorial (T) per week	1 Credit
2 Hours Practical (P) per week	1 Credit

Minimum credit required for B.Tech = 168

Structure of B.Tech (Biotechnology) Program: The structure of B.Tech. program shall have essentially the following categories of courses with the breakup of credits as given:

Course Structure Breakup

S. No.	Type	Acronym	Credits
1	Core engg. Foundation course	CEF	24
2	Core Essentials/Supportive	CEE/CES	76
3	Core Elective	CEL	30
4	Industrial Training/ Major & Mini Project	IT/ Major & Mini Project	18
5	Professional competence enhancing course (PCE)/Humanities and Social Sciences courses (HSS)	PCE/HSS	9
6	Extra academic activity (A/B)	EAA/B	8
7	**Total Credits**		**165**

Semester-wise Distributions of Credits

1st Year = 46							
Sem I (23)				**Sem II (23)**			
CEF /Oth.	EAA/B	PCE/HSS	CEE	CEF /Oth	EAA/B	PCE/HSS	CEE/CES
12	2	3	6	12	2	3	6
2nd Year = 44							
Sem III (23)				**Sem IV (21)**			
CEE/CES	CEL	HSS	EAA/B	CEE/CES	CEL		
15	3	3	2	15	6		
3rd Year = 43							
Sem V (20)				**Sem VI (23)**			
CEE/CES	CEL	EAA/B		CEE/CES	CEL		
12	6	2		11	12		
4th Year = 32							
Sem VII (18)				**Sem VIII (14)**			
CEE	CEL	Mini project		Industrial Training/ Project			
11	3	4		14			

B.Tech Biotechnology course structure First Year semester 1

S. No.	Course	Category	L	T	P	Credits	Contact hours	Remarks
1	Physics/chemistry	CEF	2	1	2	4	5	Branch specific physics and chemistry courses (alternatively in each semester) (Physics-III; PH11103)
2	Mathematics-I	CEF	3	1	0	4	4	Common course for all branches
3	English language and technical communication/Introduction to AI and machine learning	PCE	2	0	2	3	4	Common course for all branches *As per the clause 23. 13 of the NEP 2020
4	**Basics of Bio-manufacturing** (BTN11101)	**CEE**	**2**	**0**	**2**	**3**	**4**	**Branch specific course for student of that branch only**
5	**Introductory Cell and Molecular Biology** (BTN11102)	**CEE**	**3**	**0**	**0**	**3**	**3**	**Branch specific course for student of that branch only**
6	Engineering graphics/workshop and manufacturing processes	PCE	1	0	2	2	3	Common course (alternatively in each semester) *If any department does not want to adopt this/these course(s) for the specific branch, the department may float branch branch-specific course in its/their place
7	Introduction to Environment and Climate Change	PCE	1	1	0	2	2	Common course for all branches
8	Extra academic activity (A/B)	EAA	-	-	4	2	4	Common course for all branches (with different titles) ** Engagement beyond Academic Activity Duration &The evaluation of grading system should be worked out
Total			14	3	12	21	29	

B.Tech Biotechnology course structure First Year semester 2

S No	Course	Category	L	T	P	Credits	Contact hours	Remarks
1	Physics/chemistry	CEF	2	1	2	4	5	Branch specific physics and chemistry courses (alternatively in each semester)
2	Mathematics-II	CEF	3	1	0	4	4	Branches Specific Mathematics Course
3	English language and technical communication/Introduction to AI and machine learning	PCE	2	0	2	3	4	Common course for all branches *As per the clause 23. 13 of the NEP 2020
4	Fundamentals of Biotechnology (BTN12400)	CES	2	1	0	3	3	Courses to be floated by each department $Only for the students of other branches
5	**Biosafety and Bioethics** (BTN12101)	CEE	2	1	0	3	3	Branch specific course for student of that branch only
6	Engineering graphics/workshop and manufacturing processes	PCE	1	0	2	2	3	Common course (alternatively in each semester) #If any department does not want to adopt this/these course(s) for the specific branch, the department may float branch branch-specific course in its/their place
7	Extra academic activity (A/B)	EAA	-	-	4	2	4	Common course for all branches (with different titles) ** Engagement beyond Academic Activity Duration &The evaluation of grading system should be worked out
8	Introduction to Environment and Climate Change	PCE	1	1	0	2	2	Common course for all branches
Total			13	3	10	21	26	

Course code	**Semester III [Credits 23]** **Core Essential/Supportive Courses (CEE/CES)**	**Credits**	**Contact Hrs (L:T:P)**
BTN13101	Microbiology	4	3:0:2
BTN13102	Biochemistry	4	3:0:2
BTN13103	Fundamentals of Biochemical Engineering	3	3:1:0
MA****	Biostatistics	4	3:1:0
	Core Elective (CEL)		
	CEL l		
BTN13250	Biophysics & Structural Biology	3	3:0:0
BTN13251	Genetics and evolution	3	3:0:0
HS****	Course offered by HSS dept (e.g. Communication skills and technical writing/Management concept and application)	3	3:0:0
EAB****	Extra academic activity (EAB)	2	0:0:4
	Semester IV [Credits 21] **Core Essential/Supportive Courses (CEE/CES)**		
BTN14101	Bioprocess Engineering	4	3:0:2
BTN14102	Immunology (moved from Semester V to IV)	4	3:0:2
BTN14103	Advanced Cell and molecular biology	3	3:0:0
AM****	Biomaterials science and engineering	4	3:1:0
	Core Elective (CEL)		
	CEL 2		
BTN14250	Enzyme Technology	3	3:0:0
BTN14251	Food Biotechnology	3	3:0:0
	CEL 3		
BTN14252	IPR & Ethics (Open for Minor)	3	3:0:0
BTN14253	Instrumentation in Biotech	3	3:0:0
	Semester V [Credits 20] **Core Essential Courses (CEE)**		
BTN15101	Bioinformatics (Open for minor)	4	3:0:2
BTN15102	Microbial technology	4	3:0:2
BTN15103	Genetic Engineering	4	3:0:2
	Core Elective (CEL)		
	CEL 4		
BTN15250	Bioreactor & Plant design	3	3:0:0
BTN15251	Environmental Biotechnology	3	3:0:0
	CEl 5		
BTN15252	Nano-biotechnology	3	3:0:0
BTN15253	Pharmaceutical biotechnology	3	3:0:0

EAB****	Extra academic activity (EAB)	2	0:0:4
	Semester VI [Credits 23] **Core Essential Courses (CEE)**		
BTN16101	Plant Biotechnology	4	3:0:2
BTN16102	Molecular and Cell Diagnostics	3	3:0:0
BTN16103	Animal Biotechnology and cell culture technology	4	3:0:2
	Core Elective (CEL)		
	CEl 6		
BTN16250	Drug design & delivery	3	3:0:0
BTN16251	Stem Cells and tissue engineering	3	3:0:0
BTN16252	Human physiology & metabolic disorder	3	3:0:0
	CEl 7		
BTN16253	Bioresource management & Sustainable development	3	3:0:0
BTN16254	Downstream Processing (Open for Minor)	3	3:0:0
BTN16255	Microbiome in health (Open for Minor)	3	3:0:0
	CEl 8		
BTN16256	Modern Agricultural Biotechnology	3	3:0:0
BTN16257	Emerging Infectious Diseases	3	3:0:0
BTN16258	Algal Biotechnology	3	3:0:0
	CEI 9		
BTN16800	**MOOC** course on biotechnology related subjects (student choice) https://onlinecourses.nptel.ac.in/	3	
BTN16259	Health & nutrition (Open for Minor)	3	3:0:0
BTN16260	Metabolic engineering & synthetic biology	3	3:0:0
	B.Tech Honours/ B.Tech with Research		
	Basket I	4	3:0:1
	Basket II	4	3:0:1
	Semester VII [18 credits]		
	Core Essential Courses (CEE)		
BTN17101	Quality Assurance & Regulatory Affairs	3	3:0:0
BTN17102	Biomanufacturing (agri, environment and food related microbial products) (Open for Minor)	4	3:1:0
BTN17103	Biomanufacturing (Medical, Pharmaceutical related microbial products) (Open for Minor) *Students can select any of Biomanufacturing	4	3:1:0
	Core Elective (CEL)		
	CEI 10		
BTN17800	**MOOC** course on biotechnology related subjects (student choice)	3	
BTN17250	Startup, Biobusiness & Bio-Entrepreneurship (Open for Minor)	3	3:0:0
BTN17351	Mini project	4	0:0:8
	B.Tech Honours/ B.Tech with Research		
	Basket III	4	3:0:1
	Basket IV	4	3:0:1
	Semester VIII [14 credits]		

BTN18352	Major Project/ Industrial training in Biotechnology or related industries ***Evaluation will be done based on final presentation**	14	0:0:28

B.Tech with Honours (from M.Tech Biotechnology)

Semester VI

Basket I (Mandatory)

- Genetic Engineering and its applications (BTN16261)

Basket II

- Degenerative Diseases (BTN16262)
- Food Technology (BTN16263)
- Bio Business, Biosafety and IPR (BTN16264)

Semester VII

Basket III (Mandatory)

- Industrial Microbiology (BTN17251)

Basket IV

- Agrobiotechnology (BTN17252)
- Medical Biotechnology (BTN17253)
- Advanced Bioinformatics (BTN17254)

B.Tech with Research (from M.Tech Biotechnology)

Semester VI

Basket I

- Food Technology (BTN16263)
- Bio Business, Biosafety and IPR (BTN16264)

Basket II

- Genetic Engineering and its applications (BTN16261)
- Genomics and Proteomics (BTN16265)

Semester VII

Basket III

- Industrial Microbiology (BTN17251)
- Enzyme Technology (BTN17255)

Basket IV

- Medical Biotechnology (BTN17253)
- Advanced Bioinformatics (BTN17254)

B.Tech with Minor (Biomanufacturing & Bio-Entrepreneurship)

Semester IV

1. IPR & Ethics (3)

Semester V

2. Bioinformatics (4)

Semester VI

3. Microbiome in health / Downstream Processing (3)
4. Health & nutrition (3)

Semester VII

1. Biomanufacturing (agri, environment and food related microbial products) / Biomanufacturing (Medical, Pharmaceutical related microbial products) (4)
2. Startup, Biobusiness & Bio-Entrepreneurship (3)

	Credits			
Semester	**B.Tech (Biotechnology)**	**B.Tech Honour (Biotechnology)**	**B. Tech Research (Biomanufacturing & Bio-Entrepreneurship)**	**B. Tech Minor (Biomanufacturing & Bio-Entrepreneurship)**
I	23	23	23	-
II	23	23	23	-
III	23	23	23	-
IV	21	21	21	3
V	20	20	20	4
VI	23	23 + 8	23 + 8	6
VII	18	18 + 8	18 + 8	7
VII	14	14	14	-
Total	**165**	**165+16=181**	**165+16 = 181**	**20**

B.Tech. Biotechnology course details

SEMESTER I

Semester	1
Course Name	BASICS OF BIO-MANUFACTURING
Course Code	BTXXXX
Credits	03
Contact hours/ week	2-0-2 (LTP)
Prerequisite	Nil
Course objective	This course introduces students to the basic principles of bio-manufacturing techniques and their application in biotechnology sector and industrial demand.
Course outcome	• Basic understanding and training related to manufacturing of substances of industrial importance by biological interventions. • Identification of key-factors in the manufacturing of biological compounds in a regulated environment with quality control aspects. • Analyzing examples and case studies highlighting key challenges in bio-manufacturing

Theory component:

UNIT I: [5L]

Introduction, scope, market economy and need of Bio manufacturing. GMPs & GLPs related to Biotechnology.

UNIT II: [5L]

Overview of bio-manufacturing of important products, process control, validation and testing.

UNIT III: [5L]

Basics of cell culture, microbial growth and inhibition, product formulations, bio-therapeutics, cosmetics, biocompatible materials having diverse applications.

UNIT IV: [5L]

Market analysis, and case studies.

Basics of Bio manufacturing Laboratory [2 hrs per week]

1. Preparation of emulsions and colloids
2. Preparation of liposomes
3. Preparation of herbal formulation
4. Preparation of nano-formulations
5. Industrial report writing and Industrial workshop

Text Books

- Drug discovery and analytical methods for pharmaceutical formulations: Lambert Publications, Germany
- Biomanufacturing, Chander Prakash, S. Singh, S. Ramakrishna, B. S. Pabla, S. Puri, M. S. Uddin, Springer

Reference Books

- Introduction to biomanufacturing, The Northeast Bio-manufacturing center and collaborative (CNB), Montgomery County Community College.
- Biomaufacturing: 87 Advances in Biochemical Engineering/ Biotechnology, Eds Ziang Ziang Zhong, Springer.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓	✓					
CO2		✓	✓			✓	
CO3			✓			✓	✓

Semester	1
Course Name	INTRODUCTORY CELL AND MOLECULAR BIOLOGY
Course Code	BTXXXX
Credits	03
Contact hours/ week	3-0-0 (LTP)
Prerequisite	Nil
Course objective	Cell and molecular biology is the study of cells, their structure and function which provides students with a solid foundation in cell biology and molecular biology with an understanding how cells work in healthy and diseased states.
Course outcome	• Students will be able to understand and integrate knowledge of chemical and biological principles of living systems, central dogma of the cell and its regulation at various levels. • Knowledge gained in this course will serve as a foundation for other advanced courses of the same stream.

Theory component:

UNIT I: **[8L]**

Introduction, Basic properties of cells, Prokaryotic and eukaryotic cells, cell organelles.

UNIT II: **[8L]**

Introduction to bio-membranes, membrane transport, cytoskeleton and cell motility, cell-cell junction.

UNIT III: **[10L]**

Biomolecules: Carbohydrates, proteins, nucleic acids and vitamins, enzyme, gene.

UNIT IV: **[5L]**

Cell metabolism. Cell cycle and Cell signaling

Text Books:

- Essential Cell Biology by Alberts.
- L. M.Prescott, J.P. Harley and D.A.Klein, Microbiology, 6th Ed, McGraw Hill, 2005.

Reference Books

- The Cell: A molecular Approach by Cooper.
- Cell Biology by Pollard and Earnshaw.
- Genes to clone by T. A. Brown, Blackwill publication.
- Biotechnology and Genetic engineering by S. Mitra

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓	✓				✓	✓
CO2	✓	✓				✓	✓

SEMESTER II

Semester	2
Course Name	BIOSAFETY AND BIOETHICS
Course Code	BTXXXX
Credits	03
Contact hours/ week	2-1-0 (LTP)
Prerequisite	Nil
Course objective	1. To make students familiar with key concepts of bio-ethics and bio-safety. 2. To understand the various ethical issues involved in research and development to aware about various ethical conflicts.
Course outcome	• Understand basic principles of biosafety and bioethics and itspossible impact on biological sciences in both academia and industries • Realize the importance of biosafety practices and guidelines in research activities.

Theory component:

UNIT I: **[8L]**
Biosafety: Containment for biohazards; bio-safety levels and assessment; GRAS, GMOs & LMOs.

UNIT II: **[10L]**
Safety Issues: Laboratory design and facilities, Basic laboratory guidelines, Institutional bioethics and biosafety committees

UNIT III: **[8L]**
Bioethics: Ethical conflicts and legal issues. Ethics of new technology.

UNIT IV: **[5L]**
Plagiarism, Conflict of Interest, Ethical Issues in research with living organisms.

Text Books:

- IPR, Biosafety and Bioethics, Goel D &Prashar S – Pearson.
- Industrial documents/ biosafety guidelines

Reference Books

- IPR, Biosafety and biotechnology Management. Senthil Kumar Sand Mohammed Jaabir,-Jasen Publications.
- Biological Safety: Principles and Practices, Dawn P. Wooley and Karen B. Byers, Wiley

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1		√		√	√	√	√
CO2		√		√	√	√	√

Semester	2
Course Name	FUNDAMENTALS OF BIOTECHNOLOGY
Course Code	BTXXXX
Credits	03
Contact hours/ week	2-1-0 (LTP)
Prerequisite	Nil
Course objective	To provide fundamental knowledge of the field ofBiotechnology and its applications
Course outcome	• This will introduce students with the concepts of biology and their applications • Students will gain foundation to understand basic biochemistry, microbiology, cell biology, immunology, bioinformatics and biochemical principles.

Theory component:

UNIT I: [8L]

Introduction to biotechnology, its interventions and applications; Biotechnology sector: strength opportunities and challenges.

UNIT II: [8L]

Introduction to cell and biomolecules: structure, function and regulation. Enzyme, Gene: expression and regulation

UNIT III: [8L]

Introduction to bioinformatics, major bioinformatics resources and database searches. Genetically modified plants and animals.

UNIT IV: [6L]

Application of biotechnology, Current challenges and success stories/startups in biotechnology.

Text Books:

- D. L. D. L. Nelson and M. M. Cox, Lehninger Principles of Biochemistry, 5th Ed Macmillan Worth, 2007.
- Biotechnology by B.D. Singh; Kalyani Publisher India

Reference Books

- B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts,P. Walters, Molecular Biology of Cell, 5th Ed, Garland Publishing, 2007
- B. Lewin, Genes IX, International Edition,Pearson education, 2008
- Marketa Zvelebil, Jeremy O. Baum. Understanding Bioinformatics. Garland Science, 2007

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓		✓			✓	
CO2	✓		✓				✓

SEMESTER III

Semester	3
Course Name	MICROBIOLOGY
Course Code	BTXXXX
Credits	04
Contact hours/ week	3-0-2 (LTP)
Prerequisite	NIL
Course objective	• To understand the key concepts and principles of microbiology. • To provide deeper understanding of microbes, microbial diversity and their role in various fields of biotechnology. • Introduce basic techniques to students to lay strong foundation for other courses which are developed on microbiological principles and concepts.
Course outcome	• Exhibit competence in fundamental aspects of Microbiology • Students will be able to test the hypothesis involving microorganisms and demonstrate practical skills in microbiological tools and techniques. • Understand and appreciate role and importance of the microorganisms in the various domains.

Course contents:

UNIT I: **[5L]**
History of microbiology, Major contributions and events in the field of microbiology, Potential applications of microbes in industry and societal benefits, Classification systems and Identification of microorganisms, Staining techniques and Preservation methods.

UNIT II: **[7L]**
Overview of prokaryotic cell structure and functions, Characteristics of archaea, eubacteria and eukaryotes, Microbial Growth, Continuous growth, Bacteriological techniques, Methods of culturing microorganisms, Control of microorganisms by physical and chemical agents.

UNIT III: **[9L]**
An overview of microbial metabolism, Microbial nutrition and transport systems, Microbial genetics, conjugation, transformation, transduction.

UNIT IV: **[9L]**
Mechanism of bacterial pathogenicity, general characteristics of antimicrobial drugs, antibiotics: classification, mode of action and resistance. Microbial ecology and interactions. Industrial applications of microbes.

Microbiology Lab

1. Sterilization, Disinfection and Safety in microbiology Lab.

2. Examination of microorganisms by staining techniques (Gram staining, Negative staining, Endospore staining, Capsule staining and Motility)

3. Preparation of media for cultivation of microorganisms.

4. Isolation and Enumeration of microorganisms by serial dilution agar plating method.

5. To obtain pure culture of microorganisms.

6. To assess biochemical and enzymes activities of given culture of bacteria.

7. Assay of an antibiotic by zone-inhibition method using antibiotic impregnated discs.

Text/Reference Books:

- Microbiology by Presscort L.M., Harley, J.P and Klein, D.A. Mc Graw Hill.
- Microbiology by Pelczar, M.J. Chan ECS and Krieg NR, Tala McGraw Hill.
- General Microbiology by Roger Y. Stanier, Macmillan.
- Microbiology by T. D. Brocks.

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓	✓	✓			✓	
CO2	✓	✓	✓				
CO3	✓	✓	✓				✓

Semester	3
Course Name	BIOCHEMISTRY
Course Code	BTXXXX
Credits	04
Contact hours/ week	3-0-2 (LTP)
Prerequisite	Nil
Course objective	• This subject is designed to impart knowledge in understanding biochemistry of various biomolecules: their structure and functions, pathways involved for its metabolism and regulation. • To provide foundation for biotechnology and its various interdisciplinary applied areas • Introduce basic techniques to students to lay strong foundation for other courses which are developed on basic biochemistry principles and concepts.
Course outcome	• The course will assist the students to get theoretical knowledge and creative problem solver. • The understanding of this course content will be the foundation course for all courses of biotechnology and its applied area. Knowledge gained through this course will guide students to lead a healthy life style.

Course contents:

UNIT I: **[10 L]**
Carbohydrate metabolism and regulation: glycolysis, citric acid cycle (TCA Cycle), Electron transport, oxidative phosphorylation & ATP synthesis, Biosynthesis of glucose, glycogen and starch, pentose phosphate pathway, Regulation of carbohydrate metabolism and associated disease, photosynthesis.

UNIT II: **[8 L]**
Lipid metabolism: Catabolism of fatty acids, metabolism of triglycerol and cholesterol, biosynthesis of saturated and unsaturated fatty acids, phospholipids and sphingolipids. Regulation of lipid metabolism and associated disease.

UNIT III: **[7 L]**
Biosynthesis of amino acids, Catabolism of aminoacids-oxidative deamination and oxidative de-caroxylation, nitrogen excretion and Urea cycle. Regulation of amino acid metabolism and associated diseases, Cofactors, Vitamins,

Introduction of enzymes.

UNIT IV: **[5 L]**

Biosynthesis and degradation of ribonucleotides and deoxyribonucleotides, Regulation of purine and pyrimidine biosynthesis. Genetic disorders.

Lab Component

1. Qualitative tests for carbohydrates, amino acids and lipids.
2. Estimation of carbohydrates: DNS method, Phenol sulfuric acid method
3. Estimation of proteins: Lowry's method, Biurette method.
4. Extraction of Lipids.

Text/Reference Books:

- Principles of Biochemistry (Lehninger) by David. L. Nelson and Michael. M. Cox
- Outlines of Biochemistry by Conn, E.E and Stumpf P.K.
- Biochemistry by StryerLubert.
- Harper's review of Biochemistry by Martin D. W, Mayes. P. A and Rodwell. V. M
- Practical of Biochemistry by Wilson and Walker.
- Biochemistry by Champe P.C., Harvey R.A., Ferrier D.R.

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓	✓	✓				
CO2	✓	✓	✓				
CO3	✓	✓	✓				✓

Semester	3
Course Name	FUNDAMENTALS OF BIOCHEMICAL ENGINEERING
Course Code	BTXXXX
Credits	03
Contact hours/ week	3-1-0 (LTP)
Prerequisite	Nil
Course objective	• To understand basics of material and energy balance which can be applied to biochemical systems • To be able to design and analyze heat transfer equipments for fermentation systems by understanding the requirements of the bioprocesses • To evaluate the fluid flow kinetics of a system and evaluate its effect on biological processes.
Course outcome	• Understand the material and energy balance concepts and their application to biological systems • Apply the heat transfer fundamentals for design of heat exchangers

	• Identify the mass transfer kinetics and limiting steps in a bioprocess • Analyze the fluid flow to understand the homogeneity and heterogeneity of the bioprocesses for development of industrial scale systems

Course contents:

UNIT I: **[9 L]**
Material and Energy Balance: System and Process, Law of conservation of Mass and energy, enthalpy change due to bioreaction, bioenergetics.

UNIT II: **[5 L]**
Heat Transfer: Heat transfer mechanisms and equipment, Design equations for heat transfer systems, Heat exchanger design for fermentation system.

UNIT III: **[8 L]**
Mass Transfer: General reaction kinetics for biological systems, homogeneous and heterogeneous reactions in bioprocessing, Internal and external mass transfer and reaction.

UNIT IV: **[8 L]**
Fluid Flow: Streamline and turbulent flow, viscosity and its measurement, Rheological properties of fermentation broth, turbulence measurement, computational fluid dynamics for bioprocesses.

Text/Reference Books:

- Bioprocess Engineering Principles by Pauline M. Doran; Elsevier Science & Technology Books
- Advances in Biochemical Engineering by : T. K. Ghose, A. Fiechter, N. Blakebrough (Eds); Springer-Verlag Berlin Heidelberg New York
- Biochemical Engineering Fundamentals by James E. Bailey and David F. Ollis; McGraw-Hill College

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓	✓		✓		✓	
CO2	✓	✓					
CO3	✓	✓	✓				✓

Semester	3
Course Name	BIOPHYSICS AND STRUCTURAL BIOLOGY

Course Code	BTXXXX
Credits	03
Contact hours/ week	3-0-0 (LTP)
Prerequisite	Basic understanding of Biology
Course objective	• The course is designed to introduce the students about the basics of structural biology, Protein structure, DNA, RNA structure, Their denaturation kinetics. • Students will understand the methods by which the structure of macromolecules is determined and thermodynamics involved in oxidation-reduction and ATP transfer reactions. • Students will also learn dynamics of cytoskeleton system (Actin/Myosin/ Tubulin) which helps in cell motility, muscle contractility.
Course outcome	**Course outcome:** • To inculcate a strong foundation in the basic fundamentals of biological sciences. • Ability to apply the subject related technical knowledge for biotechnology related problems and provide solutions to it. • Ability to translate the acquired knowledge and core competence among his/her professionals and society. • Ability to demonstrate principles of biotechnology in inter/ multidisciplinary projects

Course contents:

UNIT I: **[8L]**

Molecular interactions holding protein structure, protein structure: primary, secondary, tertiary, quaternary structures, protein folding kinetics, Protein structural classification (Protein folds, structural families and classes), Protein structure function relationship, Protein structure and evolutionary relationships, Quaternary structures - dimers, homo & hetero dimers, fibrous proteins (structure of collagen, keratin), Transmembrane protein (G-PCR, Rhodopsin), Globular protein (Hemoglobin, Myoglobin).

UNIT II: **[7L]**

Types of double helices A, B, Z DNA and their structural features, glycosidic bond, rotational isomers, tertiary structure of DNA (Major & minor grooves in DNA), Melting of the DNA double helix (Hyperchromicity) and its kinetics, Ribose puckering and Tertiary structure of tRNA, supercoiling of DNA.

UNIT III: **[7L]**

Methods of structural determination of biomacromolecules: crystallization of macromolecules, Macromolecular structure determination by X-ray diffraction, NMR and circular dichroism.

UNIT IV: **[8L]**

Bioenergetics: Phosphoryl Group Transfers and ATP, Biological Oxidation-Reduction Reactions, Biomolecular interaction: Protein-Protein interactions, Protein-DNA interactions, Cytoskeleton dynamics: Actin/Tubulin dynamics, Cell Division, Cell motility, Muscle contraction, Nerve impulse transmission

Text/reference Books

- MOLECULAR CELL BIOLOGY, 5th Edition, Harvey LodishEt. Al.
- ESSENTIAL CELL BIOLOGY, 3rd Edition, Bruce Alberts Et. Al.
- CELL AND MOLCULAR BIOLOGY, 3rd Edition, Sheeler And Bianchi
- BIOLOGICAL SCIENCES, 3rd Edition, Taylor, Green & Stout
- Lehninger Principles of Biochemistry, Nelson and Cox, 6th edition

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓	✓					
CO2	✓	✓					
CO3				✓		✓	✓

Semester	3
Course Name	GENETICS & EVOLUTION
Course Code	BTXXXX
Credits	03
Contact hours/ week	3-0-0 (LTP)
Prerequisite	Nil
Course objective	• To create a deep understanding of how evolution works • Demonstrate the ability to analyse pedigrees and predict the inheritance of human **genetic** disease. • Demonstrate a basic understanding of DNA mutation
Course outcome	• Understand the basic concepts and processes of genetics • Have a basic understanding of evolution and evolutionary processes

Course contents:

UNIT I: **[6 L]**

Mendel laws of Inheritance and Non-Mendel Inheritance, Linkage and Crossing over; Sex determination and sex-linked inheritance. The Genetics of Bacteria & Phages. Maternal inheritance, Mutations: Chromosomal Mutations- Deletion. Gene Regulation

UNIT II: **[7 L]**

Chromosomal variation in Number & Structure: Structural and numerical change in chromosomes: Duplication, Inversion, Translocation, Aneuploidy and Polyploidy. Human Cytogenetics Genomic position effects on Gene

expression. Inborn errors of metabolism. One gene one enzyme, one gene one polypeptide theory.

UNIT III: **[8 L]**

Origin of Life and Introduction to Evolutionary Theories: Lamarckism and Neo-Lamarckism, Darwinism and NeoDarwinism, Modern synthetic theory. Biodiversity Conservation: geographical causes of diversity. Types of diversity- Genetic, Species and population diversity. Biodiversity and centers of origins of plant, Genetical and evolutionary principles of conservation.

UNIT IV: **[7 L]**

Evolution Genetics: The Hardy- Weinberg equilibrium, change in gene frequencies and mating system. Genetics of the evolutionary process and development, genetic basis of evolution and speciation, genetics of development. Concept evolution, Speciation: Methods of speciation - Allopatric and sympatric.

Text/Reference books:

- Evolution and Genetics: The Molecules of Inheritance by Jill Bailey, Oxford University Press
- Genes and Evolution by VirginieOrgogozo, Academic Press
- Genetics and Evolution by N. Arumugam, R.P. Meyyan,Saras Publication

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓	✓					
CO2	✓	✓					
CO3	✓	✓					

SEMESTER IV

Semester	4
Course Name	BIOPROCESS ENGINEERING
Course Code	BTXXXX
Credits	04
Contact hours/ week	3-0-2 (LTP)
Prerequisite	Fundamentals of Biotechnology
Course objective	• To understand the relevance, basic concepts and theories of utilizing bioprocesses engineering for industrial biotechnology applications • To understand the basics of fermentation techniques involved in product formation, the principals involved in transport mechanisms in bioreactor • Combine Theories with laboratory experience to have better understanding on bioprocess-related quarries
Course outcome	• Theoretical and practical knowledge of the basic principles of bioprocess technology and different types of fermenters and analyze microbial growth kinetic and predict important yield coefficients using the principles of stoichiometry and energetics • Students will understand the application and functioning of fermenter for industrial application • Learn skills to perform basic bioprocess-related experiments and handling equipment like ferementer

Course contents:

UNIT I: Introduction to Bioprocesses **[3 L]**

An Overview of bioprocess engineering, outline of an integrated bioprocess and the various (upstream and downstream) unit operations involved in bioprocesses.

UNIT II: Sterilization and Microbial Growth Kinetics **[10 L]**

Sterilization methods and kinetics of cells and spores, batch and continuous sterilization, air sterilization,

Kinetic modelling of cell growth: model structure, structured and un-structured models, Monod chemostat model, models with growth inhibitors, structured kinetic models.

UNIT III: Fermentation Process and Product Formation **[9 L]**

Type of fermentation: solid state and submerged state, batch, fed-batch and continuous fermentation and reactor. Growth associated and non – growth associated product formation kinetics. Substrate and product inhibition on cell growth.

UNIT IV: Aeration and Agitation in Fermentations **[8 L]**

Introduction, Mass transfer in bioprocessing systems. Oxygen transfers mechanism- assessment of KLa and its determination methods, factors affecting aeration and agitation in bioreactor.

Text/Reference Book list:

• Bioprocess engineering by M.L.Shuler and F. Kargi., Prentice Hall of India.
• Biochemical process principles by P.M. Doran., Academic Press.
• Introduction to Biochemical Engineering by D.G. Rao,
• Bioprocess Engineering Fundamentals by G.E Bailey and D.F Ollis, McGraw Hill
• Biochemical engineering by Aiba, Humphrey and Mells, academic press.

BIOPROCESS ENGINEERING- LABORATORY

- To determine Chemical oxygen demand (COD)
- To determine Biological oxygen demand (BOD)
- Media formulation and prepare a standard curve for substrate determination.
- To plot Microbial growth curve for shake flask culturing using turbidity method
- To Estimate the Monod Parameters for microbial growth kinetics.
- To get familiarized with the various bioreactors (e.g. CSTR, photobioractor, UASB)
- To determine the residence time distribution (RTD) in Biochemical reactor.
- To Determine the Oxygen transfer coefficient (KLa) in CSTR.
- Preparation of standard curve of Ethanol
- Quantitative estimation of ethanol produced during Yeast fermentation
- Demonstration of Fermenter

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓	✓	✓				
CO2				✓			
CO3	✓		✓		✓	✓	✓

Semester	4
Course Name	IMMUNOLOGY
Course Code	BTXXXX
Credits	04
Contact hours/ week	3-0-2 (LTP)
Prerequisite	This course requires basic understanding cell biology.
Course objective	• This course intends to build a foundation of basic human immunology by providing knowledge of cells, organs and molecules of immune system along with their structure and function. • The course is aimed to develop an understanding of various mechanisms involved in initiating immune defence mechanisms and techniques used to analyze the immune responses. • Laboratory exercises aims at imparting hands on training to conduct different immunological tests and their significance.
Course outcome	• With this course, students shall be able to define and elucidate various immunological processes. • They shall be able to critically think and connect the basic immunological principles with occurrence of common diseases like allergies, importance of immunization and awareness about vaccination. • Students will learn to apply this knowledge for studying antigen-antibody interactions.

Course content:

UNIT I: **[11 L]**

Cells and organs of immune system: History and evolution of immune system, Innate and acquired immunity, humoral and cell-mediated immunity, hematopoiesis, cells and organs of immune system.

Concept of Antibody and Antigen: concept of immunogenicity, antigens, epitopes, and haptens, antibodies-structure, classes, functions, monoclonal and polyclonal antibodies, primary and secondary immune response.

UNIT II: **[6 L]**

Diversity in B and T cell receptors: Molecular basis of antibody diversity: DNA rearrangements, variations arising out of V, D, J joining, somatic hyper mutation, class switching, Diversity in T cell receptors, principles of conservation.

UNIT III: **[8 L]**

Molecules in Immune response generation & regulation: MHC, antigen processing and presentation, Cytokines, Complement system, Hypersensitivity-types and their mechanism of action, Concept of tolerance, autoimmunity and immunodeficiency

UNIT IV: **[5 L]**

Techniques in immunology: Antigen-antibody interactions- agglutination, precipitation, immunodiffusion, rocket immunoelectrophoresis, immunoassay (competitive, sandwich and indirect) ELISA, RIA. Vaccines: active and passive immunization, types of vaccines.

List of Laboratory experiments

- Demonstration of Haemmaglutination through blood typing test.
- Demonstration of precipitation reaction using immunodiffusion and rocket immunoelectrophoresis tests.
- Isolation of antibody from blood and their quantification using spectrophotometer.
- Purification of antibodies using ammonium sulphate and size exclusion chromatography.
- Purification of lymphocytes from peripheral blood.
- Quantification of antigen in test sample using competitive and sandwich ELISA.
- Immunoblotting and immunodetection.

Text/Reference books:

- Essential Immunology by Roitt, I.M., Blackwell Scientific, Oxford, UK
- Immunology by Kuby J., Freeman, W.H., Oxford,UK
- Immunology by Weir W.B. Saunders and Co.
- Immunology by K.A. Abbas., W.B. Saunders and Co.

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓	✓	✓				
CO2				✓			
CO3	✓	✓	✓				✓

Semester	4
Course Name	ADVANCED CELL AND MOLECULAR BIOLOGY
Course Code	BTXXXX
Credits	03
Contact hours/ week	3-0-0 (LTP)
Prerequisite	Nil
Course objective	• Cell and molecular biology is the study of cells, their structure and function which provides students with a solid foundation in cell biology and molecular biology with an understanding how cells work in healthy and diseased states. • To provide foundation for advanced biotechnology and its various interdisciplinary applied areas
Course outcome	• Students will be able to understand and integrate knowledge of chemical and biological principles of living systems, central dogma of the cell and its regulation at various levels. • Knowledge gained in this course will serve as a foundation for other advanced courses of the same stream.

Course contents:

UNIT I: [8 L]

Cellular compartmentalization and structure and functions of cell organelles, Organization of nuclear genome.

UNIT II: [8 L]

Plasma membrane and function, transport across the plasma membrane, cell cytoskeleton and function, cell-cell junction. General strategy of the cell cycle, mechanism of cell division, cell-cycle control, programmed cell death (apoptosis).

UNIT III: [10 L]

Eukaryotic and prokaryotic gene organization, Central dogma, DNA replication and mechanism of DNA repair in prokaryotes and eukaryotes, Mechanism of transcription in prokaryotes and eukaryotes, RNA processing, Translation, Regulation of gene expression in bacteria, operon concept, inducible and repressible, catabolic repression of lac operon, Control of gene expression in eukaryotes, enhancers, silencers and other upstream controlling elements.

UNIT IV: [5 L]

Mechanisms of Signal Transduction, Intracellular receptor and cell surface receptors, Signalling via G protein linked receptors and enzyme linked receptor.

Text/Reference Books:

- Essential Cell Biology by Alberts.
- The Cell: A molecular Approach by Cooper.
- Cell Biology by Pollard and Earnshaw.
- Genes to clone by T. A. Brown, Blackwill publication.
- Biotechnology and Genetic engineering by S. Mitra

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓	✓				✓	
CO2	✓	✓		✓		✓	
CO3							

Semester	4
Course Name	ENZYME TECHNOLOGY
Course Code	BTXXXX
Credits	03
Contact hours/ week	3-0-0 (LTP)
Prerequisite	Fundamentals of Biotechnology, Microbiology, Biochemistry
Course objective	• To prepare students for critical analysis of scientific phenomena involving enzymes and competently work with enzyme systems in both academia and industry. • To introduce the students to various industrial biotechnology applications and role of enzyme technologies
Course outcome	• Knowledge about the fundamentals of enzymes would enhance the understanding of other basic and advance subjects of Biotechnology • It will make the students more enthusiastic about the applications of biotechnology in various industries. • Knowledge of about enzyme kinetics and its applications in pharmaceuticals, diagnostics, clinics and other industries will strengthen the vision of entrepreneurship and innovations.

Course contents:

UNIT I:	**[7 L]**
Introduction to Enzymes: nomenclature and their classification, production, purification and characterization of enzymes	

UNIT II: **[8 L]**

Mechanism and Kinetics of Enzyme Action: Mechanisms of enzyme action, concept of active site and energetics of enzyme substrate complex formation, specificity of enzyme action, kinetics of single substrate reactions, turn over number, estimation of Michaelis-Menten parameters.

UNIT III: **[8 L]**

Enzymes inhibition and multi-substrate enzyme kinetics: Multi substrate reaction mechanisms and kinetics, types of inhibition, allosteric regulation of enzymes, deactivation kinetics.

UNIT IV: **[7 L]**

Applications of Enzymes: Commercial applications of enzymes in food, pharmaceutical and other industries, enzymes for analytical and diagnostic applications, enzyme immobilization techniques, Applications of enzymes in analysis, design of enzyme electrodes and their application as biosensors in industry health care and environment.

Texts/Reference Books:

- Enzymes: Biochemistry Biotechnology by Trevor Palmer and Philip Bonner,
- Enzyme Chemistry: Impact and Application by Colin J. Suckling & Colin L. Gibson.,Blackie Academic &Professional.
- Biochemical Engineering by James M. Lee., Prentice Hall.
- Biochemistry by LubertStryer.
- Fundamentals of Enzymology by Nicholas C. Price and Lewis Stevens.
- Enzymes in Food Processing by Gerald Reed, Academic presses.

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1		✓		✓			
CO2				✓	✓	✓	
CO3							

Semester	4
Course Name	FOOD BIOTECHNOLOGY
Course Code	BTXXXX
Credits	03
Contact hours/ week	3-0-0 (LTP)

Prerequisite	Microbiology, Biochemistry, Bioprocess
Course objective	• To impart skills and knowledge required to apply the principles of food technology in industry • To provide knowledge about role of microorganisms in fermented foods and in food processing. • To illustrate the importance of food preservation, food safety, food quality, laws and regulations in Food industry.
Course outcome	• Understand the basics concepts of food biochemistry and microbiology and significance and activities of microorganisms in food. • Develop an appreciation about need of different emerging techniques used in food processing and preservation. • Knowledge to utilize techniques to detect the presence and identify microorganisms in foods.

Course contents:

UNIT I: **[6L]**

Historical highlights, food and its characteristics- microbiological and biochemical

UNIT II: **[8L]**

Principles of food preservation, use of low temperature, high temperature, radiation, drying, chemical preservatives for food preservation, microbial spoilage of food, food borne infections and intoxications

UNIT III: **[8L]**

Fermented dairy products, fermented alcoholic beverages, oriental fermented food, SCP and functional foods.

UNIT IV: **[8L]**

Food packaging and processing techniques, indicator organism, hazard analysis and critical control point, GMPs for food industry, sustainable operations in food industry.

Text /Reference Books:

- Modern Food Microbiology by James M. J., CBS Publishers and Publishers.
- Food Microbiology by Freiser.
- Willis Biotechnology, Challenges for the flavour and food industries by Lidsay, Elsevier Applied Science.
- Food Biotechnology by Roger A., Gordan B., and John T.
- Basic Food Microbiology by George J. B., CBS Publishers and Distributors.

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓	✓		✓		✓	
CO2							
CO3		✓		✓		✓	

Semester	4
Course Name	IPR AND ETHICS
Course Code	BTXXXX
Credits	Basics of Biomanufacturing
Contact hours/ week	3-0-0 (LTP)
Prerequisite	Nil

Course objective	• To provide basic concepts and knowledge of intellectual property rights in biotechnology • Introduce scopes of protection of intellectual property and its possible commercialization for societal benefits. • To provide information to students about different guidelines in IP management, technology transfer and different entrepreneurship opportunities in Biotechnology.
Course outcome	• The students will be able to utilize the knowledge of IP protection in research and academics. • Develop understanding about role of IPRs in biotechnology sector. • Harness the new knowledge and innovations towards product development and entrepreneurship. • Identify various entrepreneurship opportunities in Biotechnology.

Course contents:

UNIT I: **[7L]**

SWOT Analysis of Biotechnology sector in India. Innovation. Role of Research & development, GLPs, GMPs and other practices, Academia-Industry technology transfer arrangements.

UNIT II: **[8L]**

IPs of relevance to biotechnology, Trademarks, copyright and related rights, industrial design, traditional knowledge, geographical indications, patents and concept of 'prior art', patent laws, patent infringement. Commercialization of patented innovations. Marketing and public perceptions in product development.

UNIT III: **[8L]**

Introduction to GATT, WTO, WIPO and TRIPS, International Conventions.Plant variety protection and farmers rights act.

UNIT IV: **[7L]**

Introduction to Entrepreneurship, Entrepreneurship opportunities in Biotechnology, Business concept, plan, financing and new venture development. Art of Negotiation & Effective Communication.

Text/Reference Books

- Intellectual Property Rights by Neeraj Pandey, KhushdeepDharni
- Intellectual Property Law by Parameswaran Narayanan
- Innovation and Entrepreneurship by Peter Drucker
- Entrepreneurship and Small BusinessStart-up. Growth and Maturity by Paul Burns

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1					✓	✓	✓
CO2			✓	✓			
CO3				✓	✓	✓	✓

Semester	4
Course Name	INSTRUMENTATION IN BIOTECHNOLOGY
Course Code	BTXXXX
Credits	03
Contact hours/ week	3-0-0 (LTP)
Prerequisite	This course requires a basic understanding of cell biology, molecular biology, immunology and biotechnology as a whole.
Course objective	• The core strength of biotechnology is the laboratory where different instruments are used for implementing various techniques. • This course intends to provide a detailed knowledge of the instruments used to conduct various techniques, their working principles and how when such instruments can be used in their work. • It aims to make the students theoretically and practically equipped to handle any of the instruments taught.
Course outcome	• Student shall be able to learn the principle and working of different microscopes, centrifuge, electrophoretic set ups, chromatographic techniques and spectroscopes. • They shall be able to critically think and use their wisdom to decide on the use of these instruments and technique in their work. • Students may implement this knowledge in exploring novel applications of the techniques and equipment taught to them.

Course contents:

UNIT I: [10L]

Microscopy: Principle, working, sample preparation and biological applications of different microscopes – light microscope (bright field and dark field, phase contrast), electron microscope (TEM, SEM), fluorescence microscope and Atomic force microscope.

Centrifugation: Principle, construction, working of centrifugation and concept of RCF, types of instruments and rotors used in centrifugation, types of centrifugations- preparative, differential density gradient centrifugation.

UNIT II: [6L]

Electrophoresis: Principle & Working of zonal and continuous electrophoresis, Agarose gel electrophoresis, native and denaturing gels, isoelectric focusing, two dimensional gel electrophoresis, pulse-field gel electrophoresis, capillary electrophoresis.

UNIT III: **[7L]**

Chromatography: Principle, instrumentation and biological applications of paper and thin layer (TLC) chromatography, gel permeation (GPC), ion exchange chromatography, affinity chromatography, gas liquid (GC) and high pressure liquid chromatography.

UNIT IV: **[7L]**

Spectroscopy: Basic concepts of spectroscopy, beer lamberts law, principles, instrumentation and applications of UV-Visible spectroscopy, nephelometry, turbidometry, fluorescence spectroscopy, atomic absorption spectrophotometry, Basic concepts, instrumentation and biological applications of infra-red spectroscopy and mass spectroscopy.

Text/Reference books:

- Practical Biochemistry by Wilson and Walker.
- Biophysics by VasanthaPattabhi and N. Gautham.
- Handbook of analytical techniques by Helmut gunzler and Alex Williams
- Bioanalytical chemistry by Susan R Mikkeleson and E. Corton.
- Biophysical chemistry by Alan Cooper.
- Fundamentals of Analytical Biochemistry by Skoog and West.

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓	✓	✓				
CO2	✓	✓	✓				
CO3						✓	✓

SEMESTER V

Semester	5
Course Name	BIOINFORMATICS
Course Code	BTXXXX
Credits	04
Contact hours/ week	3-0-2 (LTP)
Prerequisite	Nil
Course objective	• To use & develop tools to curate (compare &analyze) biological data. • Learn to analysis and development of models for better interpretation of biological data to extract knowledge • To gain hands-on experiences
Course outcome	• Understanding theoretical and practical aspects of the basic algorithms used in Pairwise and Multiple alignments. Understanding the methodologies used for database searching, and determining the accuracies of database search. • Application of probabilistic model to determine important patterns. Prediction of structure from sequence and subsequently testing the accuracy of predicted structures. • Determine the protein function from sequence through analyzing data. Analysis and development of models for better interpretation of biological data to extract knowledge.

Course contents:

UNIT I: **[5 L]**

Introduction to Bioinformatics: Scope of Bioinformatics: Introduction to Linux and Windows GUI and commands, file formats

UNIT II: **[9 L]**

Introduction to biological databases, database search, algorithms issues in database search, sequence database search, sequence alignment, Gaps, Dynamic programming: global and local alignment, multiple sequence alignment, search tools: FASTA and BLAST, Amino acid substitution matrices: PAM and BLOSUM.

UNIT III: **[8 L]**

Evolutionary Trees and Phylogeny: Ultrametric trees, neighbour joining, Parsimony , maximum likeliood, perfect phylogeny, boot strapping, molecular clock hypothesis, evolutionary models

UNIT IV: **[8 L]**

2D and 3D structure prediction of proteins, molecular modelling and docking, molecular dynamics simulations, Large scale sequencing and alignment and assembly, gene predictions.

BIOINFORMATICS LABORATORY

1. Retrieval and analysis of sequences (nucleotides/amino acids) from biological databases.
2. Use of FASTA searching. Comparison of same search with BLAST.
3. Implementation of a selected sequence alignment algorithm.
4. Prediction secondary and tertiary structure of protein from primary structure using homology modelling.
5. Multiple sequence alignment using ClustalW
6. Calculation of physio-chemical properties of proteins

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1			✓	✓			
CO2			✓	✓			
CO3		✓	✓			✓	✓

Semester	5
Course Name	MICROBIAL TECHNOLOGY
Course Code	BTXXXX
Credits	04
Contact hours/ week	3-0-2 (LTP)
Prerequisite	Microbiology
Course objective	• To provide fundamental insights to exploit microbes for various products having immense industrial significance. • To amalgamates science and engineering knowledge with various biochemical processes to obtain industrially important products. • To provide students with a theoretical and practical understanding of industrial microbiology
Course outcome	• Appreciate how microbiology is applied in manufacture of industrial products • To impart understanding of industrial bioprocess and products. • To make students familiar with industrial applications of microbiology to build startups and bio-business.

Course contents:

UNIT I: **[6L]**

Microbial technology in human welfare, isolation, screening and preservation of industrially important microbes, strain improvement approaches

UNIT II: **[9L]**

Fermentation technology, application of fermentation, batch, fed batch and their continuous cultures of microbes. A brief outline of process for the production of commercially important primary and secondary metabolites.

UNIT III: **[8L]**

Production of alcohol, enzymes, organic acids, fatty acid, protein, bioplastic etc.

UNIT IV: **[7L]**

Microbial transformations with special reference to steroids and alkaloids, production of insulin, vitamins, antibiotics and SCP etc.

Laboratory content

Production of fermented alcoholic beverages (beer/ wine etc)

Microbial production of primary metabolite (organic acid/ amino acid/ lipid/ enzyme etc.)

Production of Single cell protein.
Demonstration of production of secondary metabolite by microbial fermentation (antibiotic/ carotenoid / alkaloid etc).
Recovery and purification of product from the fermentation broth
Production of microbial biofertilizers/ biopesticides
Microbial biotransformation of compounds (steriods/ pesticides/ metals etc).
Biodegradation of organic pollutants like pesticides, hydrocarbons, reactive dyes etc.

Text/ Reference Books:

- Biotechnology by John E.Smith., Cambridge Low Price Edition.
- Industrial Microbiology by J.E.Casida.
- Industrial Microbiology by A.H.Patel.
- Microbiology by Prescott and Dunn.

Microbial biotechnology by Glazer, A.N. and Nikaido H., NewYork.

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1		✓		✓			
CO2				✓	✓		
CO3						✓	✓

Semester	5
Course Name	GENETIC ENGINEERING
Course Code	BTXXXX
Credits	04
Contact hours/ week	3-0-2 (LTP)
Prerequisite	Molecular Biology, Genetics
Course objective	• This subject is designed to train students in understanding tools and techniques required to engineer nucleic acids which are the controlling factors for flow of information to proteins. • Applications of genetic engineering in various fields are also elaborated to expose them for the developments already taken place and in practice. • Provide hands-on laboratory experience to have better understanding of various ppplications of genetic engineering
Course outcome	• The course will assist the students to get theoretical knowledge and practical applications of genetic engineering and its future potential. • The course will help in building fundamental of other advanced course like Omics technologies and plant biotechnology.

Course contents:

UNIT I: **[6 L]**

Strategies of gene cloning, Enzyme used in cloning, polymerase, ligases, restriction endonucleases, Alkaline phosphatises, Linker, Adapter, Restriction modification system, , Introduction to various vectors, construction and screening of Genomic & cDNA libraries.

UNIT II: **[8 L]**

Primer designing for PCR, PCR methodology, Types of PCRs and their applications, Blotting and hybridization techniques, Site directed mutagenesis, Gene sequencing methods, Molecular markers (RFLP, RAPD, STMS, SNPs), DNA fingerprinting.

UNIT III: **[8 L]**

Gene expression analysis, Quantitative PCR methods, Principal and application of microarray technology, Techniques for DNA protein interaction and Protein-Protein interaction studies. Strategies of protein expression in bacteria, insects, and mammals, Methods of purification of recombinant proteins.

UNIT IV: **[8 L]**

Antisense Technology, Genome editing technology, Creation of knockouts, Production of transgenic plants and animal, Gene therapy: Introduction, Methods and Challenges, Introduction to stem cells and their applications in health care

GENETIC ENGINEERING LAB

- Isolation & purification of genomic and plasmid DNA
- Restriction digestion of genomic and plasmid DNA
- Preparation of competent cells and cloning in T/A vector
- Screening of transformants by X gal – IPTG
- Amplification of DNA fragments by Polymerase chain reaction (PCR) using RFLP/RAPD primers
- Heterologous protein expression in bacteria followed by SDS-PAGE
- Preparation of cDNA and Quantitative PCR for gene expression analysis

Text/Reference Books

- Genes to clone by T. A. Brown, Blackwill publication.
- Biotechnology and Genetic engineering by S. Mitra
- Principles of Gene Manipulation: An Introduction to Genetic Engineering Old RW and Primrose SB. Blackwell Science Publications.
- Molecular cloning: a laboratory manual: Volume II by Joseph Sambrook and David, William Russell.

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1		✓		✓			
CO2		✓		✓		✓	
CO3		✓				✓	✓

Semester	5
Course Name	BIOREACTOR AND PLANT DESIGN
Course Code	BTXXXX
Credits	03
Contact hours/ week	3-0-0 (LTP)
Prerequisite	Bioprocess Engineering
Course objective	• To understand the key design parameters for a bioprocess plant • To determine the factors affecting the operation of various types of bioreactors in different modes • To evaluate the scale up strategy for industrial scale operations and to analyse the control system for efficient fermentation
Course outcome	• Interpret fundamental bioreactor design criteria and determine the utilities required for a bioprocess plant understand design and functioning of various types of bioreactor and their components • Evaluate the output of different combinations of reactors and determine their effect on process efficiency and understand the scale-up criteria and analyse the factors affecting scale up strategies • Explain the functions and constructions of different instrumentation tools used in a bioreactor and understand the methods to control bioreactor operation

Course content:

UNIT I: **[9 L]**

Bioreactor Types and components: Introduction and key design parameters, Materials and components of construction for bioreactors, Types of bioreactors

UNIT II: **[8 L]**

Measurement and Control systems: Measurement of physical and chemical parameters in bioreactors, process control by proportional, integral and derivative control and their combinations, Direct regulatory control, Cascade control, Programmable Logic Controller (PLC), Supervisory Control and Data Acquisition (SCADA).

UNIT III: **[8 L]**

Bioreactor operation: General design information, Ideal reactors, Performance equations for single reactors; Multiple reactor systems, Residence time distributions (RTD), Exit age distribution, Recycle reactors, Modelling of reactor performance.

UNIT IV: **[5 L]**

Scale up and Plant Design: Scale-up criterion, Scale down, bioreactor system supplies, piping, storage and distribution, cGMP guidelines for bioreactor design and sustainable bioprocessing.

Text/Reference Books:

- Biochemical engineering by Aiba, Humphrey and Mells, Academic press.
- Bioprocess engineering principles by Pauline M. Doran, Academic Press.
- Biochemical Engineering by H.W. Blanch and D.S. Clark, Marcel Dekker.
- Bioreactor System Design by Juan A. Asenjo and Jose C. Merchuk; Marcel Dekker
- Principles of Fermentation Technology by Stanbury, Whitaker and Hall by Elsevier

Plant Design and Economics for Chemical Engineering by M.S. Peters and K.D.Timmerhaus., Mc GrawHill.Company.

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1		✓				✓	
CO2		✓				✓	
CO3			✓			✓	✓

Semester	5
Course Name	ENVIRONMENTAL BIOTECHNOLOGY AND CLIMATE CHANGE
Course Code	BTXXXX
Credits	03
Contact hours/ week	3-0-0 (LTP)
Prerequisite	Ecology and environment
Course objective	• The general objective of the subject is to provide theoretical and methodological knowledge of different fields of biotechnology and its environmental applications. • To make the students to understand the concepts of ecology and the role of microorganisms in biogeochemical cycles and the importance of microbial diversity in environmental microbiology and biotechnology. • Introduce the student to various technologies of biotechnology for protection of the environment including detection of pollutants, bioremediation of toxic wastes, development of environment friendly products with an emphasis to cleaner and sustainable environment.

Course outcome	• Comprehensible understanding of concepts related to our environment, ecological relationships, • They will learn about pollution and remedial measures for the conservation of natural resources and environment and application of biotechnology for the same • An overall awareness related to environmental issues and vitalindicationon individual roles and responsibilities as consumers towards the interlinked global environment

Course contents:

UNIT I: [5 L]

Ecology and ecosystem, Ecological pyramid, Food web, Food chain, Microbial interactions, water, carbon, nitrogen, phosphorus and sulphur cycles, Eutrophication, Global warming

UNIT II: [6 L]

Environmental (water, soil and air) pollution, noise and thermal pollution, Inorganic and Organic contaminants: their sources and toxic effects, Bioaccumulation, Biomagnification,

UNIT III: [10 L]

Biological Wastewater treatment, Anaerobic digestion, Bioremediation, Biodegradation of organic compounds, Phytoremediation, Solid waste management: Landfills, composting, vermicomposting, Bioleaching

UNIT IV: [9 L]

What is Climate and what is Climate Change? Ecological footprint; Greenhouse gases, Impact of climate change, Intergovernmental Panel on Climate Change (IPCC): Definition of Impacts, Adaptation and Mitigation; Climate Change Policy of India. Earth summit, Kyoto protocol, Framework convention on Climate change (UNFCCC), Climate Change -Integrated strategies for Biodiversity Conservation, environmental laws and policies

Text/reference Books:

- Environmental Microbiology by W.D. Grant and P.E. Long., Blakie, Glassgow and London.
- Manual of Environmental Microbiology by Cristian J.Hurst and Ronald L.Crawfold., ASM press.
- Wastewater Engineering, Treatment, Disposal and Reuse by Metcalf and Eddy, Tata Mc Graw Hill.
- Environmental Biotechnology by Foster C.F., John Ware D.A., Ellis Horwood Ltd.
- Environmental Biotechnology by Bruce Rittmann and Perry McCarty
- Biotechnology and Biodegradation, Advances in applied biotechnology series, by Kamely.D., Chakrabarty K and Omen G.S, Gulf publishing company.
- Standard Methods for the Examination of Water and Waste Water. American Public health Association

"Introduction to modern climate change" by Andrew Dessler, Cambridge University Press, 2012.

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1				✓	✓		
CO2			✓	✓	✓		
CO3			✓		✓	✓	

Semester	5
Course Name	NANOBIOTECHNOLOGY
Course Code	BTXXXX
Credits	03
Contact hours/ week	3-0-0 (LTP)
Prerequisite	Basic knowledge of chemistry, physics, biotechnology (biomolecules, human physiology).
Course objective	• This course aims to impart a fundamental knowledge of different nanomaterials and their properties. • It would develop an understanding of various techniques to be employed for nanoparticle characterization and the ways in which nanoparticles can be employed for biological applications.
Course outcome	• The students are expected to differentiate between bulk and nanoscale materials. Students may use the theoretical knowledge gained to engineer novel nanostructures with unique properties. • would explore their intelligence to utilize the synthesized nanostructures for novice applications.

Course contents:

UNIT I: **[5 L]**

Properties, synthesis and characterization techniques of nanomaterials, surface biology, Force spectroscopy, Surface enhanced Raman scattering, Surface plasmon resonance

UNIT II: **[6 L]**

Nanobiotechnology in drug discovery, Nanodelivery systems for drugs and vaccines, Nanomedicine, Pharmacogenomics and nanotechnology.

UNIT III: **[6 L]**

Self- assembly of DNA nanostructures, DNA template electronics, DNA based metallic nanowires and networks, DNA-gold nanoparticle conjugates, Nanosensors and Lab on chip devices

UNIT IV: **[6 L]**

Luminescent quantum dots for biological labeling, Protein based nanostructures, Engineered nanopores, Green synthesis of nanomaterials, Magnetosomes and bacteriorhodopsin, Polymer nanocontainers, Nanobiotechnology in agriculture for management of pesticide residue.

Text/Reference Books:

- Nanobiotechnology: Concepts, Applications and Perspectives by Christof M. Niemeyer and Chad A. Mirkin, Wiley-VCH.
- Nanotechnology: A gentle introduction to the next big idea by Ratner, M.Ratener, D.
- Bionanotechnology: Lessons from Nature by David S. Goodsell, John Wiley and Sons.

Introduction to Nanotechnology by Charles P. Poole, Frank J. Owens, John Wiley and Sons, Inc.

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1						✓	✓
CO2				✓		✓	
CO3							

Semester	5
Course Name	PHARMACEUTICAL BIOTECHNOLOGY
Course Code	BTXXXX
Credits	03
Contact hours/ week	3-0-0 (LTP)
Prerequisite	
Course objective	• Understanding the importance of biotechnology in the pharmaceutical Industries • Importance of biotechnology in producing immune components such as monoclonal antibodies in Industries • Learning the use of microorganisms and fermentation technology in pharmaceutical industry
Course outcome	• This course would be beneficial for the students who desire to opt R&D as their career. • This will ease their efficiency to achieve a scientific objective. • Learn to use academic knowledge to apply in Industry

Course Contents:

UNIT I: **[6 L]**
Physical, surface, colligative and flow properties of drug molecules, quality assessment of the drugs and dosage forms.

UNIT II: **[6 L]**
Equilibrium processes and physicochemical properties of drugs, principles of chemical kinetics to drug stability, factors affecting drug stability, drug diffusion, drug dissolution, absorption, bioavailability, kinetics of drug release

UNIT III: **[10 L]**
Drug manufacturing, dosage forms and drug delivery systems, solid dosage forms: powders, capsules, tablets, manufacture of tablets, Liquid dosage forms: solutions, suspensions, emulsions; Aerosol dosage forms; Semisolid dosage forms: ointments, creams, gel etc.

UNIT IV: **[8 L]**

Quality assurance and quality control; packaging, storage and labelling, Different drug release profile

Text/Reference Books:

- Walsh Gary. Pharmaceutical Biotechnology – Concepts and Applications. Wiley, Chichester, West Sussex, UK; 2007. p. 48.
- J.M. Walker and E.B. Gingold: Molecular Biology and Biotechnology by Royal society of Chemistry.

Course outcome and Program outcome mapping:

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓	✓		✓			
CO2				✓	✓		
CO3				✓	✓		

SEMESTER VI

Semester	6
Course Name	PLANT BIOTECHNOLOGY
Course Code	BTXXXX
Credits	04
Contact hours/ week	3-0-2 (LTP)
Prerequisite	Nil
Course objective	• To understand the relevance, basic concepts and functions of plants and plant systems. • To familiarise the students with techniques of manipulating the plant genome and the application of these techniques in crop improvement and gene transfer and health management.
Course outcome	• Distinguish plant culture techniques and culture types. • Evaluate several methods for stable and transient plant transformation. • Design strategies for plant genetic manipulation Designing of new plant idiotypes plant for resilience environments. • Understanding of basic and advance strategies to increase plant yield and fruit/seed quality.

Course contents:

UNIT I: **[9L]**

Plant cells and cellular organs and its functions**,** Special features and organization of plant cells, genetics and evaluation of crop plant.

UNIT II: **[5L]**

Advances in plant tissue culture techniques: Plant tissue culture laboratory and media, Cell culture, organogenesis, embryogenesis. Regeneration, production, preservation and selection of plant cells.

UNIT III: **[7L]**

Anatomy and physiology of plants and climatic change conditions: Morphogenesis and organogenesis in plants, transport and translocation, photosynthesis, respiration and photorespiration. Secondary metabolites production and plant stress physiology.

UNIT IV: **[9L]**

Plant Genetic Engineering: Plant genomes organization, techniques for plant transformation: *Agrobacterium* mediated, physical methods of gene transfer. CRISPR/Cas9 based genome editing in plant, Genes and traits modification in crop plants. Biotic and a biotic resistance plants. Bio fortification of crop plant. plants. Chloroplast transformation and production of useful products, Improvement, yield and quality in crop plants

Laboratory:

1. Aseptic culture techniques for establishment and maintenance of media and cultures.
2. Production of callus from different tissues of plant.
3. Production of somatic hybrid protoplasts techniques.
4. Micro propagation of economic impotent plants.

5. Study of abiotic resistant of plant by single cell and pot culture methods.
6. Cytological examination of somatic and zygotic tissue of plants.
7. Isolation and purification of genomic DNA.
8. Performance of Agrobacterium mediated gene transformation in plant.
9. Screening and diversity analysis of different plant accessions by PCR and restriction digestion techniques.
10. Introduction of genome editing: CRISPR/Cas9 delivery methods in plant.

Text /Reference Books:

- Plant Biotechnology: The genetic modification of plants, by Andrian Slater, Nigel W, Scott, and Mark R. Fowler (2nd Ed.) Oxford University Press Inc.New York
- Plant tissue culture: Theory and Practice by S.S. Bhojwani and M.K. Razdan Elsevier,
- Amsterdam.
- Plant Genomics and Proteomics by C.A. Cullis. John Wiley and Sons, New York.
- Plant Functional Genomics by E. Grotewold. Humana Press, Totowa.

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1		✓			✓	✓	
CO2					✓	✓	✓
CO3							

Semester	6
Course Name	MOLECULAR AND CELL DIAGNOSTICS
Course Code	BTXXXX
Credits	03
Contact hours/ week	3-0-0 (LTP)
Prerequisite	Cell biology, Biochemistry and Molecular Biology
Course objective	• Diagnostic tests are quintessential for diagnosis, prognosis, treatment and monitoring the progression of a disease. • Students are required to gain knowledge about testing a hypothesis on various diagnostic parameters, development of a new diagnostic tool, upgrading an existing diagnostic tool and drawback of a diagnostic tool.
Course outcome	• The course will help students in acquiring knowledge regarding current needs of diagnostic industry. • The expected outcome of the course is to generate curiosity and inclination to orient their interest towards pursuing research in healthcare diagnostics and contribute by bringing innovative solutions to the emerging problems.

Course contents:

UNIT I: [6L]

Specimen collection (blood, urine, spinal fluid, saliva, synovial fluid and amniotic fluid) and preservation. Principle of diagnostic enzymology, Liver function test, cardiac function test, renal function test, thyroid function test.

UNIT II: **[8L]**

Cytodiagnosis, Karyotyping, Disease detection using specialized staining methods, immunohistochemistry and its application in evaluation of cancer, CD markers, Flow cytometry, tissue in-situ hybridization, tissue microarrays.

UNIT III: **[8L]**

DNA based diagnostic approaches, PCR and Q-PCR based diagnosis of diseases, mutation detection system, fluorescent insitu hybridization, DNA microarrays, spectral karyotype imaging, comparative genome hybridization, aptamers in diagnosis.

UNIT IV: **[8L]**

Biomarker in disease diagnostics, Approaches and methods for identification of a marker, Predictive value, diagnostic value, Role of genomic, proteomics and bioinformatics tools in biomarker discovery and evaluation, Catalytic nanostructures as probes for diagnostics, Nanoparticle based single cell/molecule detection, Plasmonic nanomaterials based sensing. Rise of diagnostic industry in Indian and global scenario

Textbook and References:

• Advanced techniques in diagnostics cellular pathology by Marry Hennon-Fletcher and Perry Maxwell, Wiley-Blackwell.
• Molecular diagnostics: for the clinical laboratorian by William B. Coleman and Gregory J. Tsongalis
• Molecular diagnostics by George P. Patrinos and Wilhelm Ansorge
• Commercial Biosensors by Graham Ramsay., John Wiley and Son, INC.
• Diagnostic microbiology by W. R. Bailey, E. G. Scott and C. V. Mosby.
• Fundamentals of clinical chemistry by W.B. Saunders and Carl A. Burtis.

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓	✓	✓				
CO2	✓	✓	✓	✓		✓	
CO3							

Semester	6
Course Name	ANIMAL BIOTECHNOLOGY AND CELL CULTURE TECHNOLOGY
Course Code	BT-1603
Credits	04
Contact hours/ week	3-0-2 (LTP)
Prerequisite	FUNDAMENTALS OF BIOTECHNOLOGY, HUMAN PHYSIOLOGY
Course objective	• To learn about basic and potential applications of animal biotechnologies. • To create awareness about public and ethical concerns over the use of animal biotechnology • To familiarize the techniques involved animal biotechnology and to provide theory and particle sessions of biotechnology.
Course outcome	• Describe the biotechnologies available for application in industries or disciplines that involve animals • Explain the potential applications of current or developing biotechnologies to these animal related fields. • Evaluate and discuss public and ethical concerns over the use of animal biotechnology

Course content:

UNIT I: Introduction of animal cell culture [8L]

Basic principles of animal cell culture, basic requirements for setting up of animal cell laboratory. Safety, ethical issues, norms and guidelines for handling animal cells.
Media for culturing cells and tissues; serum free and serum based media, primary and secondary cell cultures, steps in establishing primary cell culture, characteristics of continuous cell lines, development and their maintenance of cell lines, scaling-up of cell cultures.

UNIT II: Cryopreservation, Quantitation and cytotoxicity [7L]

Need of cryopreservation, cell banks, transporting cells, steps involved in cryopreservation of cell culture, thawing of frozen cell culture. Various methods of cell quantitation-hemocytometer, electronic cell counting, quantitation by measuring total DNA and protein content, cytotoxicity assessment in cell cultures- viability assessment by dye exclusion and dye uptake test, MTT based cytotoxicity assay, clonogenic survival assay.

UNIT III: Micromanipulation of embryos & Transgenic animals [10L]

Introduction, basics and methodology of micromanipulations. Composition of IVF media, steps involved in IVF, fertilization by micro-insemination.

Concept of transgene and transgenic animals, gene transfer approaches for producing transgenic animals- pronuclear microinjection method, embryonic stem cell method, retroviral vector method, homologous recombination for producing knock-in and knockout mice, sperm mediated DNA transfer. Importance and applications of transgenic animals, study of model transgenic animals

UNIT IV: Industrial application of animal cell culture [5L]

Market existing cell culture product, different medical applications for cell culture including expression system, therapeutics etc.

Text/Reference Books:

- Culture of animal cells: a manual of basic technique by R. Ian Freshney., Wiley-Liss.
- Animal Cell Culture by John R.W., Masters Oxford University Press.
- Introduction to Cell and Tissue Culture by Jennie P. Matcher and Penelope E. Roberts.,
- Plenum Press, New York and London.
- Molecular Biotechnology by Primrose.
- Animal Cell Biotechnology by R.E. Spier and J.B. Griffiths, Academic press.
- Animal Biotechnology by Ranga M.M, Agrobios India Limited.

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1		✓		✓			
CO2				✓			
CO3				✓		✓	

Semester	6
Course Name	DRUG DESIGN AND DELIVERY
Course Code	BTXXXX
Credits	03
Contact hours/ week	3-0-0 (LTP)
Prerequisite	Nil
Course objective	• To Develop your knowledge and understanding of how drugs and medicines are made and used safely • To give detailed information transporting a pharmaceutical compound in the body as needed to safely achieve its desired therapeutic effect.
Course outcome	• To provide knowledge of various approaches, formulations, techniques in drug designing • To provide indepth understanding of systems for transporting a pharmaceutical compound in the body as needed to safely achieve its desired therapeutic effect with suitable drug delivery. • Vaccine delivery and different mode of application approach for clinical use.

Course Contents:

UNIT I: **[7 L]**

Introduction to the Drug Discovery and Development, Source of Drugs: Plant, Animal and microorganism. Structural effects on drug action: Sequence of events after drug administration, Physico-chemical properties that are related to drug action, Role and types of chemical bonding involved in drug-target interactions, Agonist and Antagonist.

UNIT II: **[6 L]**

Preclinical development. Clinical trials, Patenting and ethical issues

UNIT III: **[9 L]**

Approaches and Principles to Drug Design: Rational drug designing, structure based drug designing, Molecular Recognition, Receptor Based drug designing, ligand based drug designing, molecular docking, QSAR, ADMET, Combinatorial Library and High throughput Screening.

UNIT IV: **[9 L]**

Computer-Aided Drug Design: Lead Optimization and Computer-Aided Drug Design, Overview of Ligand-Based and Structure-Based Design, Viewing Tools and Graphics Tools, pharmacophore modelling, virtual screening, molecular docking and scoring,

Examples and mechanisms of drug action: Antihypertensive, antiviral, anticancer, antibiotics and antifungal drugs

Reference/ Text Books

Comprehensive Medicinal Chemistry (Vols. I-VI) by C. Hansch

• Design of Enzyme Inhibitors as Drugs by M. Sandler and H. J. Smith.

• Computer Aided Drug Design by T. J. Perun and C. L. Propst., Dekker.

• Molecular Modelling Principles and Applications, Longman by A.R Leach

• Molecular Dynamics Simulation Elementary methods by J.M. Haile, John Wiley.

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1			✓			✓	✓
CO2			✓	✓		✓	✓
CO3							

Semester	6
Course Name	STEM CELLS AND TISSUE ENGINEERING
Course Code	BTXXXX
Credits	03
Contact hours/ week	3-0-0 (LTP)
Prerequisite	In various diseases, stem cells therapy and tissue engineering are considered as only modalities of treatment. This is not only important for experimental science but also relevant for students interested in health and diseases. The course requires knowledge of human physiology, immunology, animal cell culture.
Course objective	• To teach the students with basic as well as application of stem cells. • To make the students equipped about the current practices being followed in the field of stem cells research.
Course outcome	• The course will assist the student to get theoretically acquainted with the stem cells and its application. • It would certainly be of help to students who desire to pursue their career in the field of health and disease.

Course content:

UNIT I: [6 L]

Stem cell biology, origin and type of stem cells, niche of stem cells, embryonic stem cells, progenitor cell, precursor cell, adult stem cells, modes of stem cells development, characterization of stem cells, fate mapping of stem cells.

UNIT II: [6 L]

Self renewal, mechanism of self renewal, pluripotency and its molecular mechanism, Checkpoints, and stem cell biology, senescence of dividing somatic cells, LIN-12/Notch/Delta signalling pathway, lateral inhibition, in vitro culture of stem cells, methods of differentiation of stem cells

UNIT III: [8 L]

Stem cell transplantation, safety issues with stem cell transplantation, Approaches to make stem cells transplant safer, Use of stem cells in prevention of autoimmune disease i.e. diabetes type-1, Use of stem cells in prevention of hematological malignancies, Use of stem cells in prevention of neurological disorder i.e. parkinson disease

UNIT IV: [6 L]

Introduction of tissue engineering, Application of stem cells in tissue engineering, general procedure of tissue engineering, extracellular matrix and its applications in tissue engineering, scaffolds for tissue engineering applications.

UNIT V: [8 L]

Application of tissue engineering and its advantage over conventional clinical approaches to tissue dysfunction, Tissue engineering for human skin substitute, Bone tissue engineering, vascular graft, Heart valves, ethical issues, recent advances and entrepreneurship in the field.

Text/Reference Books:

1. Stem cells: Scientific Progress and Future Research Directions, from National Institute of Health USA (2001)

2. The Science of Stem Cells, Author: Jonathan M. W. Slack, John Wiley & Sons, Inc. (2018)

3. Stem Cells: Scientific Facts and Fiction, Authors: Christine Mummery, Anja van de Stolpe, Bernard Roelen, Hans Clevers, Elsevier (2021)

3. Tissue Engineering , Bernhard Palsson and Sangeeta N. Bhatia; Pearson India Education Services Pvt. Ltd., India (2016)

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1		✓		✓			
CO2		✓		✓		✓	
CO3							

Semester	6
Course Name	HUMAN PHYSIOLOGY AND METABOLIC DISORDER
Course Code	BTXXXX
Credits	03
Contact hours/ week	3-0-0 (LTP)
Prerequisite	The prerequisite of the course is that student should know the cell biology.
Course objective	• This course is designed to provide students a basic as well as useful knowledge of human biology. • This will help the students to get acquainted with the basics of functioning of various organs of human body. • It is also important for them to understand the functioning of a multicellular system (organs).
Course outcome	• This course will assist them to build up their knowledge about organ system and their function(s). • This will make them well competent to understand advanced biotechnology, particularly in the field of health and diseases in coming semesters.

Course Contents:

UNIT I: **[5 L]**

Introduction to human body: Organization of body, The musculoskeletal system, Skin: Epidermis and dermis, The internal environment and homeostasis, negative and positive feedback mechanism(s), Outline of various systems, body fluid.

UNIT II: **[10 L]**

The communication system-I: Blood and its composition, Circulation, Blood vessels, Control of blood vessels diameter, Capillary exchange, Heart and its structure, The cardiac cycle, blood pressure and its control, The lymphatic system, Structure and function of neurons, Central and peripheral nervous system, Brain and spinal cord, Cerebrospinal fluid; The special senses: ear and eye, The endocrine system

The reproductive systems: Male and female reproductive systems, gross structure, different parts and their functions, fertilization; diseases of reproductive system

UNIT III: **[7 L]**

Intake of raw materials and elimination of waste: The respiratory system: Organization, Bronchi and bronchioles, Alveoli, Respiration and exchange of gases, Control of respiration; Digestive system: gastrointestinal tract, organs of digestive system; Digestion and absorption of nutrient, The urinary system: Structure of kidneys and its function, water balance and urine output, Electrolyte balance

UNIT IV: **[8 L]**

Diseases and their molecular pathology: Disorders of muscle Dystrophies and Myopathies; Disorders of Haemopoitic systems Sickle cell anemia, Thalassemias and Hemophilias; Disorders of eye Retinitis pigmentosa, Cataract, Glaucoma; Multifactorial diseases Hyperlipidemia, Atherosclerosis, Diabetes mellitus and Mitochondrial syndromes; Metabolic diseases Phenylketonuria, Mucopolysaccharidosis

Text/Reference Books:

- Ross and Wilson Anatomy And Physiology In Health And Illness (13th Edition), Authors: Anne Waugh & Allison Grant , Elsevier (2018)

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓	✓		✓			
CO2		✓		✓	✓		
CO3							

Semester	6
Course Name	BIORESOURCE MANAGEMENT, SUSTAINABLE DEVELOPMENT AND BIOECONOMY
Course Code	BTXXXX
Credits	03
Contact hours/ week	3-0-0 (LTP)
Prerequisite	Ecology and environment
Course objective	• understand the fundamental concepts of bioresource, biodiversity and its conservation • develop knowledge and critical thinking on to assess the benefits, and challenges of bioresources, and bioprospecting in today's bioeconomy • Develop the concept of the Sustainable Development Goals and its importance in management of bioresource in sustainable way today's economy
Course outcome	• Students attending the course will possess knowledge, expertise, and analytical skills to deal with the sustainability aspects of bioresource management • Demonstrate deeper insight into current research practice and methodologies in the field of bioresource technology, biodiversity conservation and management for sustainable development • Students will acquire knowledge on the agricultural. • Students will be able to critically examine the 17 Sustainable Development Goals and how to achieve it in practice.

Course contents:

UNIT I: **[10L]**

Bioresources concept and definition, Microbial resources: forms and their importance in business application by the industry. Marine bioresources-management and utilization of marine bioresources-types. Plant resources – medicinal plants, Biodiversity in India, Loss of Biodiversity, Conservation of Biodiversity, National policies

UNIT II: **[6L]**

Organic farming and sustainable use of natural and bioresources, organic standards and certification of organic produce and products, biological control, global initiatives on future prospects.

UNIT III: **[6L]**

Bioprospecting for food, feed, health care and other products. Indigenous knowledge and bioprospecting, Bioprospecting of Extremophiles. Ethnobiology

UNIT IV: **[8L]**

Sustainable Development Goals (SDGs), Bioresources and bioeconomy, Industrialization and its impacts, societal impacts, Sustainable bioresource management, ethics of sustainable utilization

Text/Reference Books:

- Biodiversity: New leads for the pharmaceutical and agrochemical industries by S.K., Hayes M.A., Thomas R, Chrystal E.J.T. and Nicholson L. Royal Society of Chemists., Wrigley
- Biological and Biotechnological Resources by G Tripathi and Y.C. Tripathi., Campus Books International.
- King, A., H. Cleveland and G. Streatfeild. 1980. Bioresources for development: The renewable way of life. Pergamon Press.
- "Sustainability: multi-disciplinary perspectives" by Heriberto Cabezas& Urmila Diwekar (eds.), Bentham Science Publishers, 2012
- Rogers, Peter P., Kazi F. Jalal, and John A. Boyd. 2007. An Introduction to Sustainable Development. Earthscan.

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1		✓			✓		
CO2		✓		✓	✓	✓	
CO3	✓			✓	✓		

Semester	6
Course Name	DOWNSTREAM PROCESSING
Course Code	BTXXXX

Credits	03
Contact hours/ week	3-0-0 (LTP)
Prerequisite	Basics of Bioprocess Engineering
Course objective	• To understand the concept of RIPP of downstream processing • To demonstrate the recovery methods for the purification of bio-products • To identify the purity of the desired bio products and product polishing and packaging methods
Course outcome	• Understand the concept of downstream processing for biochemical product recovery • To determine the qualitative and quantitative purity of a product • Design and evaluate the purification strategy of a biological product • Understand the critical regulatory and validation guidelines for successful bioseparation

Course contents:

UNIT I: [6 L]

Introduction and Recovery: Importance of DSP in biotechnology, Concept of Recovery, Isolation, Purification and Polishing (RIPP), Criteria for selection of bio-separation techniques; Pretreatment, coagulation and flocculation; Microfiltration; Centrifugation; Cell disruption.

UNIT II: [9 L]

Isolation: Precipitation; Dialysis; Solid Liquid extraction, Adsorption, Batch adsorption, Liquid-Liquid extraction, Reversed micellar and aqueous two phase extraction.

UNIT III: [10 L]

Product Purification and Polishing: Chromatography, HPLC, GC; Ultrafiltration and Electrophoresis, Crystallization; Distillation and Drying.

Unit IV: [5 L]

Regulations for DSP: Concept of Quality by Design (QbD) and Process Analytical Technology (PAT) by FDA, Critical Quality Attributes (CQA), Applications of QbD and PAT for DSP in biotech industry.

Text/ Reference Books:

1. Bioseparations: Downstream Processing for Biotechnology by Paul A. Belter (Author), E. L. Cussler (Author), Wei-Shou Hu (Author); Wiley-Interscience
2. Principles and Techniques of Biochemistry and Molecular Biology by KeithWilson and JohnWalker; Cambridge University Press
3. Bioprocess Engineering Principles by Pauline M. Doran; Elsevier Science & Technology Books
4. Biochemical Engineering And Biotechnology Ghasem D. Najafpour; Elsevier Publication
5. Process Validation in Manufacturing of Biopharmaceuticals by Anurag S. Rathore and Gail Sofer; CRC Press

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1		✓	✓				
CO2			✓				
CO3					✓	✓	

Semester	6
Course Name	MICROBIOME IN HEALTH
Course Code	BTXXXX
Credits	03
Contact hours/ week	3-0-0 (LTP)
Prerequisite	Microbiology, biochemistry, introductory cell and molecular biology
Course objective	• The course will introduce students with basic composition of the human microbiome, its impact on functioning of human body and related disorders/ diseases. • Also, students shall learn about the application of the microbiome in management of diseases and development of relevant potential therapies.
Course outcome	• The course will offer a thorough understanding of the composition and diversity of human microbiome • They shall develop critical concepts of the effect of microbiome on human body and interactions between them. • The course will help them understand the relation between the two and application of microbiome in developing diagnostics techniques and therapeutic approaches

Course Contents:

UNIT I:

Introduction to human microbiome: gut microflora, dental microflora, skin microflora; microflora of mucosal lining etc. and their significance. Holobiont/ superorganism concept.

UNIT II:

Interactions between the microflora and cell/ tissues: metabolites produced by microflora and their impacts on human; factors effecting the composition and diversity of microbiome, nutritional modulation etc.

UNIT III:

Diseases caused due to change in the microbiome; application of the microbiota in diagnostics and therapeutics like

UNIT IV:

Basic and advance and techniques to study the microbiome: including culture techniques, metagenomic techniques, metabolite detection, microfluidics etc.

Text/ Reference Books

- Human Microbiome, Natalia V. Beloborodova, Andrey V. Grechko, Miroslav Blumenberg, UntechOpen publications, London, UK

- Human Microbiome in Health and Disease - Part A, Bhabatosh Das, Vijai Singh, Elsevier
- Human Microbiome in Health and Disease - Part A, Bhabatosh Das, Vijai Singh, Elsevier
- The Role of Dietary Interventions in The Regulation of Host-Microbe Interactions, Zongxin Ling, Tingtao Chen, Yuan Kun Lee, Qixiao Zhai, Xinglin Zhang, Frontiers Media SA.
- Bacteria and Bacterial Metabolites: Molecular Interplay with Gut Immunity, Jun Fang, Yongguo Cao, Ganwu Li, Qiyuan Yang, Frontiers Media SA

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1		✓		✓		✓	✓
CO2		✓		✓		✓	✓
CO3		✓		✓			

Semester	6
Course Name	MODERN AGRICULTURAL BIOTECHNOLOGY
Course Code	BTXXXX
Credits	03
Contact hours/ week	3-0-0 (LTP)
Prerequisite	Basic knowledge of chemistry, physics, biotechnology (biomolecules, human physiology).
Course objective	• To learn what forms of technology are used in Modern Agriculture • Know about Resilient crops developed via use of biotechnology. • To gain knowledge on Improving farm yields and supply chain management use Big Data.
Course outcome	• To identify and overcome the problems encountered in day-to-day agriculture. • To provide extensive knowledge on agri-allied sectors like livestock, Poultry. • To give detailed knowledge about agri-allied sectors and to disseminate recent agricultural technologies through new communication tools.

Course contents:

UNIT I: **[7 L]**

Modern agriculture in India: Traditional and modern agricultural practices. Use of modern tools and techniques for advancement of agriculture. Farming-as-a-Service and industries.

UNIT II: **[8 L]**

Information-Based Agro Tech: Technologically-advanced infrastructure and smart systems, Internet of Things (IoT) sensors and analytics, Big Data-led innovation management. Image base information collection and application for diagnostic of plant disease. Sensing for precision agriculture: Development of intelligent *sensors*, climate *sensors* and management *sensors for farm data monitoring.*

UNIT III: **[7 L]**

Advanced Farming Techniques: Uses new techniques to increase farm profitability in agriculture, horticulture, and aquaculture, Vertical Farming, Hydroponic. Irrigation and storage. Minimized the use of synthetic fertilizers.

UNIT IV: **[8 L]**

Trends in Agritech Innovation: Start-up momentum in agriculture, business opportunities and innovative solution. Government schemes and initiatives in agriculture**,** Supply chain models for dairy and horticulture products. Biovillage, Climate resilient Villages

Reference/ Text books

- Biodiversity: New leads for the pharmaceutical and agrochemical industries by S.K., Hayes M.A., Thomas R, Chrystal E.J.T. and Nicholson L. Royal Society of Chemists., Wrigley.
- Biological and Biotechnological Resources by G Tripathi and Y.C. Tripathi., Campus Books International.

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1			✓				
CO2			✓	✓			
CO3						✓	✓

Semester	6
Course Name	EMERGING INFECTIOUS DISEASES
Course Code	BTXXXX
Credits	03
Contact hours/ week	3-0-0 (LTP)
Prerequisite	Microbiology
Course objective	• To develop an understanding about emerging infectious diseases and their pathology. • To learn about effective prevention and control of emerging infectious diseases. • To develop a sense of preparedness among students against any new emerging infectious diseases.
Course outcome	• The students will be having basic understanding about the emerging disease • They will gain knowledge about disease etiology, epidemiology, their prevention and control and treatment approaches. • This course will enable students to have a sense of preparedness towards infectious diseases and contribute in their management

Course contents:

UNIT I: **[6 L]**

Definition of emerging or emerged infectious diseases, causes of their emergence, factors in the emergence or re-emergence of infectious diseases, Modes of transmission, prevalence and incidence rates, general measures for

infection control

UNIT II: **[8 L]**

Re-emergence of viral infectious diseases: HIV, Hepatitis, Dengue, Chieckengunia etc., epidemiology, their transmission and factors responsible for their prolonged stay/emergence in society, clinical manifestation and their diagnosis, pathology and immune response, general measures for prevention and control, chemotherapy

UNIT III: **[8 L]**

Newly emerged viral infectious diseases: Ebola, NIPAH, Influenza, SARS, COVID etc., clinical manifestation and their diagnosis, their transmission and factors responsible for their prolonged stay/emergence in society, clinical manifestation and their diagnosis, pathology and immune response, general measures for prevention and control, chemotherapy

UNIT IV: **[8 L]**

Emerging bacterial infectious diseases: Clostridium sps. infection, drug resistant tuberculosis etc. epidemiology, transmission, factors are involved in disease pathogenesis, clinical manifestations and diagnosis, preventive and infection control measures, general immune response, therapy

Other emerging infectious diseases, causative agents: fungi and parasites, epidemiology, transmission, Clinical Manifestations and diagnosis, Preventive and Infection Control Measures, general immune response, therapy

Text/ Reference Books:

- Emerging Infectious Diseases, Ed. OnderErgonul, Fusun Can, Murat Akova and Lawrence Madoff, Academic Press (2014)
- Emerging Infectious Diseases, a peer reviewed journal published monthly by the Centre for Disease
- Control and Prevention, https://wwwnc.cdc.gov/eid/about/general

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓			✓		✓	
CO2				✓		✓	
CO3				✓		✓	

Semester	6
Course Name	ALGAL BIOTECHNOLOGY
Course Code	BTXXXX
Credits	03
Contact hours/ week	3-0-0 (LTP)
Prerequisite	
Course objective	• Looking at the present scenario of food and clean water crisis, global warming and also the declining health of the most intelligent species on earth (Homo sapiens) the objective of algal biotechnology course is to create awareness and build knowledge among students about the potential role of algae in different field like medicine, nutraceutical and bioremediation or environment restoration.
Course outcome	• Students would have basic understanding about the versatile nature of algae • Enhance knowledge its potential use in different environmental and food industrial sectors. • Enhance knowledge its potential use in different medicinal industrial sectors

Course Contents:

UNIT I: [6L]

Introduction to algae: What are algae, its organelles, structure and composition of algal cell membrane and cell wall. Pigments in algae such as chlorophyll, carotenoids, and phycobiliproteins. Algal exopolysaccharide and its importance. Growth conditions required for algal growth. Photosynthesis in algae.

UNIT II: [6L]

Algal biotechnology: Commercial utility of algae, Large-scale production algae, Algal-production systems, Algal growth curve, strain selection, different media used for algal growth (e.g., BG11). Scale-up strategies. Different bioreactors (photobioreactors, and open pond bioreactor) used for the production of algal-based products such as Vitamins, Proteins, and pigments. Algal immobilization and its applications**.**

UNIT III: [6L]

Economical importance of algae: Economically and industrially important algae. Use of following algae: Chlorella, Spirulina, Dunaliella, Sargassum, Botryococcus, Turbinaria, Laminaria, Ulva, Porphyra and Gracilaria and Gelidium.

UNIT IV: [10L]

Application of algae: Algal engineering for Bioenergy (biohydrogen production, biodiesel production and other carbon-neutral biofuels). Algal-based approaches for Bioremediation. Industrial wastewater treatment using microalgae. Biomedical application of microalgae. Nutraceutical products obtained from algae. Role of algae in mitigation of green-house gases (Such as CO2). Blue-green algal-based biofertilizers. Role of algae in nanobiotechnology.

Text/ Reference Books:

- Tiwari A. & Pandey A. Algal Biofuels Natural and Artificial Photosynthesis (2013) Wiley, ISBN 978-1-118-16006-0.
- The Algae World (2019) Netherlands: Springer Netherlands.
- Prospects and Challenges in Algal Biotechnology. (2017). Singapore: Springer Singapore.
- Thajuddin, N., & Dhanasekaran, D. (Eds.). (2016). Algae: Organisms for Imminent Biotechnology. BoD–Books on Demand.
- Integrated Algal Engineering for Bioenergy, Bioremediation, and Biomedical Applications 1st Edition (2022)- Ashfaq Ahmad, Fawzi Banat, HanifaAlBlooshi, Paperback ISBN: 9780323904766, eBook ISBN: 9780323904360.
- Ahmad, A., Banat, F., Alsafar, H., & Hasan, S. W. (2022). Algae biotechnology for industrial wastewater treatment, bioenergy production, and high-value bioproducts. Science of The Total Environment, 806, 150585.
- Sahoo, D., & Seckbach, J. (Eds.). (2015). The algae world. Dordrecht: Springer Netherlands.
- Young, A. T. (1990). Algae and Biotechnology (Vol. 1). US Department of Agriculture, National Agricultural Library.
- Larkum, A., Douglas, S., & Raven, J. A. (Eds.). (2003). Photosynthesis in algae (Vol. 14). Springer Science & Business Media.

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓	✓					
CO2			✓		✓	✓	✓
CO3			✓		✓	✓	✓

Semester	6
Course Name	HEALTH AND NUTRITION
Course Code	BTXXXX
Credits	03
Contact hours/ week	3-0-0 (LTP)
Prerequisite	
Course objective	• This course requires understanding about human food, its metabolic functions, neutraceutical actions and harmful effects on human health.
Course outcome	• To introduce the students to the fundamentals of Nutrition, food and health. • To familiarize them with importance of nutrition during various stages of life. • To impart knowledge regarding etiology and management of nutritional disorders ranging from nutritional deficiencies to life style disorders.

Course Contents:

UNIT I: **[5 L]**

Understanding relationship between food, nutrition and health, Functions of food-Physiological, psychological and social, Balanced diets, nutritional guidelines, nutritional concerns and healthy food choices, food adulteration, Concept of food safety

UNIT II: **[8 L]**

Functions, dietary sources and clinical manifestations of deficiency/ excess of the nutrients, Definition of public nutrition; Etiology, prevalence, clinical features and preventive strategies of undernutrition – and Overnutrition

UNIT III: **[7 L]**

Principles of nutrition care, therapeutic adaptations of the normal diet, nutritional management of Infections and diseases; nutritional management of the life style disorders i.e. diabetes; Food allergy and food intolerance

UNIT IV: **[9 L]**

Maternal health and nutritional status: maternal mortality and issues relating to malnutrition, Malnutrition among new borne, children and aged individuals. Current policies by Government of India to target malnutrition, significant advancement towards elimination of malnutrition, scope of entrepreneurship in health and nutrition, small catering unit and story of successes, home based catering

Text/reference Books:

1. Name-Human Nutrition, Ed./authors: Catherine Geissler, Hilary Powers; Elsevier Health Sciences (2010)

2. Name-Biochemical, Physiological, and Molecular Aspects of Human Nutrition, Ed./authors:Martha H.

Stipanuk, Marie A. Caudill; Elsevier Health Sciences (2018)

3. Name-Textbook of Nutrition in Health and Disease, Ed./authors:KaveriChakrabarty, A. S. Chakrabarty;

Springer publishers (2021)

Course outcome and Program outcome mapping

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓	✓	✓				
CO2	✓	✓	✓				
CO3	✓			✓		✓	

Semester	6
Course Name	METABOLIC ENGINEERING & SYNTHETIC BIOLOGY
Course Code	BTXXXX
Credits	03
Contact hours/ week	3-0-0 (LTP)
Prerequisite	Microbial technology, Bioprocess engineering, Genetic engineering
Course objective	• To provide fundamental knowledge of metabolic engineering and synthetic biology and their applications. • The course will enable the students to think critically and apply the fundamental knowledge for industrial application like biofuels, biomedicine, industrial fermentations and others.
Course outcome	• A fundamental understanding of basic and advance concepts of metabolic engineering and synthetic biology. • Application of metabolic engineering in biological processes in different industries. • To understand possible applications of synthetic biology and related ethical concerns.

Course Contents:

UNIT I:

Metabolic Engineering: introduction and basic concepts and applications, Overview of control and regulation of metabolic pathways

UNIT II:

Thermodynamics and energetic of cellular processes, Stoichiometry of cellular reactions Metabolic flux and its analysis.

UNIT III:

Introduction to synthetic biology, general concepts and applications, ethical considerations.

UNIT IV:

DNA synthesis and assembly, gene circuit connection, construction of synthetic pathways, synthetic regulatory elements

Text/ Reference Books:

- Metabolic Engineering, Principles and Methodologies; G N Stephanopoulos, A A Aristidou, J Nielsen
- Advances in Biochemical Engineering/Biotechnology; Metabolic Engineering, Volume Editor: Jens Nielse
- Systems Metabolic Engineering, Methods and Protocols; H S Alper
- An Introduction to Systems Biology: Uri Alon, Design Principles of Biological Circuits, Chapman & Hall/CRC (2006).
- Eric Davidson, The Regulatory Genome: Gene Regulatory Networks In Development And Evolution, Academic Press (2006).
- Hamid Bolouri, Computational Modeling Of Gene Regulatory Networks - A Primer, Imperial College Press (1st edition) (2008).

Course outcome and Program outcome mapping

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓	✓					
CO2				✓			✓
CO3				✓			✓

SEMESTER VII

Semester	7
Course Name	STARTUP, BIOBUSINESS AND BIO-ENTERPRENEURESHIP
Course Code	BTXXXX
Credits	03
Contact hours/ week	3-0-0 (LTP)
Prerequisite	Nil
Course objective	• To provide information about role of innovation and entrepreneurship opportunities with respect to Biotechnology. • To provide knowledge about business and marketing strategies, documentation and financial management for start-ups working in field of biotechnology. • The course will impart knowledge to students about different entrepreneurship development programmes and start-up opportunities offered by various agencies in India.
Course outcome	• After the completion of the course, the students will be able to explain the biobusiness opportunities. • In addition, the students will also be able to prepare and submit documents for setting up start-ups alongside its marketing strategies and financial management of bio-businesses.

Course contents:

UNIT I: **[7L]**

Innovation and entrepreneurship in bio-business: Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics of the biotech sector, Strategy and operations of biotech sector firms, Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make in India), Commercialization strategies.

UNIT II: **[8L]**

Bio markets: business strategy and marketing: Journey from lab to the market, Pricing strategy, Challenges in marketing in bio business, Basic contract principles, different types of agreement and contract terms typically found in joint venture and development agreements, Dispute resolution skills. Managing technology transfer, Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP).

UNIT III: **[8L]**

Business Plan and Finances: Business plan preparation including statutory and legal requirements, Business feasibility study, financial management. Collaborations & partnership.

UNIT IV: **[7L]**

Start-ups: Startup opportunities, Legal and other requirements for new ventures, Financial Issues of start-ups, Sustainability and growth of startups, Exit strategies. Government Initiatives, Successful start-ups case studies.

Text/Reference Books:

- Small Business Management: Essential Ingredients for Success; Best Business BooksBy Meir Liraz
- "Think" And "Do" in Business and ManagementBy D. Radhakrishnan Nair
- A Textbook of Agri-Business Management By A. C. Broadway, Arif A. Broadway

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1			✓	✓			
CO2			✓	✓			✓
CO3			✓			✓	✓

Semester	7
Course Name	QUALITY ASSURANCE AND REGULATORY AFFAIRS
Course Code	BTXXXX
Credits	03
Contact hours/ week	3-0-0 (LTP)
Prerequisite	Nil
Course objective	• To provide the knowledge about the quality of product with specified requirements • To establish and maintain set requirements for products • To study national and international guidelines and regulatory affairs of studied products or processes
Course outcome	• Explain the importance of three tier documentation and records in quality management system. • Detail the various aspects of manufacturing operations and controls in industry. • Acquire knowledge of intellectual property rights, concept of trade mark, copyright and patents.

Course contents:

UNIT I: [5 L]

Concept and Evolution of Quality Control and Quality Assurance. Good Laboratory Practice, GMP, Overview of ICH Guidelines - QSEM, with special emphasis on Q-series guidelines. Quality assurance unit, protocol for conduct of non-clinical testing, control on animal house, report preparation and documentation.

UNIT II: [6 L]

Definition of cosmetic products as per Indian regulation. Indian regulatory requirements for labelling of cosmetics Regulatory provisions relating to import of cosmetics. Misbranded and spurious cosmetics. Regulatory provisions relating to manufacture of cosmetics – Conditions for obtaining license, prohibition of manufacture and sale of certain cosmetics, loan license, offences and penalties.

UNIT III: [10 L]

Regulatory requirement for product approval: API, biologics, novel, therapies obtaining NDA, ANDA for generic drugs ways and means of US registration for foreign drugs.

UNIT IV: **[9 L]**

Regulations and guidelines for herbal product formulations:

Drugs and Cosmetics Act 1940 and Rules 1945: DPCO and NPPA. Other relevant provisions (rules schedules and guidelines for approval of Drugs & Cosmetics, Biologicals & Herbals, in India)

Optional: Introduction, US cGMP Part 210 and Part 211.EC Principles of GMP (Directive 91/356/EEC) Article 6 to Article 14 and WHO cGMP guidelines GAMP-5; Medical device and IVDs Global Harmonization Task Force(GHTF) Guidance docs.

Text/reference Books

- FDA Regulatory Affairs: A Guide for Prescription Drugs, Medical Devices, and Biologics, Second Edition by Douglas J. Pisano and David S. Mantus
- Good Drug Regulatory Practices: A Regulatory Affairs Quality Manual (Good Drug Development Series, Vol 1) by Helene I. Dumitriu
- Quality Assurance of Pharmaceuticals: A Compendium of Guidelines and Related Materials (v. 1) by WHO
- Industrial manuals

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1			✓			✓	
CO2			✓			✓	
CO3						✓	✓

Semester	7
Course Name	BIOMANUFACTURING-I (Level 2 for Specialization/Level 1 for Minor)
Course Code	BTXXXX/MRXXXX
Credits	04
Contact hours/ week	3-1-0 (LTP)
Prerequisite	Fundamentals of Biotechnology
Course objective	• To give students a theoretical background and working knowledge of the manufacturing on agricultural, food, microbes based products • To enable students for basic biomanufacturing practices in compliance with regulatory guidelines • To develop entrepreneurship and scientific skills to the students in the field of biomanufacturing industries
Course outcome	• Students will have a basic and practical knowledge of the manufacturing on agricultural, food, microbes based products. • Students will know about basic biomanufacturing practices in compliance with regulatory guidelines to use in future • Students will be able to develop entrepreneurship and scientific skills in the field of biomanufacturing industries

Course contents:

Unit I: **[8 L]**

Microbiome for sustainable biomanufacturing, biomanufacturing of food related products, biopolymers as food and food

packaging material, manufacture of plant, animal, microbe based value added products for food industry applications, food fortification (enzymes, vitamins growth factors), additives, preservatives etc

Unit II: **[7 L]**

Biomanufacturing and application of biofertilizers and biopesticides, nano-formulations in agriculture.

UNIT III: **[8 L]:**

Biomanufacturing processes in environment, plastic, textile sectors etc., bioenergy, bioleaching, biosensors for environmental applications, etc.

UNIT IV: **[7 L]**

Biomanufatcuring for sustainable industrial applications, engineering of synthetic metabolic pathways for efficient biomabufacturing, Cases studies.

Text/reference Books:

- Industrial Biotechnology By Debabrata Das, Soumya Pandit. Taylor & Francis
- Industrial manuals

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1			✓			✓	✓
CO2			✓			✓	✓
CO3					✓	✓	✓

Semester	7
Course Name	BIOMANUFACTURING II (Level 2 for Specialization/Level 1 for Minor)
Course Code	BTXXXX/MRXXXX
Credits	04
Contact hours/ week	3-1-0 (LTP)
Prerequisite	Fundamentals of Biotechnology
Course objective	• To prepare students to understand and engineer innovative on biomanufacturing processes including natural, herbal and medicinal products etc • To enable students for basic biomanufacturing practices in compliance with regulatory guidelines • To develop entrepreneurship and scientific skills to the students in the field of biomanufacturing industries
Course outcome	• Students will have a basic and practical knowledge of the biomanufacturing processes including natural, herbal and medicinal products. • students will know about basic biomanufacturing practices in compliance with regulatory guidelines to use in future • students will be able to develop entrepreneurship and scientific skills in the field of biomanufacturing industries

Course contents:

UNIT I: **[8 L]**

Biomaufacturing of animal, plant, microbial products in medicine and health care. Biomaterials for stem cell engineering

UNIT II: **[8 L]**

Study of Natural products as leads for new pharmaceuticals for the following class of drugs a) Drugs Affecting the Central Nervous System b) Anticancer Drugs c) Cardiovascular Drugs: d) Diabetes e) for arthritis and bone disorder(s) f) Digestive and immunity boosters e) anti-infective, anti- biofilms anti-quorum formulations.

UNIT III: **[7 L]**

Biomanufacturing of vaccines, recombinant protein, antibodies etc.

UNIT IV: **[7 L]**

Case studies, future applications and research directions

Text/Reference Books:

- Biomanufacturing by Chander Prakash, Sunpreet Singh, Rupinder Singh, Seeram Ramakrishna, B. S. Pabla, Sanjeev Puri, M. S. Uddin. Springer
- Industrial manuals

Course outcome and Program outcome mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1			✓			✓	✓
CO2			✓			✓	✓
CO3					✓	✓	✓