BIOTECHNOLOGY

2023 Curriculum

B.Tech. Biotechnology – 2023 Batch

Sl. No	Specializations Offered	Type	Credit Distribution
1	**Drug Engineering**	Major/Hons.	**165 credits** as per B.Tech biotechnology curriculum **+ 18 credits** in the Specialization domain from Biotechnology Division
2	**Genome Engineering and Technology**	Major/Hons.	**165 credits** as per B.Tech biotechnology curriculum **+ 18 credits** in the Specialization domain from Biotechnology Division
3	**Artificial Engineering**	Minor	**165 credits** as per B.Tech biotechnology curriculum **+ 18 credits** in the Specialization domain from across University

PROGRAM EDUCATIONAL OBJECTIVES (PEOs):

1. Demonstrate knowledge towards sustainable development in Biotechnology meeting the International standards.
2. Exhibit skills in Biotechnological process development, product optimization, commercialization and social application.
3. Establish bioethical practices and ensure awareness on professional codes.

PROGRAM SPECIFIC OUTCOMES (PSOs)

1. Graduates have strong knowledge in the field of biotechnology and applied sciences.
2. Graduates will design and conduct experiments in biotechnology as well as analyze and interpret data.
3. Graduates will use current techniques, skills and modern tools necessary for modeling and design of bioprocesses.

PROGRAMME STRUCTURE

S. No.	Category	Category Code	Credits
1	Humanities and Social Sciences including Management and Entrepreneurship courses	HSMC	15
2	Basic Science Courses	BSC	16
3	Engineering Science courses including workshop, drawing, basics of electrical/mechanical/computer etc.	ESC	14
4	Professional Core Courses	PCC	65
5	Project work, seminar and internship / Product Development in industry or appropriate work place/ academic and research institutions in India/abroad	Project	17/11
6	Professional Elective courses relevant to chosen	PEC	18/24

	specialization/branch		
7	Open subjects – Electives from other technical and /or emerging Courses	OEC	9
8	Mandatory Courses	MC	0
9	Skill based Courses	SBC	6
10	Online Courses	MOOC	5
	Total		**165**

Course components and Credit Structure with Year wise distribution				
Component	I Year	II Year	III Year	IV Year
Humanities, Social Sciences including Management Courses	6	6		3
Basic Science Courses	16			
Engineering Science	11	3		
Programme Core	3	24	27.5	10.5
Professional Electives		3	9	6
Open Electives		3	6	
Mandatory Courses		0	0	
Skill Based Courses	2	2	1	1
Project / Internship/ Mini Projects		1	2	14
MOOC	5			
Total Credits(Regular students)	**38**	**42**	**45.5**	**34.5**

COURSE COMPONENTS

Category 1: Humanities and Social Sciences including Management and Entrepreneurship courses [HSMC]

S.No.	Course Code	Course Title	Hours per week			Credit
			L	T	P	
1.	23MS2001	Concepts and Applications in Entrepreneurship	3	0	0	3
2.		Technical Communication English/French/German/Spanish	2	0	0	2
3.	20MS2005	Soft Skills	1	0	0	1
4.	23BT2011	Entrepreneurship Product Development	3	0	0	3
5.	19CS2012	Artificial Intelligence for Biotechnology	3	0	0	3
6.	20BT2057	Bioethics, IPR and Biosafety	3	0	0	3
		Total Credits				**15**

Category 2: Basic Science Courses [BSC]

S.No.	Course Code	Course Title	Hours per week			Credit
			L	T	P	
1.	22MA1001	Basic Mathematics and Numerical Computing using Python	2	0	2	3
2.	20PH1017	Applied Physics for Biotechnology Engineering	2	0	2	3
3.	20BT2001	Chemistry of Biomolecules	3	0	0	3
4.	20BT2002	Chemistry of Biomolecules Laboratory	0	0	2	1

5.	20MA2009	Probability, Statistics using R programming	2	0	2	3
6.	22BT2071	Good Manufacturing and Laboratory Practices	3	0	0	3
		Total Credits				**16**

Category 3: Engineering Science courses including workshop, drawing, basics of electrical/mechanical/computer etc.[ESC]

S.No.	Course Code	Course Title	Hours per week			Credit
			L	T	P	
1.	20EE1003	Sensors and Measurement Techniques in Biotechnology	2	0	2	3
2.	20CS1003	Fundamentals of Programming for Problem Solving	3	0	2	4
3.	20BT2004	Workshop Practices in Biotechnology	0	0	2	1
4.	20BT1002	Basics of Python Programming	2	0	2	3
5.	20BT2015	Bioprocess Principles	3	0	0	3
		Total Credits				**14**

Category 4: Professional Core Courses [PCC]

S.No.	Course Code	Course Title	Hours per week			Credit
			L	T	P	
1.	20BT2003	Cell Biology	3	0	0	3
2.	20BT2005	Basics of Industrial Biotechnology	3	0	0	3
3.	20BT2009	Biochemistry	3	0	0	3
4.	20BT2007	Bio-analytical Techniques	3	0	0	3
5.	20BT2011	Microbiology	3	0	0	3
6.	20BT2012	Microbiology Lab	0	0	3	1.5
7.	20BT2010	Biochemistry Lab	0	0	3	1.5
8.	20BT2008	Bio-analytical Techniques Laboratory	0	0	3	1.5
9.	20BT2017	Molecular Biology	3	0	0	3
10.	22BT2072	Metabolic Engineering	3	0	0	3
11.	22BT2075	Bioprocess Lab	0	0	3	1.5
12.	20BT2018	Genetic Engineering	3	0	0	3
13.	22BT2074	Bioprocess Engineering	3	0	0	3
14.	20BT2025	Immunology	3	0	0	3
15.	20BT2059	IoT in Biotechnology	2	1	0	3
16.	20BT2026	Cell Biology and Immunology Lab	0	0	3	1.5
17.	20BT2019	Molecular biology and Genetic Engineering Lab	0	0	3	1.5
18.	22BT2073	Cheminformatics and Medicinal Chemistry	2	1	0	3
19.	20BT2068	Principles of Plant Biotechnology and Applications	3	0	0	3
20.	20BT2069	Advances in Animal Biotechnology	3	0	0	3
21.	20BT2052	Plant and Animal Tissue Culture Lab	0	0	4	2
22.	22BT2097	Comprehensive practices	0	0	3	1.5
23.	20BT2023	Downstream processing	3	0	0	3
24.	20BT2054	Environmental Biotechnology	3	0	0	3
25.	20BT2030	Concepts of Bioinformatics	2	0	2	3
26.	20BT2024	Downstream processing Lab	0	0	3	1.5
		Total Credits				**65**

Category 5: Project work, seminar and internship / Product Development in industry or appropriate work place/ academic and research institutions in India/abroad [Project]

S.No.	Course Code	Course Title	Hours per week			Credit
			L	T	P	
1.	ITP2921	Industry Internship-I	0	0	2	1
2.	MP2921	Mini project-I	0	0	2	1
3.	ITP2911	Industry Internship-II	0	0	4	2
4.	MP2911	Mini project-II	0	0	4	2
5.	23BT2999/ 23BT2998	Project	0	0	14	14/8
		Total Credits Required				**17/11**

Category 6: Professional Elective courses relevant to chosen specialization/branch [PEC]

S.No.	Courses	Hours per week			Credit
		L	T	P	
1	Professional Electives – 1	3	0	0	3
2	Professional Electives – 2	3	0	0	3
3	Professional Electives – 3	3	0	0	3
4	Professional Electives – 4	3	0	0	3
5	Professional Electives – 5	3	0	0	3
6	Professional Electives – 6	3	0	0	3
	Total Credits				**18/24**

Category 7: Open subjects – Electives from other technical and /or emerging Courses [OEC]

S.No.	Courses	Hours per week			Credit
		L	T	P	
1	Open Elective 1	3	0	0	3
2	Open Elective 2	3	0	0	3
3	Open Elective 3	3	0	0	3
	Total Credits				**9**

Category 8: Mandatory Courses [MC]

S.No.	Courses	Hours per week			Credit
		L	T	P	
1.	Constitution of India	2	0	0	0
2.	Environmental Studies	2	0	0	0
3.	Indian Knowledge System	2	0	0	0
	Total Credits				**0**

Category 9: Skill based Courses [SBC]

Sl. No	**Course Code**	**Course Name**	**Hours per week**			**Credits**
			L	T	P	
1	23BT2005	Fundamental laboratory practices	0	0	2	1
2	23BT2006	Industrial design and layout	0	0	2	1
3	23BT2007	Medical laboratory practices	0	0	2	1
4	23BT2008	Bioproduct development	0	0	2	1
5	23BT2009	Molecular diagnostics	0	0	2	1

6	23BT2010	Quality control and management	0	0	2	1
		Total Credits				**6**

Category 10: MOOC

S.No.	Courses	Credit
1	The students shall earn 5 credits through online courses between 2nd and 7th semester (both inclusive)	5
	Total Credits	**5**

Professional Electives

S No	Course Code	Course Title	Hours per week			Credit
			L	T	P	
1.	22BT2076	Data analysis and simulations	2	1	0	3
2.	22BT2077	Big Data Analytics	2	1	0	3
3.	22BT2078	Biosimilars Technology	3	0	0	3
4.	22BT2079	Waste Management and Upcycling	3	0	0	3
5.	22BT2080	Gene Expression and Transgenics	3	0	0	3
6.	22BT2081	Rational Drug Discovery	2	1	0	3
7.	22BT2082	Precision Medicine and Wellness	3	0	0	3
8.	22BT2083	Nano Biotechnology	3	0	0	3
9.	22BT2084	Structural Biology	3	0	0	3
10.	22BT2085	Synthetic and Systems Biology	2	1	0	3
11.	22EC2028	Fundamentals of bio imaging	3	0	0	3
12.	20BT2043	Stem Cell Technology	3	0	0	3
13.	20BT2058	Tissue Engineering	3	0	0	3
Open Electives						
1	22BT2095	Biomaterials	3	0	0	3
2	22BT2096	Bioterrorism and National Security	3	0	0	3

SEMESTER-WISE CURRICULUM

SEMESTER I (FIRST YEAR)

S. No	Course Code	Course Title	Category	Hours / Week			Credits [L:T:P:C]
				L	T	P	
1		Induction Programme		-	-	-	-
THEORY							
1.	22MA1001	Basic Mathematics and Numerical Computing using Python	BSC	2	0	2	3
2.	20PH1017	Applied Physics for Biotechnology Engineering	BSC	2	0	2	3
3.	20EE1003	Sensors and Measurement Techniques in Biotechnology	ESC	2	0	2	3
4.	20BT2001	Chemistry of Biomolecules	BSC	3	0	0	3
5.	23MS2001	Concepts and Applications in Entrepreneurship	HSMC	3	0	0	3
6.		Mandatory Course- I	MC				0
7.		Technical Communication English/French/German/Spanish	HSMC	2	0	0	2
PRACTICALS							

8.	20BT2002	Chemistry of Biomolecules Laboratory	BSC	0	0	2	1
9.	23BT2005	Fundamental laboratory practices	SBC	0	0	2	1
	Total C						**19**

SEMESTER II (FIRST YEAR)

S.No	Course Code	Course Title	Category	Hours/Week			Credits [L:T:P:C]
				L	T	P	
THEORY							
1.	20BT2003	Cell biology	PCC	3	0	0	3
2.	20MA2009	Probability, Statistics using R programming	BSC	2	0	2	3
3.	20CS1003	Fundamentals of Programming for Problem Solving	ESC	3	0	2	4
4.	20BT1002	Basics of Python Programming	ESC	2	0	2	3
5.	20MS2005	Soft Skills	HSMC	1	0	0	1
6.	22BT2071	Good Manufacturing and Laboratory Practices	BSC	3	0	0	3
7.		Mandatory Course - II	MC				0
PRACTICALS							
8.	20BT2004	Workshop Practices in Biotechnology	ESC	0	0	2	1
9.	23BT2006	Industrial design and layout	SBC	0	0	2	1
Total							**19**

SEMESTER III (SECOND YEAR)

S.No	Course Code	Course Title	Category	Hours/Week			Credits [L:T:P:C]
				L	T	P	
THEORY							
1.	20BT2009	Biochemistry	PCC	3	0	0	3
2.	20BT2007	Bio-analytical Techniques	PCC	3	0	0	3
3.	20BT2011	Microbiology	PCC	3	0	0	3
4.	20BT2005	Basics of Industrial Biotechnology	PCC	3	0	0	3
5.		Open Elective I	OEC	3	0	0	3
PRACTICALS							
6.	20BT2012	Microbiology Lab	PCC	0	0	3	1.5
7.	20BT2010	Biochemistry Lab	PCC	0	0	3	1.5
8.	20BT2008	Bio-analytical Techniques Laboratory	PCC	0	0	3	1.5
9.	23BT2007	Medical laboratory practices	SBC	0	0	2	1
10.	ISP2921/MP2921	Industry Internship-I/ / Mini project-I/	Project	0	0	2	1
Total							**21.5**

SEMESTER IV (SECOND YEAR)

S.No	Course Code	Course Title	Category	Hours/Week			Credits [L:T:P:C]
				L	T	P	
THEORY							
1.	20BT2015	Bioprocess Principles	ESC	3	0	0	3
2.	20BT2017	Molecular Biology	PCC	3	0	0	3
3.	22BT2072	Metabolic Engineering	PCC	3	0	0	3

4.	23BT2011	Entrepreneurship Product Development	HSMC	3	0	0	3
5.	19CS2012	Artificial Intelligence for Biotechnology	HSMC	3	0	0	3
6.		Professional Elective – 1	PEC	3	0	0	3
PRACTICALS							
7.	22BT2075	Bioprocess Lab	PCC	0	0	3	1.5
8.	23BT2008	Bioproduct development	SBC	0	0	2	1
		Total					**20.5**

SEMESTER V (THIRD YEAR)

S.No	Course Code	Course Title	Category	Hours/Week			Credits [L:T:P:C]
				L	T	P	
THEORY							
1.	20BT2018	Genetic Engineering	PCC	3	0	0	3
2.	22BT2074	Bioprocess Engineering	PCC	3	0	0	3
3.	20BT2025	Immunology	PCC	3	0	0	3
4.		Professional Elective-2	PEC	3	0	0	3
5.		Professional Elective-3	PEC	3	0	0	3
6.	20BT2059	IoT in Biotechnology	PCC	2	1	0	3
PRACTICALS							
7.	20BT2026	Cell Biology and Immunology Lab	PCC	0	0	3	1.5
8.	20BT2019	Molecular biology and Genetic Engineering Lab	PCC	0	0	3	1.5
9.	23BT2009	Molecular diagnostics	SBC	0	0	2	1
10.	ITP2911/ MP2911/	Industry Internship-II/ Mini project-II/	Project	0	0	4	2
	Total						**24**

SEMESTER VI (THIRD YEAR)

S.No	Course Code	Course Title	Category	Hours/Week			Credits
				L	T	P	
THEORY							
1.	22BT2073	Cheminformatics and Medicinal Chemistry	PCC	2	1	0	3
2.	20BT2068	Principles of Plant Biotechnology and Applications	PCC	3	0	0	3
3.	20BT2069	Advances in Animal Biotechnology	PCC	3	0	0	3
4.		Professional Elective-4	PEC	3	0	0	3
5.		Open Elective-2	OEC	3	0	0	3
6.		Open Elective-3	OEC	3	0	0	3
PRACTICALS							
7.	20BT2052	Plant and Animal Tissue Culture Lab	PCC	0	0	4	2
8.	22BT2097	Comprehensive practices	PCC	0	0	3	1.5
Total							**21.5**

SEMESTER VII (FOURTH YEAR)

S.No	Course Code	Course Title	Category	Hours/Week			Credits [L:T:P:C]
				L	T	P	
THEORY							

1.	20BT2023	Downstream processing	PCC	3	0	0	3
2.		Professional Elective-5	PEC	3	0	0	3
3.		Professional Elective-6	PEC	3	0	0	3
4.	20BT2054	Environmental Biotechnology	PCC	3	0	0	3
5.	20BT2030	Concepts of Bioinformatics	PCC	2	0	2	3
6.	20BT2057	Bioethics, IPR and Biosafety	HSMC	3	0	0	3
PRACTICALS							
7.	20BT2024	Downstream processing Lab	PCC	0	0	3	1.5
8.	23BT2010	Quality control and management	SBC	0	0	2	1
Total							**20.5**

SEMESTER VIII (FOURTH YEAR)

S.No	Course Code	Course Title	Category	Hours/Week			Credits [L:T:P:C]
				L	T	P	
1	23BT2999/ 23BT2998	Project	Project	0	0	28/16	14/8
Total				**0**	**0**	**28/16**	**14/8**

B Tech (Hons.) Biotechnology with Specialization in Drug Engineering
COURSE STRUCTURE

Sl. No	Course Code	Course Title	Course Component	No of Courses	Credits for Course	Total Credits
1	22BT2086 or 22BT2087	Molecular Pharmaceutics or Computer Aided Drug Design	Professional Elective Courses	1	3	3
2	22BT2088	Drug Formulation Development Lab	Laboratory Course	1	2	2
3	22BT2997	Project	Project	1	6	6
4			MOOC Course			3
5			Certificate Course	1	4	4

B Tech. (Hons.) Biotechnology with Specialization in Genome Engineering and Technology
COURSE STRUCTURE

Sl. No	Course Code	Course Title	Course Component	No of Courses	Credits for Course	Total Credits
1	22BT2089 or 22BT2090	Genome engineering in Livestock and Agriculture Or Genome Editing for Therapy	Professional Elective Courses	1	3	3
2	22BT2091	Genetic Manipulation Lab	Laboratory Course	1	2	2
3	22BT2997	Project	Project	1	6	6
4			MOOC			3

			Course			
5			Certificate Course	1	4	4

B Tech. (Hons.) Biotechnology with Specialization in Artificial Intelligence
COURSE STRUCTURE

S. No	Course Code	Course Title	Course Component	No of Courses	Credits for Course	Total Credits
1			Elective Courses in Artificial Intelligence			5
2	22BT2997	Project	Project	1	6	6
3			MOOC Course			3
4			Certificate Course	1	4	4

LIST OF NEW COURSES

Sl. No	Course Code	Course Name	Hours per week			Credits
			L	T	P	
1.	23BT2001	Artificial Intelligence in Smart Agriculture	3	0	0	3
2.	23BT2002	Artificial Intelligence for Energy and Environment	3	0	0	3
3.	23BT2003	Artificial Intelligence in Drug Design and Clinical Studies	3	0	0	3
4.	23BT2004	Artificial Intelligence in Healthcare and Biosciences	3	0	0	3
5.	23BT2005	Fundamental laboratory practices	0	0	2	1
6.	23BT2006	Industrial design and layout	0	0	2	1
7.	23BT2007	Medical laboratory practices	0	0	2	1
8.	23BT2008	Bioproduct development	0	0	2	1
9.	23BT2009	Molecular diagnostics	0	0	2	1
10.	23BT2010	Quality control and management	0	0	2	1
11.	23BT2011	Entrepreneurship Development	3	0	0	3

Course Code	Artificial Intelligence in Smart Agriculture	L	T	P	C
23BT2001		3	0	0	3

Course Objectives:

Enable the student to:

1. Examine the role of AI in agriculture
2. Evaluate the process of monitoring the crops
3. Facilitate farmers in the implementation of AI in crop monitoring

Course Outcomes:

The student will be able to:

1. Describe tools used in AI in agriculture farming
2. Conclude manmade intelligence and Artificial intelligence in agriculture
3. Interpret the results of smart agriculture process
4. Evaluate AI based monitoring for pest and disease management
5. Predict the yield of the agriculture products and their quality
6. Formulate AI implementation with farmers

Module: 1	AI in Farming	8 Hours

Introduction to AI, Applications of AI in Precision Agriculture, Drones for Mapping for field planning and seed planting, Soil Quality and plant disease assessment, Crop monitoring. Optical sensors, Location sensors, NPK Sensors.

Module: 2	Green House Monitoring	7 Hours

Background and driving forces, Operating principle, System architecture and technology equipment, System and equipment specification.

Module: 3	Cloud Computing in Agriculture	7 Hours

The Cloud-Computing Models for Smart Agriculture, Smart agriculture process, Disruptive technologies. Limitations and future scope.

Module: 4	Farmer's Advisory and Communication	7 Hours

Curtailing Challenges of AI in Agriculture, Man-Made Intelligence and ML-Based Advising System for Farmers Crop Production, Artificial Intelligence Found Farmer Supporter Chatbot

Module: 5	Plant Disease and Pest Detection	7 Hours

Disease Detection in Plants by Different Imaging Sensors, Tomogrphy, thermography, Thermal Imaging. Applications of Artificial Intelligence in Pest Management.

Module: 6	Artificial Intelligence-Aided Phenomics	8 Hours

Introduction to Phenomics, Fields of AI in Agriculture sector, Robotics in Agriculture, Advancement in irrigation system, Crop health monitoring, Status of AI innovation for Agriculture in India. High-Throughput Stress Phenotyping of Plants

Total Lectures	45 Hours

Text Books

1. Kose, U V B., Prasath, S., Mondal, M R M., Podder, P and Bharati S, (2022) "Artificial Intelligence and Smart Agriculture Applications", Ist Ed., Auerbach Publications, ISBN 9781003311782.

2.	Naresh R.K, (2022) "Artificial Intelligence in Indian Agriculture". Ist ed., ISBN: 9789390611959.
Reference Books	
1.	Singh, R., Geholt, A., Prajapat, M K. and Singh, B, (2022), "Artificial Intelligence in Agriculture" Ist ed., CRC Press. ISBN: 9781032158105.
2.	Abraham, A., Dash, S., Joel, J P C., Acharya, B. and Pani, S K, (2021) "AI edge and IoT- based smart Agriculture", Ist ed., ISBN: 9780128236949.
3.	Dutta,S., Sinha, A. and Basu, D, (2022) "Role of Artificial Intelligence in Agriculture : Current Scenario and Future Prospects", Ist ed., New Delhi Publishers, ISBN NO:9788194899358.
4.	Rathore, N S., Joshi, S., Choudhary, N, (2021) "Digital Technologies for Agriculture", Ist ed., New India Publishing agency, ISBN 9789390591916.
5.	Javaid M., Haleem A., Khan I. H. and Suman R, (2023) "Understanding the potential applications of Artificial Intelligence in Agriculture Sector", Advanced Agrochem, Vol 2(1).

Recommended by Board of Studies	
Approved by Academic Council	

Course Code	**Artificial Intelligence for Energy and Environment**	**L**	**T**	**P**	**C**
23BT2002		3	0	0	3

Course Objectives:

Enable the student to:

1. Describe the principles of AI in Bio efficiency.
2. Illustrate knowledge of AI in Bioenergy, and Environment.
3. Investigate the facts on sustainable development goals in AI

Course Outcomes:

The student will be able to:

1. Describe the basics and search algorithms in Artificial Intelligence.
2. Identify AI tools for substrate optimization, fermentation and production process.
3. Discuss AI prediction model for biofuel and electricity generation.
4. Determine AI techniques for the feedstock cultivation process and bioenergy supply chain.
5. Analyze AI based monitoring techniques for environmental challenges.
6. Formulate AI approaches for climate change and environmental sustainability

Module: 1	**Exploration of Artificial Intelligence**	**8 Hours**

Overview of Artificial intelligence, Problem solving Methods - Search Strategies- Uninformed - Informed - Heuristics - Local Search Algorithms, Knowledge Representation – First order predicate logic, Artificial Neural Network, Convolutional Neural network, Support vector machine algorithms.

Module: 2	**AI process in Bioenergy Production Process**	**7 Hours**

Role of artificial intelligence in the advancement of bioenergy, prediction of biomass feedstock properties, the prediction of process performance of biomass conversion including pathways and technologies, AI studies on hydrolysis and fermentation.

Module: 3	**AI Based Optimization for Bioconversion of Green Energy**	**8 Hours**

AI for Anaerobic conversion of green biomass into high-calorie liquid, Anaerobic processing of organic waste: general characteristics of fermentation, AI for Optimization of organic waste in a biogas plant, multilevel optimization in sustainable energy economics.

Module: 4	**AI applications in Bioenergy**	**8 Hours**

AI applications to bioenergy end-use systems, bio-energy used for heat and electricity generation, bioenergy supply chain, integration of the machine-learning informed semi-continuous algal cultivation (SAC) and aggregation-based sedimentation (ABS) for biofuel production.		
Module: 5	**Tackling Environmental Challenges**	**7 Hours**
Current environmental problems and use of artificial intelligence, Monitoring methane emissions, tracking air quality, Measuring environmental footprints, Reducing ICT emissions.		
Module: 6	**Climate Change and Environmental Sustainability**	**7 Hours**
Smarter decision-making for decarbonising industries, the ecosystem for information and communications technology, Greening cities, AI to address Environmental Challenges, Artificial intelligence (AI) applications in water resource, Biodiversity and Conservation, health oceans, weather and disaster management. Social and Economic outcomes.		
Total Lectures		**45 Hours**

Text Books	
1.	S. Russell and P. Norvig, (2016) "Artificial Intelligence: A Modern Approach", Prentice Hall, Third Edition, ISBN-1537600311, 97-81537600314.
2.	Mason. C. L., (2020) "Artificial Intelligence and The Environment: AI Blueprints for 16 Environmental Projects Pioneering Sustainability"
References	
1.	Manish Meena, Shubham Shubham, Kunwar Paritosh, Nidhi Pareek, Vivekanand, (2021) "Production of biofuels from biomass: Predicting the energy employing artificial intelligence modelling", Bioresource Technology, Volume 340.
2.	Mochen Liao, Yuan Yao, (2021) "Applications of artificial intelligence-based modeling for bioenergy systems: A review", GCB Bioenergy 13:774–802.
3.	Emmanuel Kwame Nti, Samuel Jerry Cobbina, Eunice Efua Attafuah, Evelyn Opoku, Michael Amoah Gyan, (2022) "Environmental sustainability technologies in biodiversity, energy, transportation and water management using artificial intelligence: A systematic review", Sustainable Futures, Volume 4.
4.	Pandian Vasant, Gerhard-Wilhelm Weber, Joshua Thomas, José Antonio Marmolejo-Saucedo, Roman Rodriguez-Aguilar, (2022) "Artificial Intelligence for Renewable Energy and Climate Change", ISBN: 9781119768999, Scrivener Publishing LLC.
5.	Pandian Vasant, Joshua Thomas,Elias Munapo Gerhard-Wilhelm Weber, (2022) "Advances of Artificial Intelligence in a Green Energy Environment", ISBN 978-0-323-89785-3.
Recommended by Board of Studies	
Approved by Academic Council	

Course Code	**Artificial Intelligence in Drug Design and Clinical Studies**	**L**	**T**	**P**	**C**
23BT2003		3	0	0	3

Course Objectives:

Enable the student to:

1. Describe the concepts of Artificial Intelligence.
2. Apply Artificial Intelligence in Drug Discovery
3. Introduce the concepts of machine learning for various applications

Course Outcomes:

The student will be able to:

1. Infer to problems that are amenable to solution by AI methods.

2. Demonstrate the various Artificial Intelligence methods to solve a given problem.
3. Illustrate a given problem in the language/framework by Artificial Intelligence
4. Examine machine learning integration in knowledge inference
5. Acquire knowledge on Networks and tools
6. Formulate AI based solutions in Drug Discovery

Module: 1	**Introduction**	**7 Hours**
Introduction to AI, History of Artificial Intelligence and Chemistry, Chemical Topic Modeling – An Unsupervised Approach Originating from Text-mining to Organize Chemical Data, Deep Learning and Chemical Data		
Module: 2	**AI in Drug Discovery**	**7 Hours**
Definition, Drug Discovery Process, Applications of Machine Learning in Drug Discovery, Applications of AI in Drug Discovery, drug classifications, Target selection and validation, Compound screening and lead optimization, Preclinical studies, Clinical trials and Trial master file.		
Module: 3	**Drug Designing**	**7 Hours**
Role of AI in Drug Product Designing, Development & Manufacturing: Tapping into the drug discovery potential, driven by data, lifecycle of pharmaceutical products, drug screening, and designing drug molecules.		
Module: 4	**AI in Pharmaceutics**	**8 Hours**
AI in advancing pharmaceutical product development, quality control and quality assurance, clinical trial design, nanorobots for drug delivery, advanced pharmaceutical product development, combination drug delivery and synergism/antagonism prediction		
Module: 5	**AI in Computational Drug Designing**	**8 Hours**
Concepts and Applications of Conformal Prediction in Computational Drug Discovery, Predicting Protein-ligand Binding Affinities, Virtual Screening with Convolutional Neural Networks		
Module: 6	**Machine Learning**	**8 Hours**
Machine Learning in the Area of Molecular Dynamics Simulations, Compound Design Using Generative Neural Networks, Junction Tree Variational Autoencoder for Molecular Graph Generation, AI via Matched Molecular Pair Analysis, Active Learning for Drug Discovery and Automated Data Curation		
Total Lectures		**45 Hours**

Text Books

1.	Nathan Brown Artificial Intelligence in Drug Discovery, (2020). United Kingdom: Royal Society of Chemistry.
2.	Anil Philip, Aliasgar Shahiwala, Mamoon Rashid, Md Faiyazuddin (2023) "A Handbook of Artificial Intelligence in Drug Delivery", United States: Elsevier Science.

Reference Books

1.	Alexander Heifety, (2022) "Artificial Intelligence in drug design",Springer US.
2.	Alex Zhavoronkov and Jianfeng, (2021) "Artificial Intelligence for drug discovery and development",Frontiers Media SA.
3.	Dominic Magirr, Jacob Bradley, Roberta Dousa, Ayaka Shinozaki, John Cassidy, Kristofer Linton-Reid, Steve Gardner, Sayoni Das, Krystyna Taylor Edited by John W. Cassidy and Belle Taylor, (2020) "Artificial Intelligence in Oncology Drug Discovery and Development", IntechOpen.

4.	Ruby Srivastava, (2021) "Transformation of Drug Discovery towards Artificial Intelligence: An in Silico Approach"**,** IntechOpen. ISBN: 978-1-83969-845-3.
5.	Szolovits, P. (Ed.). (2019) "Artificial intelligence in medicine", Routledge.

Recommended by Board of Studies	
Approved by Academic Council	

Course Code	**Artificial Intelligence in Healthcare and Biosciences**	**L**	**T**	**P**	**C**
23BT2004		3	0	0	3

Course Objectives:

Enable the student to:

1. Summarize the integration of AI in health care and biosciences.
2. Apply Artificial Intelligence in technological and industrial environments to improve quality and productivity.
3. Interpret the applications of AI and ML in healthcare and bioscience.

Course Outcomes:

The student will be able to:

1. Explain core elements of AI and ML
2. Evaluate the Programming and Descriptive Statistics and carry out Statistical Analysis
3. Restate basics and applications of AI and ML
4. Evaluate the AI data mining technologies and their application in healthcare and Biosciences
5. Discuss Ethical framework of AI when applied in medicine.
6. Effectively communicate and disseminate knowledge in any science or engineering domain in the context of computing, systems, and/or biomedical applications.

Module: 1	**AI Foundation and Introduction**	**7 Hours**

Introduction to Artificial Intelligence, AI fundamentals, Use-cases and applications of AI, Issues concerning AI in business, ethics and bias, jobs and scope. Brief history of AI and ML in Healthcare and Pharmacy, Machine Learning workflow and terminologies, computational models of intelligence.

Module: 2	**Data Management and Visualization**	**8 Hours**

Introduction to Data Science, Flow of Data Science, NumPy, Pandas: Data Frames, operations, Pandas built-in data visualization, Matplotlib, Matplotlib visualization. Power BI and ChatGPT

Module: 3	**Machine Learning and Medical bio-sensors**	**8 Hours**

ML in micro biosensors and devices for electronic data capture (ECG, Actigraphy, Oximetry), data disambiguation techniques, Bayesian ML, SVM-optimal mix, Shallow learning, Ensemble Learning, anomaly detection.

Module: 4	**Machine Learning for Healthcare**	**7 Hours**

Fundamental concepts and principles of machine learning as it applies to medicine and healthcare Machine learning approaches, medical use cases, metrics unique to healthcare, as well as best practices for designing, building, and evaluating machine learning applications in healthcare.

Module: 5	**AI and Data Analytics in Physiology and Biomedicine**	**8 Hours**

Successes and limitations of applications of artificial intelligence (AI) in physiology and biomedicine. Bioimage diagnostic tools, medial risk assessment and prognosis, individualized medicine, drug discovery, protein folding, and classification of microbial communities. Theoretical and practical challenges in ML and AI, convolutional neural networks on digital pathology for diagnostic and outcome prediction and personalized treatment schemes.

Module: 6	**AI application and Case Studies in Bioscience**	**7 Hours**
AI and Data science in biology: Molecular data produced methods of transcriptomics, proteomics and metabolomics. Unix analysis of large genome sequence data. AI data analytics in ecology and Evolutionary biology. Frontiers of research and development in the application of AI methods in the biosciences. Overview of successes and limitations of applications of artificial intelligence (AI) in physiology and biomedicine.		
Total Lectures		**45 Hours**

Text Books	
1.	Russell, Norvig, (2010) "Artificial Intelligence: A Modern Approach", Third edition, Prentice Hall.
2.	Tony J. Cleophas and Aeilko H. Zwinderman, (2015) "Machine Learning in Medicine - a Complete Overview", Springer.
Reference Books	
1.	Hastie, Tibshirani, Friedman (2009) "The elements of statistical learning", Second edition, Springer.
2.	Daphne Koller and Friedman (2009) "Probabilistic Graphical Models - Principles and Techniques", The MIT Press.
3.	Natarajan, Prashant, John C. Frenzel, and Detlev H. Smaltz (2017) "Demystifying big data and machine learning for healthcare" CRC Press.
4	Catania, Louis J (2020) "Foundations of Artificial Intelligence in Healthcare and Bioscience: A User Friendly Guide for IT Professionals, Healthcare Providers, Researchers, and Clinicians", Academic Press.
5.	Stuart Russell and Peter Norvig, (2009) "Artificial Intelligence: A Modern Approach", 3rd ed. Prentice Hall Press.
Recommended by Board of Studies	
Approved by Academic Council	

Course Code	**Fundamental Laboratory Practices**	**L**	**T**	**P**	**C**
23BT2005		0	0	2	1

Course Objectives:

Enable the student to:

1. Apply the laboratory guidelines in reagent preparations.
2. Develop hands on skills in operation of instruments.
3. Demonstrate different techniques in laboratory practices.

Course Outcomes:

The student will be able to:

1. Solve calculations for the preparation of solutions.
2. Prepare reagents and media for various biological experiments.
3. Operate basic laboratory equipment.
4. Calculate the concentration of unknown samples.
5. Adopt various sterilization techniques.
6. Demonstrate different microbial culture techniques.

List of Experiments:

1. Safety guidelines for laboratory experiments in biotechnology.
2. Collection techniques and volumetric analysis of samples.
3. Preparation of solutions in terms of Normality, Molarity, % (w/w), % (w/v) and % (v/v).
4. Calibration of pH meter.
5. Preparation of buffers.
6. Colorimetric determination of the glucose concentration.

7. Handling the instruments; centrifuges, incubators, LAF, microscope 8. Dry and wet heat sterilization techniques. 9. Media preparation and inoculation of bacteria. 10. Procedure for fumigation of laboratory	
Total Lectures	**15 Hours**
Text Books	
1.	Seidman, L.A., Moore C.J. and Mowery, J, (2021), "Basic Laboratory Methods for Biotechnology", CRC Press, ISBN: 9781000480764.
2.	Seidman, L.A., (2021), "Basic Laboratory Calculations for Biotechnology", CRC Press, ISBN: 9781000480795.
Reference Books	
1.	Bonner, P.L.R., Hargreaves, A.J (2022), "Basic Bioscience Laboratory Techniques", CRC Press, ISBN: 9781119663485.
2.	Seidman, L.A., Kraus, M.E., Brandner, D.L., Mowery, J. (2022) "Laboratory Manual for Biotechnology and Laboratory Science", CRC Press, ISBN: 9781000750119.
3.	Jani, A., Agarwal, J. and Venkatesh, V. (2020) "Microbiology Practical Manual", Elsevier Science, ISBN: 8131253546.
4.	Olaniyan, M., (2017) "Laboratory Instrumentation and Techniques", Create Space Independent Publishing Platform, ISBN: 9781547012220.
5.	Sabari, G., Avasthi, Sharma, A. (2018) "Fundamentals of Bioanalytical Techniques and Instrumentation", 2nd Edition, PHI Learning Pvt. Ltd., ISBN: 9789387472402.
Recommended by Board of Studies	02.08.2023
Approved by Academic Council	

Course Code	**Industrial Design and Layout**	**L**	**T**	**P**	**C**
23BT2006		0	0	2	1

Course Objectives:

Enable the student to:

4. Acquire knowledge on the fundamentals of Engineering Design.
5. Develop skills in AutoCAD for plant layout.
6. Design industrial biotech equipment.

Course Outcomes:

The student will be able to

7. Classify unit operation symbols, letters and plant layout.
8. Identify suitable materials for the fabrication of parts.
9. Apply engineering design tools in industrial design.
10. Develop plant layouts for pharma and biotech industries.
11. Differentiate various reactors.
12. Design heat exchangers, evaporators and distillation column.

List of Experiments

1. Customization drawing aids, page setup and printing, engineering letters, lines and numbering
2. Introduction to basic shapes used in industrial design
3. Basics of various unit operation symbols
4. Generate the layout of pharmaceutical industry plant
5. Develop biotech industry plant layout
6. Design of batch reactor
7. Design of airlift fermenter
8. Design of shell and tube heat exchanger
9. Design of single effect evaporator
10. Design of fractional distillation column

Total Lectures	**15 Hours**

Text Books	
1.	Ganesan G., (2018), "Basic Computer Aided Design and Drafting using AutoCAD 2015", McGraw Hill.
2.	Sham T., (2014), "AutoCAD 2015 for Engineers and Designers", Dream Tech Press.
Reference Books	
1.	Elliot G., (2014), "Up and Running with AutoCAD 2015", 2D and 3D Drawing and Modeling. Academic Press.
2.	Gary R. B., Eric N. W., (2014) "Fundamentals of Graphics Communication", McGraw Hill,.
3.	Mccabe, W. L.,Smith, J. C., Harriott,P., (2022), "Unit Operations of Chemical Engineering", McGraw Hill, NewYork, 7th Edition.
4.	Randy H. S., (2023) 'AutoCAD 2023 Tutorial: 2D Fundamentals', SDC Publications, New Delhi.
5.	Natarajan, K.V., (2022), "Engineering Drawing and Graphics", Dhanam Publication, 25th Edition.
Recommended by Board of Studies	02.08.2023
Approved by Academic Council	

Course Code	**Medical Laboratory Practices**	**L**	**T**	**P**	**C**
23BT2007		0	0	2	1

Course Objectives:

Enable the student to:

1. Illustrate the principles in biochemical analysis.
2. Perform clinical analysis of body fluids.
3. Assess body vitals.

Course Outcomes:

The student will be able to:

1. Adopt standard procedures in analysis of clinical samples.
2. Perform routine clinical laboratory procedures in Hematology.
3. Analyse urine sample for various biochemical parameters.
4. Evaluate the samples for respiratory tract infections.
5. Compare normal and abnormal clinical observations.
6. Interpret the results for medical diagnosis.

List of Experiments

1. Determination of Serum cholesterol.
2. Analysis of Serum Sugar.
3. Quantification of Urine albumin
4. Estimation of total platelet count.
5. Quantification of Urine Bile salt.
6. Estimation of Urine sugar.
7. Collection of throat and nasal swabs.
8. Measurement of blood pressure.
9. Determination of blood clotting time.
10. Estimation of bleeding time.

Total Lectures	**15 Hours**
Text Books	
1.	Erkmen, O.,(2021), "Laboratory Practices in Microbiology". Netherlands, Elsevier Science.
2.	Lynne, S G., (2020), "Clinical Laboratory Management. United States", Wiley, 2nd Edition.
Reference Books	
1.	Nagarajan, P., Gudde, R., Srinivasan, R., (2021), "Essentials of Laboratory Animal Science: Principles and Practices", Springer Nature Singapore.
2.	Marzinke, M., Clarke, W., (2020), "Contemporary Practice in Clinical Chemistry". Netherlands, Elsevier Science, 4th Edition.

3.	Donaldson, L., Tartaglia, R., Sheridan, S., Ricciardi, W., (2020) "Textbook of Patient Safety and Clinical Risk Management", Springer International Publishing, Germany.
4.	Sandhya, B., Apurba, S., (2021) "Essentials of Medical Microbiology", Jaypee Brothers Medical Publishers Pvt. Limited, India, 3rd Edition.
5.	Rifai, N., (2018), "Tietz Fundamentals of Clinical Chemistry and Molecular Diagnostics", Elsevier, India, 8th Edition.
Recommended by Board of Studies	02.08.2023
Approved by Academic Council	

Course Code	**Bioproduct Development**	**L**	**T**	**P**	**C**
23BT2008		0	0	2	1

Course Objectives:

Enable the student to:

1. Demonstrate processes involved in bio-product development.
2. Identify key parameters that enhance the quality of bioproducts.
3. Formulate personal care products.

Course Outcomes:

The student will be able to:

1. Ascertain upstream requirements for formulation of bioproducts.
2. Identify experimental requirements for development of bioproducts.
3. Evaluate the optimal process parameters.
4. Assess the quality of bioproducts.
5. Formulate scale up strategies.
6. Analyze cost estimation.

List of Experiments

1. Evaluation of sugar content in wine.
2. Preparation of beer and evaluation of its turbidity.
3. Mushroom cultivation.
4. Cultivation of Azolla.
5. Demonstration of Vermi technology.
6. Preparation of herbal oil for dandruff treatment.
7. Preparation of herbal face pack.
8. Development of herbal mosquito repellent candle
9. Large scale preparation of liquid biocontrol formulation.
10. Determination of calcium content in prepared health mix

Total Lectures	**15 Hours**

Text Books

1	Peter F S., Allan W., Stephen H., (2016). "Principles of Fermentation Technology". 3rd Edition. ISBN: 9780080999531.
2.	Sharma A., (2017). "Food Product Development. CBS publishers". ISBN: 9789386827951

Reference Books

1.	Manickavasagan, A., Loong-Tak L., Amanat A., eds. (2022). "Plant Protein Foods". Cham: Springer International Publishing.
2.	Amaresan, N., Dhanasekaran, D., Olubukola, O. B., eds. (2023). "Agricultural Microbiology Based Entrepreneurship". Vol. 39. Singapore: Springer Nature Singapore.
3.	Verma, P., ed. (2022). "Industrial Microbiology and Biotechnology". Singapore: Springer Singapore
4.	Baskar, C., Seeram R., Shikha B., Rashmi S., Amutha C., Rashmi S., eds. (2022). "Handbook of Solid Waste Management". Singapore: Springer Nature Singapore.
5.	Chen, G., Randall J. W., Stacy D. S., eds. (2018). "Plant Bioproducts". Springer, New York.
Recommended by Board of Studies	02.08.2023
Approved by Academic Council	

Course Code	Molecular Diagnostics	L	T	P	C
23BT2009		0	0	2	1

Course Objectives:

Enable the student to:

1. Identify the role of rapid diagnostic techniques.
2. Apply the principle and techniques in disease diagnosis.
3. Develop rapid methods for specific disease diagnosis.

Course Outcomes:

The student will be able to:

1. Apply the fundamentals of molecular diagnostics.
2. Articulate the diagnostic characteristics for detection of disease.
3. Appraise the concepts of rapid detection.
4. Adopt molecular techniques in diagnosis of diseases
5. Demonstrate immunodiagnostic techniques.
6. Develop novel diagnostic techniques for disease detection.

List of Experiments

1. Collection of blood through Venipuncture.
2. Diagnosis of Dengue using serum
3. Polymerase Chain Reaction: Basic Protocol and setting up
4. Blotting as a diagnostic method - Demonstration of Southern Blotting
5. Study the principal components of DoT-COVID 19 Kit
6. Kit assay for diagnosis of Malaria
7. Detection of human chorionic gonadotropin (HCG) in urine sample
8. Quantification of genetic material using nanodrop
9. RT-PCR - Demonstration
10. Development of simple disease diagnosis kit

Total Lectures	**15 Hours**

Text Books

1. Chang-Hui, S., (2023), "Diagnostic Molecular Biology", 2nd Edition, Academic Press, ISBN: 9780323917889
2. Laura, A., (2018), "Rapid Test: Advances in Design, Format and Diagnostic Applications", BoD – Books on Demand, ISBN: 978-1789239010

Reference Books

1. Diwakar, S., Suthur, K.P., Mehtha, R., (2020) "Molecular Diagnostics A Practical Manual", New India Publishing Agency (NIPA), ISBN: 9789389571905
2. Ford, M., (2019), "Medical Microbiology: Fundamentals of Biomedical Science", 3rd edition, Oxford University Press, ISBN: 9780198818144
3. Robert, R. R., (2018), "Clinical Immunology: Principles and Practice" 5th edition, Elsevier, 978-0702068966
4. Sandeep, K. V., Luong, J., (2018), "Handbook of Immunoassay Technologies Approaches, Performances, and Applications", Academic Press, ISBN: 9780128117620
5. Michael, R. G., Sambrook, J., (2012), "Molecular Cloning -A Laboratory Manual", 3rd Edition, Cold Spring Harbor Laboratory Press, ISBN 978-1-936113-41-5

Recommended by Board of Studies	02.08.2023
Approved by Academic Council	

Course Code	Quality Control and Management	L	T	P	C
23BT2010		0	0	2	1

Course Objectives:

Enable the student to:

1. Acquire knowledge on the principles of quality control in the Biotechnology industry.
2. Implement quality control and management strategies.
3. Assess product service quality.

Course Outcomes:

The student will be able to:

1. Comprehend the significance of documentation.
2. Categorize the quality certifications applicable to biotech industries.
3. Evaluate internal and external audits.
4. Appraise on standard operating protocols.
5. Analyze influence of environment on product quality.
6. Investigate the compliance towards quality standards.

List of Experiments

1. Standard Operating Procedure (SOP) and Standard Test Procedure (STP) preparation based on Schedule M /Monographs/ISO.
2. Quality Management System (QMS) documentation for testing lab according to Schedule M/ISO.
3. Environmental Monitoring in Clean Room Area for Sterility.
4. Microbial contamination analysis.
5. Handling and disposal of hazardous microorganisms and waste management.
6. Analytical data review and release.
7. Conduction/setting up of inspection and audits.
8. Corrective actions for non-conformity of quality issues.
9. Investigation on customer complaints.
10. Addressing Internal and External Quality Issues – Complying with regulatory guidelines.

Total Lectures	**15 Hours**

Text Books

1	Jimenez, L., (2019), " Microbial Contamination Control in the Pharmaceutical Industry", CRC Press; Floroda, USA. ISBN-10 : 0367393948
2	Goel, P. R., Potdar, M. A., Shaikh, S. K., (2021), "Audit And Regulatory Compliance For Master Of Pharmacy (QAT) Students", Nirali Prakashan Publishers, ISBN: 9789354511813

Reference Books

1.	Yamini, R., (2019), "Quick Reference Guide - ISO 9001:2015: Quality Management System", White Falcon Publishing, ISBN: 1097424146, 9781097424146.
2.	Ljungqvist, B., Reinmuller, B., (2019), "Clean Room Design Minimizing Contamination Through Proper Design", CRC Press, Floroda, USA. ISBN:1-57491-032-9.
3.	Lawrence, K., Yung-Tse H. W., Nazih K. S., (2010), "Handbook of advanced industrial and hazardous wastes treatment Boca Raton", CRC Press. ISBN : 9786612336188
4.	Rodriguez, J., (2016), "CAPA in the Pharmaceutical and Biotech Industries", Elsevier Publication. DOI: https://doi.org/10.1016/C2013-0-18185-8
5.	Potdar, M. A., Dubey, R. (2018), "cGMP Current Good Manufacturing Practices for Pharmaceuticals", 2nd Edition, Pharmamed press/Bsp books, pp854.

Recommended by Board of Studies	02.08.2023
Approved by Academic Council	

Course Code	**Entrepreneurship Development**	**L**	**T**	**P**	**C**
23BT2011		3	0	0	3

Course Objectives:

Enable the student to:

1. Develop an entrepreneurial mindset
2. Analyze practical aspects in promotion of a start- up.
3. Design innovative products

Course Outcomes:

The student will be able to:

1. Recognize the requirements of an entrepreneurial endeavour
2. Identify critical factors involved in real case studies
3. Develop product concepts, design and prototype fabrication
4. Apply lean start-up techniques in development of business idea.
5. Analyze go-to -market strategy required for a start-up.
6. Evaluate the action plan for successful entrepreneurial career.

Module 1: Basics of Entrepreneurship and types 8 Hours

Concepts of Entrepreneurship and Product Development - Evolution of the concept of Entrepreneur-Entrepreneur Vs. Intrapreneur, Entrepreneur Vs. Entrepreneurship, Entrepreneur Vs. Manager –Types of entrepreneur-Type of Business-Use of Technology-New generations of entrepreneurship viz. Social entrepreneurship, Ideapreneurship, Health Entrepreneurship-Tourism Entrepreneurship-Women entrepreneurship. Success and failure stories of Entrepreneurs and Product development.

Module 2: Creating Entrepreneurial Venture 5 Hours

Business Planning Model- Environmental Analysis - Search and Scanning Identifying problems and opportunities- Defining Business Idea- Basic Government Procedures to be complied with Entrepreneurship.

Module 3: Project Management & Resource Mobilization 8 Hours

Technical, Financial, Marketing, Personnel and Management Feasibility- Estimating and Financing funds requirement - Schemes offered by various commercial banks and financial institutions like IDBI, ICICI, SIDBI, SFCs-Venture Capital Funding-raising funds (including Angel investor).

Module 4: Government & Organization Assistance 5 Hours

Role of Central Government and State Government in promoting Entrepreneurship - Introduction to various incentives, subsidies and grants - Export Oriented Units - Fiscal and Tax concessions available

Module 5: Role of agencies in Entrepreneurship Development 10 Hours

District Industries Centers (DIC), Small Industries Service Institute (SISI), Entrepreneurship Development Institute of India (EDII), National Institute of Entrepreneurship & Small Business Development (NIESBUD), National Entrepreneurship Development Board (NEDB), Carry on Business (COB) license-MSME Act Small Scale Industries-National Small Industries Corporation (NSIC)-Quality Standards with special reference to ISO. Directorate General of Supplies and Disposals (DGS& D)-Registration with DGS & D -Registration Categories-Registration Procedure.

Module 6 :Support to Entrepreneurs 9 Hours

Sickness in small Business: Concept, Signals, Symptoms, Magnitude, Causes and Consequences, Corrective Measures – Government Policy for Small Scale Enterprises – Growth Strategies in Small Scale Enterprise – Institutional Support to Entrepreneurs: Need and Support -Taxation Benefits to Small Scale Industry: Need, Depreciation, Rehabilitation, Investment.

Total Lectures	**45 Hours**

Text Books

1.	Robert D. H., Michael P P., Dean A. S., (2010), “Entrepreneurship”, McGraw Hill, ISBN: 0077434862
2.	Thomke, S., Ashok N., (2000), "IDEO Product Development." Boston, MA: Harvard Business School Case, 9-600-143

Reference Books

1.	Donald F K., (2023), “Entrepreneurship: Theory, Process and Practice”, Cengage Learning Custom Publisher, 12th Edition.
2.	Srinivasan, N.P., Gupta G.P., (2020), “Entrepreneurial Development”, Sultanchand & Sons.
3.	Satish Taneja, (2014) “Entrepreneur Development ", New Venture Creation.
4.	Vasanth D., (2011), “Dynamics of Entrepreneurial Development and Management”, Himalaya, ISBN 9350244543
5.	Ulrich, K., Eppinger, S., (2003), “Product Design and Development’ 3rd Edition. McGraw- Hill. ISBN: 9780072471465

Recommended by Board of Studies	02.08.2023
Approved by Academic Council	

20BT2001	CHEMISTRY OF BIOMOLECULES	L	T	P	C
		3	0	0	3

Course Objectives:

1. To gain knowledge on structure, composition, bonding and function of various biomolecules.
2. To illustrate the basic nature and properties of biomolecules which are involved in metabolic pathways
3. To articulate the significance of these biomolecules and to apply these fundamentals in biotechnology

Course Outcomes:

The students will be able to

1. Recall the chemical bonding properties of biomolecules
2. Understand biochemistry at the atomic level, and draw the basic structures of biomolecules.
3. Recognize the significance of biomolecules in the proper functioning of living cells
4. Illustrate the structure and functions of conjugated biomolecules – proteoglycans, glycoproteins and glycolipids.
5. Discuss the applications of biomolecules in biotechnology industries
6. Analyze the clinical and biological significance of biomolecules

Module 1: Chemical bonding (5 hrs)

Matter and its nature, Dalton's atomic theory, concept of atom, molecule, element and compound. Principles of Chemical Bonding, Water- chemical properties, function as medium of cellular reactions and activities. Acids and Bases, Buffer systems of the blood, Buffering against pH changes in Biological Systems.

Module 2: Carbohydrates (8 hrs)

Classification, structure, properties and functions of carbohydrates: Monosaccharides –classes, examples, Disaccharides – classes- homo and hetero, examples. Oligosaccharides-examples; Polysaccharide – classes, examples; complex and conjugated carbohydrates- proteoglycan, glycoprotein, glycolipid. Industrial and clinical significance of carbohydrates- a review

Module 3: Lipids and fatty acids (8 hrs)

Fatty acids- basic structure, types, properties, functions and essential fatty acids; ketone bodies, Classes, structure, properties and functions of lipids: Simple lipid- examples, Compound lipid- examples, ether lipid, Derived lipid – cholesterol. Review on industrial and clinical significance of fatty acids and lipids.

Module 4: Amino acids and Proteins (8 hrs)

Amino acids- basic structure, classification, properties; Essential amino acids; Peptide bond, significant natural and artificial peptides. Review on industrial and clinical significance of amino acids, peptides and proteins.

Module 5: Nucleic acids (8 hrs)

Nucleotides- composition, structure, properties and functions; Nucleic acids- types (RNA, DNA), DNA structure-composition, RNA types, structure and functions, properties of nucleic acids

Module 6: Significance of Vitamins, Minerals and Nutraceuticals (8 hrs)

Classification of Vitamins; biological functions of Vitamins – roles in metabolism and regulatory pathways, anti-oxidant roles; clinical symptoms of Vitamin deficiency;Biological significance of minerals; Vitamin and mineral supplementations-nutraceuticals.

Text Books

1. Lehninger, A.L, Nelson D.L and Cox, M.M, "Principles of Biochemistry", Freeman Publishers, New York, 7th edition, 2017.
2. Murray R.K, Granner B.K, Mayes P.A, Rodwell V.W. "Harper's Biochemistry", Prentice Hall International, 2008.

References Books

1. Lubert Stryer, "Biochemistry", WH Freeman & Co., 4th edition, 2000.
2. Voet and Voet, "Biochemistry", John Wiley & Sons Inc., 2nd Edition, 2013.

3. Jain and Jain "Biochemistry", Chand publication, 4th edition, 2008.

20BT2002	CHEMISTRY OF BIOMOLECULES LAB	L	T	P	C
		0	0	2	1

Course Objectives:

1. To understand the basic units and measurements of biochemical solutions
2. To acquaint students with the concepts in biochemical analysis
3. To articulate the skills of quantifying the various biomolecules

Course Outcomes:

1. Understand the basic concept, applications of tests, titrations and estimations of biomolecules
2. Demonstrate the basic lab skill in preparing different solutions of different concentrations and their measurement tools with representing units
3. Apply the basic reaction principle in estimation of different biomolecules using suitable method
4. Analyze the various tests and identify the different carbohydrate, amino acid and lipid molecules present in the given sample solution.
5. Explain the suitable extraction methods for the estimation of different biomolecules.
6. Evaluate the level of biomolecules in different food materials

List of Experiments:

1. Study of biochemical solutions, units and measurements
2. Preparation of buffers
3. Qualitative analysis of carbohydrates
4. Tests for lipids: - Fats and cholesterol
5. Qualitative analysis of amino acids
6. Tests for phytochemicals
7. Dry ashing of food materials and colorimetric estimation of phosphorus
8. Estimation of ascorbic acid content in foods
9. Analysis of nucleic acid by spectrophotometer
10. Estimation of beta carotene in carrot
11. Titration of amino acid
12. Analysis of clinical samples- Blood sugar

Reference Book:

1. Sawhney S. K., Randhir Singh, Introductory practical Biochemistry. Narosa publishers, 2006

20BT1002	BASICS OF PYTHON PROGRAMMING	L	T	P	C
		2	0	2	3

Course Objectives:

To impart knowledge on

1. Fundamental programming constructs such as variables, arrays, loops, subroutines and input/output in Python.
2. Concepts of modules in Python and Biopython.
3. Utilization of Biopython packages in big data analytics

Course Outcomes:

The students will be able to

1. Understand, write, compile, and run Python programs.
2. Analyze Python structures that implement decisions, loops, and store arrays and use these structures in a well designed, OOP program.
3. Create Python programs that make use of various modules and packages
4. Understand regular expressions and extract required information from file and databases.
5. Relate and arrange information from multiple files
6. Apply the principles of object-oriented programming and well-documented programs in the Python language, including use of the Bio-python packages in big data analytics

Module 1: Install and run Python program **(8 Hours)**

System command lines and files, module imports and reloads. The IDLE user interface, Numeric type's basis, Numbers in action, Comparison, Decimal and Fraction type, Sets, Booleans

Module 2: Strings **(8 Hours)**

String literals, Strings in action, String methods, the original string module, String formatting expressions

Module 3: Lists and files **(8 Hours)**

Lists, Lists in action, basic operations, comprehensions, indexing, slicing, matrixes

Module 4: Tuples **(6 Hours)**

Tuples in action, compare list and tuples, files and examples.

Module 5: Control statement in python **(8 Hours)**

If statement, Python syntax rules, truth test, while loop, break, continue, pass, for loops, loop coding techniques, examples.

Module 6: Modules and package **(7 Hours)**

Module creation, module usage, package import basics and examples, Bio-python.

Lists of Experiments:

1. Demonstrate the working of 'id' and 'type' functions.
2. Write a Python program to find all prime numbers within a given range
3. Write a Python program to print 'n terms of Fibonacci series using iteration
4. Write a Python program demonstrate use of slicing in string.
5. Write a Python program to compute the frequency of the words from the input.
6. Write a Python program that accepts a comma separated sequence of words as input and prints the words in a comma-separated sequence after sorting them alphabetically.
7. Write a Python program to get a string from a given string where all occurrences of its first char have been changed to '$', except the first char itself
8. Write a Python program to demonstrate use of list & related
9. Write a Python program to demonstrate use tuple, set & related
10. Biopython packages uses in big data analytics

Text Book:

1. Alex Martelli and David Ascher, "Python cookbook", O'Reilly,USA, 2ndEdition 2002.
2. Randal L. Schwartz, brian d foy, Tom Phoenix, "Learning Perl" O'Reilly Media, Inc., 2016
3. Mark Lutz, "Learning Python" "O'Reilly Media, Inc.", 2013

Reference Book:

1. Jason Kinser, "Python for bioinformatics" Jones and Bartlett Publishers,UK,1st edition, 2009

Martin Jones, "Python for Biologists: A programming course of complete beginners" Copyright © 2013

20BT2003	CELL BIOLOGY	L	T	P	C
		3	0	0	3

Course Objective:

1. To acquaint students with the concepts in Cell Biology.
2. To appraise on cellular processes and regulation
3. To familiarize the recent trends in cell and molecular research

Course Outcome:

1. Exhibit a knowledge base in cell structure, organelles and their functions
2. Outline the process that control cell cycle, and cell death
3. Relate how cell movement and cell to cell communication occur and discuss mechanisms of signal transduction
4. Link the rapid advances in cell and molecular biology to a better understanding of diseases including cancer
5. Evaluate and apply knowledge of recent techniques in cellular biology
6. Critique and professionally present literature articles in cell and molecular biology

Module 1: Cell and Molecular Organization of Cell Membrane (8)

Brief overview of cell and cell organelles, Membrane organization of cell membrane-Functions and Models, Components of membrane - lipids and protein, Fluid and Dynamic membrane, Diffusion across membranes

Module 2: Membrane Transport (8)

Facilitated diffusion and active transport, Voltage gated channels and transmission of action potential in neurons. Endomembrane systems - Protein synthesis, targeting and trafficking, Glycosylation, Quality control and vesicular transport. Endocytosis and Exocytosis, Entry of virus and toxins into the cells.

Module 3: Cell Mobility (7)

Cytoskeleton and Microtubule based movement, Intracellular transport, Motile appendages, Microfilament based movement, Actin filament based movement – Sliding filament theory and Actin myosin interactions in muscular contractions.

Module 4: Cellular Communications (10)

Modes of signal transmission, ECM, Cell-ECM interactions, ECM and cancer metastasis, Cell-cell interactions, Cell signaling and signal transduction - Signaling molecules, Cytosolic, nuclear and membrane bound receptors. G-protein coupled receptor - Role of cyclic AMP, cyclic GMP and Inositol triphosphate (IP3) in signal transduction, Enzyme linked receptors -Receptor Tyrosine kinases andTGFβ signaling.

Module 5: Cell Cycle and Cancer (6)

Cell cycle and molecules that control cell cycle, Regulation of cell cycle. Cell aging and apoptosis, Properties of cancer cells, Transformation of cells in culture.

Module 6: Current Trends in Cell Biology (6)

Stem cells and progress in stem cell therapy. Cell imaging techniques: Fluorescence microscopy and Confocal microscopy, FACS. Breakthrough in cell biology – review on the research of Nobel prize winners 2015-2019

Total Hours: 45

Text Books

1. Geoffrey M. Cooper and Robert E. Hausman, The Cell: A Molecular Approach, Fifth Edition, ASM Press and Sinauer Associates, Inc., USA, 2015.
2. Bruce Alberts, Alexander Johnson, Julian Lewis and Martin Raff, Molecular Biology of the cell, fifth edition, Taylor and Francis group, 2012.

Reference Books

1. De Robertis & De Robertis, Cell Biology, 4th Edition, 2010.
2. Lodish, H. and D. Baltimore, Cell Biology, W.H. Freeman publishers, 2012.
3. Gerald Karp, Cell and Molecular Biology, John Wiley and sons Inc, 2013.

22BT2071	GOOD MANUFACTURING AND LABORATORY PRACTICES	L	T	P	C
		3	0	0	3

Course objectives:

1. To understand the importance of documentation practices and record-keeping
2. To appreciate the importance of quality control
3. To recognize the scope of quality certifications applicable to Food and Pharmaceutical industries.

Course Outcome:

Upon completion of this course the student should be able to

1. Understand the key regulatory and compliance elements with respect to Good Manufacturing Practices, Good Laboratory Practices and Good Clinical Practices.
2. Formulate check lists and SOPs for various assessment and accreditation process
3. Implement Good laboratory and manufacturing practices in Food and Pharma Industries
4. Organize readiness in conduct of audits and trials
5. Assess biological safety and hazards
6. Gain knowledge on regulatory affairs

Module 1: Introduction to GxP (GMP, GLP, GCP) (6 Hours)

GxP-Introduction, definitions, requirements and historical background, WHO guidelines on GLP and GMP, Quality assurances in Good Laboratory Practices, Principles for documentation (SOP).

Module 2: Quality Standards and Quality Assurances (6 Hours)

Quality Standards- Advantages and Disadvantages, Concept of Quality Control Quality Assurance- Their functions and advantages, Quality assurance and quality management in industry, Customer requirement of quality

Module 3: Good Manufacturing Practices in Pharmaceutical and Food Industries (12 Hours)

Types of validation in Pharma industry Scope and importance of Validation, Limitations, Validation of Analytical Procedures as per ICH Guidelines, Hygienic design of food plants and equipment's, Sanitation in warehousing, Principles of quality by design (QBD), Introduction to the concept of Design of Experiment (DOE), Application of QBD principles in Biotech product development. Case studies: Example of QBD and DOE in Process Development, Example of DOE in analytical development

Module 4: Quality Control (8 Hours)

Introduction to Quality control and Total Quality Control in the food industry, Food Inspection and Food Law, Critical Control Points in Food Industries: Critical Quality control point in different stages of production including raw materials and processing materials, Food Quality and Quality control including the HACCP system, ISO 9000 & ISO14000: Overview, Benefits, Elements, steps for registration, NABL accreditation: Principles and procedure

Module 5: Biosafety (8 Hours)

Introduction: Historical Background, Biosafety in Laboratory/ institution. Laboratory associated infections and other hazards, Assessment of Biological Hazards and levels of biosafety, Primary Containment of Biohazards, Biosafety Levels, Recommended Biosafety Levels for Infectious Agents and Infected Animals Biosafety guidelines, Government of India Guidelines; Industrial hygiene: Check for microbial contaminants, evaluation and control

Module 6: Regulation on Clinical and Preclinical Studies (5 Hours)

Regulation on Clinical and Preclinical Studies, Formulation, Production, Management, Authorization and marketing of drugs, Guidelines on animal studies

Textbooks:

1. Emmet P. Tobin, cGMP starter guide: Principles in Good Manufacturing Practices for Beginners, , Createspace Independent Publishing Platform, April 2016.
2. Cooper BN, Good Manufacturing Practices for Pharmaceuticals: GMP in Practice, Createspace Independent Publishing Platform, July 2017.
3. Sarwar Beg and Md Saquib Hasnain, Pharmaceutical Quality by design: Principles and application, Academic press, March 2019.
4. Andrew Teasdale, David Elder, Raymond W. Nims, ICH quality guidelines- An implementation guide, Dec 2017.

Reference Books:

1. Gajendra Singh, Gaurav Agarwal an Vipul Gupta, Drug regulatory affairs, CBS publication, 2005.
2. Ron S. Kenett, Shelemyahu Zacks, Daniele Amberti, Modern Industrial Statistics: with applications in R, MINITAB and JMP, 2nd Edition, Wiley, January 2014.
3. Marc P. Mathieu, New Drug Development: A regulatory overview, Nov 2000.

20BT2004	WORKSHOP PRACTICES IN BIOTECHNOLOGY	L	T	P	C
		0	0	2	1

Course Objectives:

1. To impart knowledge ongood Laboratory Practices
2. To impart knowledge on planning and procedures to develop models in biotechnology laboratories.
3. To impart knowledge on sequence of operations adopted in laboratories to fabricate models.

Course Outcomes:

1. Understand various laboratory tools and their applications.
2. Prepare basic solutions for chemical applications and their disposal.
3. Learn basic electrical processes involved in equipment and their trouble shooting.
4. Understand plumbing
5. Design and fabricate the various objects in sheet metal using hand tools.
6. Apply manufacturing process for various biotech applications.

List of Experiments:

1. Measurements, tools and its usages
2. Fundamental electricals, electronics and trouble shooting
3. Basics of laboratory safety, first aid and disposal process
4. Basics of calculations and measurements
5. Introductory plumbing
6. Computer hardware and installations

Sheet metal fabrication and carpentry

20BT2009	BIOCHEMISTRY	L	T	P	C
		3	0	0	3

Course Objectives:

1. To facilitate strong knowledge on metabolic pathways and their regulations
2. To articulate the importance of bioenergetics
3. To gain knowledge on the inborn errors of metabolism.

Course Outcomes:

The students will be able to

1. Acquire knowledge on the metabolic pathways
2. Summarize the biosynthesis and degradation pathways of amino acids
3. Explain the importance of bioenergetics and energy rich compounds.
4. Understand the metabolic reactions of nucleotides
5. Learn the various inborn errors of metabolism
6. Analyze the anabolic and catabolic reactions of lipids

Module 1: Carbohydrate metabolism (8 hrs)

Introduction to metabolism and bio-catalysis, Glycolysis, TCA cycle Pentose phosphate pathway, Glycogenesis and Glycogenolysis; Glycogen storage diseases; Photosynthesis – C3,C4 and CAM.

Module 2: Amino acid metabolism (8 hrs)

Transamination and urea cycle. Biodegradation of selected amino acids- Ala, Thr, Leu, Ile, Tyr, Phe, Trp. Biosynthesis of amino acids- tyrosine. phenylalanine and tryptophan and inborn errors of amino acid metabolism.

Module 3: Fatty acid metabolism (8 hrs)

Biosynthesis and oxidation of fatty acids, ketogenesis, energetics of Beta oxidation, cholesterol biosynthesis and degradation, inborn errors of lipid metabolism

Module 4: Nucleic acid metabolism (8 hrs)

Anabolism of purines and pyrimidines, catabolism of purines and pyrimidines, regulatory pathways, inborn errors of purine and pyrimidine metabolism

Module 5: Bioenergetics (5 hrs)

Definition, redox biochemistry. Energy rich compounds. Respiratory chain and Oxidative phosphorylation.

Module 6: Integration of metabolic pathways and regulation (8 hrs)

Overview of integrated metabolic pathways – primary and secondary metabolites; Coordinated Regulation of Glycolysis and Gluconeogenesis, The Metabolism of Glycogen, Coordinated Regulation of Glycogen Synthesis and degradation.

Text Book:

1. Murray R.K, Granner B.K, Mayes P.A, Rodwell V.W. "Harper's Biochemistry", Prentice Hall International, 4th edition, 2008.

Reference Books

1. Lehninger, David L. Nelson & Michael M. Cox, "Principles of Biochemistry", Freeman Publishers,7th edition, 2017.
2. Lubert Stryer, "Biochemistry", WH Freeman & Co., 4th edition, 2000.
3. Voet and Voet, "Biochemistry", John Wiley & Sons Inc., 2nd Edition, 2013.

20BT2007	BIO-ANALYTICAL TECHNIQUES	L	T	P	C
		3	0	0	3

Course Objectives:

1. To provide the students an ability to understand the principles of instrumentation
2. To impart the knowledge of different techniques and methods in biotechnology
3. To improve the understanding of applications of techniques in the field of biotechnology

Course Outcomes:

1. Understand the concepts of calibration and testing
2. Illustrate the different methods of analytical techniques for quantitative analysis
3. Explain importance of centrifugation and chromatography as analytical techniques
4. Demonstrate the gel electrophoresis and thermal analytical techniques
5. Analyze the methods of structural elucidation of different compounds
6. Illustrate importance of radioactive isotopes in modern research

Module 1:Basics of Bio-Analytical Techniques (9)

Classification of instrumental methods; Concepts of accuracy, precision and limits of detection (LOD); Types of errors–random and systematic; Calibration of instrumental methods comparison with standards, Buffers, pH – pH meter and applications, Extraction techniques–Principle of solid extraction (Soxhlet)

Module 2:Spectroscopy Techniques (9)

Basic principle of Spectroscopy -Beer-Lambert's law, Principle, Instrumentation and applications of colorimeter, Fluorimeter, Flame photometer, Nephelometer, Conductivity meter, spectrofluorometric and Spectrophotometer: types– UV – visible – NIR spectroscopy, Raman spectroscopy.

Module 3:Analytical Centrifugation (6)

Basic principle of centrifugation- centrifugal force, sedimentation coefficient, Svedberg units (S), Instrumentation for centrifugation- ultracentrifuges. Application of centrifugation, analytical and preparative centrifugation, Comparison of differential, zonal and isopycnic centrifugation methods, Safety and rules of operation.

Module 4:Chromatography Techniques (9)

Principle, types and applications of analytical chromatography- Thin layer, Normal phase chromatography, reversed phase chromatography, Ion exchange chromatography, gel permeation

chromatography, Chiral chromatography, Bioaffinity chromatography, hydrophobic interaction chromatography, Chromatogram analysis for quantitation GC and HPLC.

Module 5:Electrophoresis &Thermal Analytical Techniques (7)

Principle, Types and applications of Electrophoresis– agarose gel, polyacrylamide gel (PAGE), SDS-PAGE–principle, instrumentation and applications; Quantitative electrophoresis, isoelectric focusing–principle and applications; Thermo gravimetric analysis (TGA)-Principle, instrumentation and applications

Module 6:Structural Elucidation and Radioisotope Methods (5)

Mass spectrometry–principle, instrumentation (electron spray ionization [ESI] & chemical ionization [CI]) and applications; nuclear magnetic resonance (NMR) –principle, instrumentation and applications, Radioactive isotopes, GM counter, Scintillation counter, Applications in Medicine & Diagnosis.

Total Hours: 45

Text Books:

1. Willard and Merrit, Instrumental Methods and Analysis. VI Edition, CBS Publishers & Distributors; 2002.

Reference Books:

1. Gurdeep R. Chatwal and Sham K. Anand. Instrumental Methods of Chemical Analysis. 5th Edition. Himalaya Publishing House, India. (2012).
2. Sharma B.K.. Instrumental Methods of Chemical Analysis. 24th revised and enlarged edition. GOEL Publishing House, India. (2014).
3. Keith Wilson and John WalkerPrinciples and Techniques of Practical Biochemistry and Molecular Biology. 7th Edition. Cambridge University Press, U.K. (2010).
4. Douglas A. Skoog, F.James Holler and Stanley R. Crough. Instrumental Analysis. 6th Edition. Brooks Cole Publishing Company. USA, (2007).
5. Avinash Upadhyay, Kakoli Upadhyay and Nirmalendu Nath. Biophysical Chemistry: Principles and Techniques. Himalaya Publsihing House Pvt. Ltd. India, (2014).

20BT2008	BIO ANALYTICAL TECHNIQUES LAB	L	T	P	C
		0	0	3	1.5

Course Objective:

1. To impart technical knowledge about the working principle and applications of different equipment related to biotechnology experiments.
2. To enable the students to understand the principles of instrumentation
3. To impart the knowledge of different techniques and methods in biotechnology

Course Outcome:

1. Understand the basic measurement methods and its applications in biotechnology
2. Describe the instrumentation and applications of different spectroscopic techniques
3. Demonstrate the principles, techniques and applications of chromatography.
4. Explain the determination of pH and their applications in buffer preparations
5. Understand different purification techniques of primary and secondary metabolites
6. Examine the applications of equipment involved in experimental biotechnology

List of Experiments

1. Verification of Beers Law and Construction of Beers Law plot
2. Determination of analytical wavelength for given sample
3. Calculation of LOD and LOQ of an analytical technique
4. Estimation of Polyphenol by Colorimetric method
5. Preparation of buffer solution with Henderson-Hasselbach equation and its verification with pH meter
6. Titration curves of Acetic acid and Citric Acid using pH meter
7. Determination of protein molecular weight by SDS-PAGE
8. Identification of amino acids by ascending paper chromatography
9. Determination of turbidity by nephelometry

10. Conductivity measurement in titration
11. Separation of secondary metabolites by Silica gel column chromatography and quantification using spectrophotometer
12. Extraction of secondary metabolites from plant samples using Soxhlet apparatus and quantification using spectrophotometer

References:

1. R. Mahesh, Sajeev C, N. Sridhar, Laboratory manual on "Instrumental Methods of Analysis" – EDD Notes. 4 thEdition. 2003.
   B. K. Sharma. "Instrumental Methods of Chemical Analysis", 27th Edition. Goel Publishing House, Meerut. 2011

20BT2011	MICROBIOLOGY	L	T	P	C
		3	0	0	3

Course Objective:

1. To highlight the functions and characteristics of microorganisms
2. To study the growth of microorganisms and the impact of environment on their growth
3. To evaluate explicitly, the metabolic pathways, role of microbes in public health; insight into the physical and chemical control of microorganisms

Course Outcome:

The students will be able to;

1. Recall the basic knowledge on the development of microbiology
2. Recognize the fundamental concepts pertaining to the structure and functions of microbes
3. Appraise the importance of microscopy, staining techniques and classify the microorganisms
4. Apply appropriate physical and chemical methods to control the growth of microbes
5. Formulate the nutritional requirements for microbial growth and their metabolism
6. Compare and categorize the interactions of microorganisms with humans and animals

Module 1: History and Classification (9)

Historical perspectives of microbiology, Classification-systemic and numerical classification, 16Sr RNA classification Microscopy – light, phase, fluorescent and electron microscopy (SEM and TEM), Confocal Laser Scanning Microscopy (CLSM)- principles of different staining techniques - Gram staining, acid fast, capsular staining and spore staining.

Module 2: Microbial Structure and Multiplication (7)

Cell Morphology and Structure of Prokaryotes-bacterial cell wall, Multiplication of bacteria, Life cycles-viruses (bacteriophage), algae (Chamydomonas), protozoa (Plasmodicum vivax), fungi (Rhizopus stolonifer), yeast (Neurospora crassa) and actinomycetes, Lichen symbiosis.

Module 3: Microbial Nutrition, Growth and Control (7)

Nutritional requirements of microorganisms, factors affecting the growth of microorganisms, Bacterial Growth- Growth curve pattern, measuring the bacterial growth, Growth kinetics, mathematical nature and expression of growth, concept of geometric & arithmetic nature of growth, asynchronous and synchronous cultures, diauxic growth-

Module 4: Control of Microorganisms (6)

Prevention of bacterial growth- Physical and chemical control of organisms, Antibiotics- antibacterial agents, anti-fungal agents and anti-viral agents, Antibiotic susceptibility test. -

Module 5: Medical Microbiology (8)

Normal flora of human healthy host, Common diseases caused by microbes: Bacterial diseases: Typhoid, Diphtheria, Cholera, Tuberculosis, Leprosy, Plague, Syphilis, Gonorrhea; Viral diseases: Herpes, Polio, Hepatitis, AIDS, Rabies, SARS, H1N1, Ebola and Covid-19; Protozoan diseases: Malaria: common types of fungal infections-Candidiasis.

Module 6: Soil, Environmental and Food Microbiology (8)

Soil microflora and biogeochemical cycles, Bio fertilizers: VAM and Rhizobium, Aerosols, fresh water microflora, Microbiology of potable water, purification and sewage disposal, Significance of microbes in food- Probiotics and fermented products-sauerkraut, cheese.

Total Hours: 45

Text Books

1. Pelczar MJ, Chan ECS and Krein NR, Microbiology, Tata McGraw Hill Edition, New Delhi, India.2007
2. Ananthanarayanan and Panicker, "Microbiology" Orientblackswan, 2015.

Reference Books

1. Talaron K, Talaron A, Casida, Pelczar and Reid. Foundations in Microbiology, W.C.Brown Publishers, 2001.
2. Prescott LM, Harley JP, Klein DA, Microbiology, 3rd Edition, Wm. C. Brown Publishers, 2001.
3. Lim D, "Microbiology", Second Edition, WCB-Mc Graw Hill, 2001.

20BT2012	MICROBIOLOGY LAB	L	T	P	C
		0	0	3	1.5

Course Objectives:

1. To enable the students to understand the basic principles involved in the isolation of different kinds of microorganisms and gain accurate handling of microorganisms
2. To learn the different parts of microscopes and their functions
3. To identify the microorganisms using various staining techniques and biochemical tests

Course Outcomes:

1. Understand the basic knowledge on microbiological lab safety guidelines
2. Recognize the parts/functions of microscopes
3. Experiment with transfer of living microbes using aseptic technique
4. Develop media for cultivation of microorganisms
5. Demonstrate microbial isolation and staining techniques for identification of microorganism
6. Analyze different kinds of microorganisms present in clinical and environmental samples

List of Experiments:

1. Lab safety method and Regulations, Sterilization techniques- Autoclave, Hot air oven, Filter sterilization
2. Media preparation- Nutrient broth, Nutrient agar, slants, soft agar
3. Culturing of microorganisms– in broth and in plates (pour plates, streak plates)
4. Staining Techniques (Simple, Gram staining and negative staining)
5. Exposing the Sabouraud's agar plate in different location -Fungal identification by LPCD mount
6. Motility test by Hanging drop method
7. Antibiotic sensitivity assay – Disc and Well diffusion method
8. Effect of Disinfectants- Phenol Coefficient
9. Enumeration of micro-organisms- Serial dilution plating
10. Biochemical test -Gram negative –Indole test, Methyl red test, Voges Proskauer test, Cirtate test, Triple sugar iron test
11. Biochemical test -Gram positive – Catalase test, Coagulase test, Starch hydrolysis test
12. Growth Curve in Bacteria and preservation of bacterial culture

20BT2010	BIOCHEMISTRY LAB	L	T	P	C
		0	0	3	1.5

Course Objectives:

1. To acquire knowledge on the various biochemical analysis
2. To facilitate for understanding the skills of the students in Qualitative and Quantitative Analysis of biomolecules.

3. To articulate the various estimation techniques

Course Outcomes:

1. Understand the basic concept, applications of tests, titrations and estimations of biomolecules
2. Demonstrate the basic lab skill in preparing different solutions of different concentrations and their measurement tools with representing units
3. Apply the basic reaction principle in estimation of different biomolecules using suitable method
4. Analyse the various tests and identify the different carbohydrate, amino acid and lipid, DNA, RNA, enzymes and antioxidant molecules present in the given sample solution.
5. Apply suitable extraction methods for the estimation of different biomolecules.
6. Evaluate the level of biomolecules in different food materials

List of Experiments

1. Estimation of total carbohydrate by Anthrone method
2. Estimation of reducing sugars by Di Nitro Salicylic acid method
3. Estimation of cholesterol by Zak's method
4. Estimation of protein by Lowry's/ Bradford's method
5. Enzyme assay – Alkaline phosphatase
6. Enzyme assay - Amylase
7. Estimation of amino acid by Ninhydrin method
8. Estimation of DNA by diphenylamine method
9. Estimation of RNA by orcinol method
10. Antioxidant assay
11. Estimation of starch
12. TLC separation of phytochemicals

Reference Book:

1. Sawhney S. K., Randhir Singh, Introductory practical Biochemistry. Narosa publishers, 2006

20BT2005	BASICS OF INDUSTRIAL BIOTECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objective:

1. To ensure students have a base on the History of Biotechnology and its source of origin and the analysis on the different kinds of microorganisms which could be deployed for industrial biotechnology.
2. To facilitate knowledge for the various production strategies of bio products employed for sustainable bioprocess development
3. To ensure the need to know various production strategies of bio products employed for better sustainable bioprocessdevelopment on an industrial scale.

Course Outcome:

At the end of the course students will be able to

1. Remember the use of microbes for developing industrial products and processes.
2. Understand the techniques for genetic improvement of micro-organisms to improve yield of bio-products.
3. Explain the technical issues related with microorganisms in the production of bio products.
4. Analyze industrial-market value of these bio products and relate them with the scope of biotechnology
5. Relate the clinical and biological significance of these bio products for sustainable bioprocess engineering
6. Evaluate the difference in manufacturing commercial bio products and all the ethical issues involved in it.

Module 1: Introduction to Industrial Bioprocess (9)

Historical overview of industrial bioprocess: Fermentation – Bacterial, Fungal and Yeast, Biochemistry of fermentation. Traditional and Modern Biotechnology – A brief survey of organisms, reactors, processes,

products, media- design of experiment. Basic concepts of upstream and downstream processing, process flow sheeting – block diagrams, pictorial representation and the future perspectives in Industrial Biotechnology.

Module 2: Production of Primary Metabolites (9)

Primary metabolites; Industrial production of commercially important organic acids, amino acids, alcohols and Vitamins.

Module 3: Production of Secondary Metabolites (9)

The production of secondary metabolites of high commercial value like antibiotics and steroids: Penicillin V, Streptomycin and Ampicillin sodium salt and steroids.

Module 4: Production of Enzymes and other Products (9)

Production of industrial enzymes such as lipases, cellulase, lysozyme, bio preservatives (Nisin), cheese, biopolymers (xanthan gum, PHB), bio-flavours and bio-pigments-luciferin, carotene,antioxidant – glutathione.

Module 5: Production of Modern Biotechnological Products (5)

Production of recombinant fine bio products for pharmaceutical applications like monoclonal antibodies and vaccines. Products from plant and animal cells.

Module 6: Production of Target Specific Fine Bioproducts: (4)

Production of Single Cell Proteins; Bio-fertilizers, Plant Products of Industrial Importance-Synthetic Seeds, Arbutin. Animal Products of Industrial importance-Gelatin, spray dried yolk powder. Bioremediation and Bioenergy-fuel from biomass, biogas, bio-refineries, Microbial Enhanced Oil Recovery (MEOR).

Text Books

1. Prescott and Dunn, Industrial Biotechnology, Agro bios (India), 2005.
2. A.H.Patel, Industrial Microbiology, 2nd Edition, 2011.
3. P.F. Stanbury and Whitaker, Fermentation Technology, Second Edition, 2009.

References Books

1. Elmar Heinzle, Sustainable Bioprocess Development, 2008.
2. Robert H. Perry, Handbook of Chemical Engineering, 2000.
3. Glazer AN, Nikaido H, The process of Microbial Enhanced Oil Recovery and Microbial Leaching Text books, 2007.
4. Poonam Kushwaha, Handbook of Pharmaceutical Technology, Jaypee Digital, 2015.

20BT2015	BIOPROCESS PRINCIPLES	L	T	P	C
		3	0	0	3

Course Objectives:

1. To understand the principles of bioprocessing and appreciate its applications in Bioprocess Technology
2. To ensure students to have a strong knowledge on the importance of medium formulations and optimization
3. To provide facts on sterilization kinetics

Course Outcomes:

1. Understand the process of fermentation and its requirements
2. Remember the process of media formulation and medium optimization for fermentation process
3. Analyze the kinetics of sterilization process
4. Apply knowledge on isolation and storage of industrially important microbes
5. Analyze parameters to control during fermentation process
6. Evaluate the process of sterlization by filtration

Module 1: Overview of Fermentation Process (6 hrs)

Overview of fermentation industry, general requirements of fermentation processes, basic configuration of fermenter and ancillaries, aseptic condition and containment, Sampling

Module 2: Parameters to be Monitored and Controlled in Fermentation Processes (6 hrs)

Basic configuration of fermenter and ancillaries, main parameters to be monitored and controlled in Fermentation processes- Temperature, pressure, flow measurement, rate of stirring, shaft power, weight, Dissolved Oxygen, pH, inlet and exit gas analysis.

Module 3: Medium Formulation and Optimization (12 hrs)

Criteria for good medium, medium requirements for fermentation processes, carbon, nitrogen, minerals, vitamins and other complex nutrients, oxygen requirements, medium formulation for optimal growth and product formation, examples of simple and complex media, design of various commercial media for industrial fermentations, medium optimization

Module 4: Sterilization Kinetics (9 hrs)

Thermal death kinetics of microorganisms, Death kinetics problems, Design of sterilization time- batch and continuous heat sterilization of liquid media, design of sterilization equipment - batch and continuous.

Module 5: Filter Sterilization of Air and Media (6 hrs)

Filter sterilization of liquid media, air sterilization and design of depth filters and problems

Module 6: Selection of Seed Culture for Industrial Fermentation (6 hrs)

Screening and selection of industrially important microbes- primary screening- Crowded plate technique, Auxonography, enrichment culture and indicator dye, screening based on desired characteristics, preservation and storage of industrially important microbes, Quality control of preserved stock cultures.

Total Hours: 45

Text Book:

1. Peter F. Stanbury, Stephen J. Hall & A. Whitaker, "Principles of Fermentation Technology", Butterworth – Heinemann an Imprint of Elsevier India Pvt.Ltd., 2nd edition, 2005.

Reference Book:

1. Shuler, M.L. and Kargi,F. " Bioprocess Engineering - Basic concepts" , Prentice Hall of India Pvt. Ltd., 2nd edition, 2002

20BT2017	MOLECULAR BIOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

1. To understand the basics of molecular biology and gene expression.
2. To understand DNA damage and repair systems
3. To impart an overview on the regulation of gene expression

Course Outcomes:

1. Recall the fundamental concepts of the prokaryotic and eukaryotic genome organization, its replication and gene expression
2. Understand the process of replication, transcription and translation
3. Recognize common mutations, their natural repair systems and inhibitors of gene expression
4. Distinguish the process of replication, transcription and translation of prokaryotes and eukaryotes
5. Appraise the post-synthesis modifications for transcription and translation
6. Comprehend the role of genetic code, chromatin, operons and cis/trans elements in gene regulation

Module 1: Genome Organization (8 hrs)

Classical experiments to prove genetic material: Griffith, Hershey and chase; Avery McLeod & McCarty. Genome organization in prokaryotes and eukaryotes – Molecular structure of DNA and RNA, Forms of DNA and RNA; Bacterial Recombination: Transformation, Transduction –types and Conjugation.

Module 2: DNA Replication – Prokaryotes (9 hrs)

DNA replication- Semi conservative replication - Meselson Stahl experiment, Enzymes in replication, Replication in prokaryotes-E.coli, D-loop and rolling circle mode of replication, regulation of replication, replication in virus - linear viral DNA replication, RNA replicase, Reverse transcriptase.

Module 3: DNA Replication – Eukaryotes and Mutations (5 hrs)

Replication in eukaryotes and telomere replication. Mutation: types, DNA repair systems - methylation, mismatch repair, Photo reactivation repair, SOS repair, recombination repair.

Module 4: Transcription (9 hrs)
RNA polymerase, features of promoters and enhancers, transcription factors, Prokaryotic and eukaryotic transcription, post-transcriptional modification - RNA splicing and RNA editing, Inhibitors.
Module 5: Genetic Code and Translation (7 hrs)
Elucidation of genetic code - salient features, Process of translation in prokaryotes and eukaryotes, Post-translational modifications, Inhibitors.
Module 6: Regulation of Gene Expression (7 hrs) Regulation of gene expression: In prokaryotes - lac and trp operons. Regulation in eukaryotes – cis and trans elements, chromatin re-organization in gene regulation, Regulation at transcription and Translation
Review on loss of regulation and defect in DNA repair system leading to genetic disorders and diseases.

Total Hours: 45

Text book:

1. David Friefelder, "Molecular Biology", Narosa Publ. House. 6th edition 2003.

Reference books:

1. David R. Hyde, "Genetic and Molecular Biology", Tata McGraw Publications, New Delhi, 4th edition, 2010.
2. Lehninger, A. L, Nelson. D. L and Cox, M. M, "Principles of Biochemistry", Freeman Publishers, New York, fourth edition, 2005.

22BT2072	METABOLIC ENGINEERING	L	T	P	C
		3	0	0	3

Course Objectives:

1. To develop skills in the area of metabolic engineering
2. To impart knowledge on complex regulatory mechanisms to control the dynamics of the cellular metabolism
3. To familiarize advanced molecular techniques to enhance the product yield

Course Outcomes:
At the end of course student will be able to

1. Comprehend modern biology with engineering principles
2. Recall the principles and regulation of metabolic pathways
3. Construct suitable metabolic flux models using available metabolic engineering tools
4. Familiarize with the conceptual framework involved in metabolic control analysis
5. Appreciate the process of bioconversion to produce commercial product
6. Describe the industrial applications of metabolic engineering in the field of medicine, energy, and environment

Module 1: Introduction to metabolic engineering and its importance (8 hours)
Introduction to metabolism, catabolism, anabolism; Key differences between metabolic controls of prokaryotes and eukaryotes; Improvement of cellular properties, altering transport of nutrients including carbon and nitrogen; Methods for metabolic characterization: Genome, Transcriptome, Proteome
Module 2: Regulation of Metabolic Pathways (6 hours)
Induction-Jacob Monod Model and its regulation, differential regulation by isoenzymes, concerted or cumulative feedback regulation. Regulation in branched pathways, Mutants which do not produce feedback inhibitors or repressors- auxotrophs-lysine, purine nucleotides; trophophase- idiophase relationship
Module 3: Metabolic Flux Analysis (10 Hours)
Metabolic flux analysis; Building stoichiometric matrix; Steady state and pseudo steady state assumptions; Methods for experimental determination of metabolic fluxes by isotope labeling metabolic fluxes using GC-MS
Module 4: Metabolic Control analysis (8 Hours)
Metabolic Control analysis (MCA); control coefficients, MCA of linear and branched pathways, control of flux distribution at branch point, grouping of reactions, optimization of flux amplification
Module 5: Bioconversion (6 hours)

Bioconversion- Factors affecting bioconversion, mixed or sequential bioconversions- Co metabolism, Product inhibition, Conversion of insoluble substances, Applications of Bioconversions

Module 6 Applications of Metabolic Engineering (7 hours)

Strategies for overproduction of commercially important primary and secondary metabolites (e.g. amino acids, organic acids, alcohols and therapeutic compounds), industrially relevant enzymes and recombinant proteins

Textbooks:

1. Gregory N. Stephanopoulos, Aristos A. Aristidou & Jens Nielsen, "Metabolic Engineering: Principles and Methodologies", Academic Press, An Imprint of Elsevier India Pvt. Ltd., 1st edition, 1998.
2. Cortassa S., Aon M.A., Iglesias A.A. and Llyod D., "An Introduction to Metabolic and Cellular Engineering", World Scientific Publishing Co. Pte. Ltd, 2002.
3. Smolke, C.S. (2010) Metabolic Pathway Engineering Handbook: Fundamentals. 1st ed. New York: CRC Press.

Reference Books:

1. Freemont, P.S and Kitney, R.I. (2012). Synthetic Biology – a Primer. World Scientific Publishing Co pvt Ltd
2. Peter F. Stanbury, Stephen J. Hall & A. Whitaker, "Principles of Fermentation Technology", Butterworth – Heinemann An Imprint of Elsevier India Pvt. Ltd., 3rd edition, 2016
3. Crueger W. and Crueger A., "A Text Book of Industrial Microbiology", Panima Publishing Corporation, 2005
4. Cheng Q. "Microbial Metabolic Engineering: Methods and Protocols", Humana Press, First Edition (2011).

22BT2075	BIOPROCESS LAB	L	T	P	C
		0	0	3	1.5

Course Objectives:

1. To learn the culturing of microbes and quantifying biomass production
2. To provide extensive knowledge on enzyme kinetics and growth kinetics
3. To learn immobilization techniques

Course Outcomes:

The students will be able to

1. Acquire knowledge in the process of fermentation.
2. Illustrate medium optimization
3. Demonstrate enzyme assay qualitatively and quantitatively
4. Apply methods to estimate mass transfer coefficient
5. Utilize solid state fermentation for production of fermented products
6. Assess the growth kinetics and enzyme kinetics during fermentation

List of Experiments:

1. Culturing of Different Types of Microorganism in Batch Reactor
2. Estimation of Biomass Production by Wet Weight and Dry Weight Method
3. Comparative study between Free & Immobilized Enzyme
4. Determination of MM Parameters
5. Determination of volumetric mass transfer coefficient using sulphite oxidation method.
6. Immobilization of Enzyme and microbe by entrapment method
7. Medium Optimization Plackett Burmann method
8. Citric acid production by Solid State Fermentation
9. Qualitative Assay of enzyme α-amylase- Starch Plate Technique
10. Quantitative Assay of enzyme α-amylase
11. Production of Wine
12. Growth kinetics of Baker's Yeast

Reference Books:

1. Peter F. Stanbury, Stephen J. Hall & A. Whitaker, "Principles of Fermentation Technology", Butterworth – Heinemann An Imprint of Elsevier India Pvt.Ltd., 2nd edition, 2014.
2. Shuler, M.L. and Kargi,F. " Bioprocess Engineering - Basic concepts" , Prentice Hall of India Pvt. Ltd., 2nd edition, 2016.

20BT2018	GENETIC ENGINEERING	L	T	P	C
		3	0	0	3

Course Objective:

1. Acquaint students with the concepts in Genetic engineering.
2. Develop technical skills about different types of restriction enzymes, types of vectors used for cloning.
3. Impart knowledge in the applications in genetic engineering through transgenesis

Course Outcome:

The students will be able to

1. Describe the basics of genetic engineering
2. Understand the basic tools employed in genetic engineering.
3. Relate and evaluate the use of cloning vectors in genetic engineering.
4. Comprehend the concept of polymerase chain reaction and its applications.
5. Discuss and appraise the strategy and applications of gene cloning.
6. Analyze the importance of transgenesis in biotechnological research.

Module 1: Restriction Enzymes (9)

Restriction enzymes- Classification-nomenclature;Endonucleases, Exonucleases, Ligases- Modifying enzymes; Linkers, Adapters and Homopolymer tailing.

Module 2: Cloning and Expression Vectors (9)

Properties of ideal vectors, Plasmids as vectors- PBR322- pUC vectors--M13-Lambda phage vectors, Cosmid vectors, Phagemids, Shuttle vectors, Expression vectors, YAC, BAC, Mammalian cells-SV40

Module 3: Polymerase Chain Reaction and Hybridization Techniques (9)

Mechanism of Polymerase chain reaction, types of PCR, Inverse PCR, Nested PCR, Molecular beacons, RACE PCR, RAPD, RFLP. Probe Preparation and methods of Labeling, Southern hybridization-Northern hybridization; Western blotting, Autoradiography; DNA finger printing.

Module 4: Construction of Recombinant DNA (5)

Construction of recombinant DNA: Preparation of competent cell-Transformation (Physical, chemical and biological methods of Transformation), transfection- Recombinant selection and screening of Recombinant DNA

Module 5: Gene Sequencing, Libraries and rDNA Applications (9)

Gene Sequencing, Chromosome Walking, Gene Editing- CRISPR-CAS, Genomic Libraries, cDNA libraries, DNA Finger printing.

Module 6: Transgenesis and Bioethics (4)

Transgenic principles in Plant and Animal, Ethical, moral and societal issues pertaining to rDNA technology

Total Hours: 45

Text Books

1. Desmond S. T. Nicholl, "An Introduction to Genetic Engineering", 3rd Edition Cambridge University Press; South Asian edition, 2010.
2. Gene Cloning and DNA Analysis, 6th Edition, Blackwell Publishing Ltd 2010
3. Barry R. Schaller "Understanding Bioethics and the Law: The Promises and Perils of the Brave New World of Biotechnology" Praeger Publishers Inc, 2007.

Reference Books

1. Sandy B. Primrose, Richard Twyman “Principles of Gene Manipulation and Genomics” Backwell Scientific Publications 2010.
2. Sandhya Mitra, “Genetic Engineering Principles and Practice”, Macmillan Publications, 2008.
3. Richard Sherlock, John D. Morrey "Ethical Issues in Biotechnology" Rowman & Littlefield Publishers, 2002.

20BT2019	MOLECULAR BIOLOGY AND GENETIC ENGINEERING LAB	L	T	P	C
		0	0	3	1.5

Course Objectives:

1. Develop comprehensive understanding in the salient features involved in the isolation of Nucleic acids
2. Provide technical skills about cloning methods in genetic engineering
3. Impart knowledge about recombinant molecules and its applications

Course Outcomes:

1. Define the basic concepts involved in the nucleic acid isolation from plant, animal and microorganism sources
2. Explain the principles of quantification of nucleic acids and molecular weight analysis
3. Demonstrate the methods involved in restriction digestion, ligation and transformation
4. Interpret and report the data both quantitatively and qualitatively
5. Knowledge in the amplification of DNA using PCR
6. Design experiments for basic research in rDNA technology and adapt biosafety rules of the labortory

List of Experiments:

1. Isolation of genomic DNA from plant and animal tissue
2. Isolation of genomic and plasmid DNA from microorganism (E-coli)
3. Isolation of RNA by Orcinol method
4. Quantitative and qualitative analysis of isolated genomic DNA using spectrophotometer
5. Agarose gel electrophoresis of DNA and analysis of their molecular weights by gel documentation
6. Amplification of DNA using Polymerase Chain Reaction
7. Restriction enzyme digestion of DNA samples confirmation through agarose gel electrophoresis
8. Ligation of DNA fragments and confirmation through agarose gel electrophoresis
9. Competent bacterial cell preparation
10. Transformation of DNA into competent cells
11. Extraction of proteins from plant or animal tissue and confirmation with qualitative tests
12. Separation and identification of proteins by SDS-PAGE using Coomassie Brilliant Blue stain

Reference

1. Michael R. Green, Joseph Sambrook, Molecular Cloning a Laboratory Manual, 4th ed., Chsl Press, New York.2018.

22BT2074	BIOPROCESS ENGINEERING	L	T	P	C
		3	0	0	3

Course Objective:

1. This course aims at making the students understand the fundamental principles and concepts of Bioprocess engineering.
2. This will help the student understand stoichiometric calculations, models of growth and product formation
3. To understand the basics of oxygen transfer in microbial bioreactors

Course Outcome:

The students will be able to

1. Gain knowledge on principles of stoichiometry and concepts of bioreactor engineering
2. Understand the growth kinetics and enzyme kinetics in fermentation process
3. Apply bioreactor design fundamental in scale up process
4. Evaluate the oxygen requirement in aerobic culture and oxygen limited growth
5. Analyze various bioreactors for fermentation process.
6. Evaluate application of enzymes and the techniques of immobilization

Module 1: Enzyme Kinetics and Inhibition (8 hrs)

Kinetics of enzyme catalyzed reactions. Importance and estimation of Michelis – Menten parameters, Enzyme inhibition types and models- Competitive, Noncompetitive and Uncompetitive inhibitions. Inhibition kinetics- substrate, product and toxic compound

Module 2: Stoichiometry of Cell Growth and Product Formation (6 hrs)

Stoichiometry of cell growth and product formation, elemental balances, degrees of reduction of substrate and biomass, available electron balances, various yield coefficients of biomass and product formation, oxygen consumption and heat evolution in aerobic cultures.

Module3 Simple Unstructured Kinetic Models For Growth (6hrs)

Simple unstructured kinetic models for microbial growth, Monod model, Substrate uptake kinetics and maintenance coefficient, growth of filamentous organisms, product formation kinetics - Leudeking- Piret models, substrate and product inhibition on cell growth and product formation. Determination of kinetic parameters for Monod equation.

Module 4: Oxygen Transfer in Microbial Bioreactors (6 hrs)

Oxygen transfer in microbial bioreactors; oxygen uptake rates and determination of oxygen transfer coefficients (kLa) by correlations and experimental methods; Mass transfer in heterogeneous biochemical reaction system, role of aeration and agitation in oxygen transfer and types of aerators and agitators.

Module 5: Bioreactors for Free and Immobilized Cells (12 hrs)

Bioreactors for free cells – batch, continuous, fed batch, chemostat, Bubble column, air lift loop reactor. Physical and chemical techniques for enzyme immobilization, Design of Bioreactors for immobilized cells: packed – bed and fluidized bed bioreactors, and membrane reactors., comparison of the productivity in batch and continuous culture, concept of HRT, SRT, OLR in CSTR,

Module 6: Scale up and scale down criteria for bioreactors (7 hrs)

Power requirements in mixing under aerated and non-aerated conditions, effects of heterogeneity and bases for scale-up. Mechanistic background of dimensional analysis, the use of dimensionless groups for scaling up, Scale up procedure from laboratory to pilot scale, Fermentation process scale down: benefits of process scale down, regime analysis and strategies for scale down experimentation

Text Books

1. Shuler, M.L. and Kargi,F. " Bioprocess Engineering - Basic concepts" Prentice Hall of India Pvt. Ltd.,2nd edition, 2015.
2. Peter F. Stanbury, Stephen J. Hall & Whitaker. A, "Principles of Fermentation Technology", Butterworth – Heinemann an Imprint of Elsevier India Pvt. Ltd., 2nd edition, 2016.

Reference Books

1. Panda, Tapobrata. Bioreactors: Process and Analysis. India, Tata McGraw Hill Education, 2011.
2. S.Liu, Bioprocess Engineering: Kinetics, Biosystems, Sustainability, and Reactor Design, Elsevier, 2016
3. Najafpour, Ghasem. Biochemical Engineering and Biotechnology. Netherlands, Elsevier Science, 2015.

20BT2025	IMMUNOLOGY	L	T	P	C
		3	0	0	3

Course Objective:

1. This course aims to impart basic knowledge in Immunology encompassing, history, development, trend and its impact on society.

2. To help the students familiarize with the organs and cells of the immune system, the immune response and molecular interactions involved in immune response.
3. To make the students aware of the applications of immunology such as, immunodiagnosis and immunotherapy.

Course Outcome:

The students will be able to

1. Learn the history and development and controversies of the field of immunology.
2. Recognizes the types of immunity, the basic plan of the immune of the immune system and the organs of the immune system.
3. Identify the cells of the immune system and their functions.
4. Understand the functioning of the innate and adaptive immune system
5. Interpret the cellular & molecular interactions, physiology and the pathology of the immune system.
6. Infer of the applications of immunology in diagnosis and treatment of diseases.

Module 1: Immune System (7)

Introduction and an overview of immunology, History of immunology, Types of Immunity - Innate and acquired immunity, Cell mediated and humoral immunity; Design of immune system- recognition & response. Organs of the immune system: Lymphoid organs - primary and secondary.

Module 2:Cells of the Immune System (9)

Granulocytes and Agranulocytes, T and B Lymphocytes, NK cells, macrophage and dendritic cells their structure, characteristics, function and their identification. Haematopoiesis, extravasation, phagocytosis.

Module 3:Humoral System (7)

Molecular nature and function of ; Antigens, epitopes, haptens; Adjuvants. Antibody – structure, Classes, Antibody diversity. Antigen Antibody reactions; Neutralization, Opsonization. Complement system.

Module 4: Adaptive Immunity - Recognition, Responses & Regulation (7)

Major histocompatibility complex; antigen processing and presentation, T-Cell activation and the cellular immune response. Cytokines

Module 5:Immune Function and Dysfunction (8)

Immunity to infections: immunity to virus, prokaryotic (Bacteria), & eukaryotic pathogens (parasites & fungi); Transplantation, graft rejection Immunosuppression –Immune Dysfunction: Autoimmunity, Allergy, Hypersensitivity& Immunodeficiency.

Module 6: Application and Impact of Immunology (7)

Diagnostics; Haemagglutination, ELISA, Immunofluorescence & Immunohistochemistry. Therapeutics and prophylactics; Abzymes, Monoclonal Antibody production, Chimeric & humanized antibodies. Vaccines, anti-vaccination movement and its impact.

Total Hours: 45

Text Books:

1. Roitt I, Male, Brostoff, “Immunology”, Elsevier Saunders, 17th September 2012
2. S.R. Ramesh “Immunology”, McGraw Education -Hill, 2017
3. Kuby J, “Immunology”, WH Freeman & Co., January 2019

Reference Books:

1. Richard Coico, Geoffrey Sunshine, Immunology: A Short Course 7th Edition, Wiley-Blackwell; 7 edition (April 27, 2015)
2. Kenneth Murphy and Casey Weaver, Janeways Immunobiology 9th Edition by Kenneth Murphy and Casey Weaver, Garland Exclusive, June 2016.

20BT2059	IoT IN BIOTECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

The students will be able:

1. To learn the basics of IOT.

2. To identify the various components and application of Biotechnology in IOT.
3. To integrate concepts for research and development in biotechnology using IOT.

Course Outcomes:

The students will be able:

1. Understand the history and basic concepts of IOT.
2. Identify the various components of IOT.
3. Use IOT for different biotechnological applications.
4. Categorize IOT to different pharmaceutical applications.
5. Justify significance of IOT in research and development.
6. Plan IOT with future trends in biotechnology.

Module 1: Historical background of IoT[4 Hours]

The concept, The idea of connected device - "embedded internet" or "pervasive computing". Pioneering work done by Kevin Ashton at Procter & Gamble in 1999 in the field of supply chain management by RFID technology. Gap until 2010. Emergence from 2011 as a technology, Concept - "The Internet of Things".

Module 2: Components of IoT[5 Hours]

Sensors & Actuators, Transceivers, Communication platforms - Ethernet, cellular, and Wi-Fi. Processors & Boards, Power Supplies - Conventional thin film batteries; photovoltaic panels and energy harvesting modules, Gateways & Routers, Devices & Equipment Products used by end users - enabled equipment, wearables, hand-held scanners, and tracking devices.

Module 3: IoT in Biotechnology [6 Hours]

IoT in Agricultural Biotechnology - the demand of more food with other challenges including extreme climatic and weather conditions, reducing ground water supply and associated environmental impact, development of smart sensors, automated hardware's and vehicles, robotics control systems, Agricultural farming - variable rate irrigation optimizer (VRI), soil moisture probes, virtual optimizer PRO and other IoT based systems. Soil fertility. Smart green houses, Drones for aerial monitoring of land. Cloud computing in agriculture.

Module 4: IoT in Pharmaceutical Biotechnology [5 Hours]

Discovery of novel drugs and biologics, Challenges - product instability and subsequent recalls, GMP and GDP regulations, supply chain management. Concept of "Organ in a Chip", Smart warehouses, 2D bar-coding, RFID tags, Automatic Information Data Collection (AIDC) in packaging, Complete digital foot print - cold chains for the temperature-sensitive drugs during the transport.

Module 5: IoT in Research and Development in Biotechnology – Case Studies [5 Hours]

Era of "omics" - high evolutionary pace of novel microbial strains, phages and other biological breakthroughs, acquisition of reproducibility and consistency, Challenge of reproducibility, Case Study - Healthcare leader Bayer, Amgen. Negative Case Study - Amyris (bioreactors). IoT enabled instruments with intelligence, interconnected communication protocols - RF and Bluetooth low energy, high end sophisticated sensors, Cloud servers, Case Study - Laboratory automation - Synbio. (Europe British) enhancing productivity, accuracy and reproducibility, Automated smart labs (USA), Case Study - Ginkgo Bio-works.

Module 6: Current Challenges and Future Prospects [5 Hours]

The emergence of IoT paradigm, Innovation, invention and productivity in biotechnological research for the successful implementation at global scale, Challenges - The complex configurations of IoT devices, Acceptance in biotech industry, End users, Security interfaces, Auditing and logging. Future perspectives - Establishment of network integrity in the R&D laboratory, Networking. Automation in the laboratory.

Total Hours: 30

Text Book:

1. B.K. Tripathy, J. Anuradha. INTERNET OF THINGS (IoT), Technologies, Applications, Challenges, and Solutions. CRC Press London. 2018.

Reference Books:

1. Michael Miller. The Internet of Things: How Smart TVs, Smart Cars, Smart Homes, and Smart Cities Are Changing the World. 2015.

2. Dieter Uckelmann, Mark Harrison, Florian Michahelles. Architecting the Internet of Things. 2011.
3. Sean Dodson and Rob van Kranenburg. The Internet of Things. 2008.

20BT2026	CELL BIOLOGY AND IMMUNOLOGY LAB	L	T	P	C
		0	0	3	1.5

Course Objectives:

1. To enable the students to understand the principles of immunology through experimentation.
2. To impart practical knowledge about the working of the immune system using fish as a model system.
3. To impart the knowledge on the application of immunology in diagnostic and therapeutics.

Course Outcomes:

1. Understand the behaviour of cells
2. Demonstrate the basic skill in preparation of antigen and administering
3. Demonstrate the skill in collecting blood and separating serum.
4. Evaluate the generation of antibodies through different experimental methods.
5. Analyze the effect of adverse immune reactions.
6. Apply skill in screening epitopes and production of antibodies.

List of Experiments

1. Blood Grouping
2. Detection of Typhoid Antigens using Widal Test
3. Stages of Mitosis & Meiosis
4. Study of Tonicity using RBC model
5. Maintenance of Fish & Dissection of Lymphoid organs
6. Preparation and Administration of Antigen.
7. Drawing Blood and separation of Serum.
8. Estimation of specific Antibodies using Haemagglutination.
9. Estimation of specific Antibodies using immunodiffusion
10. Graft Rejection
11. Delayed type hypersensitivity in Fish
12. Immunoinformatics & Epitope Prediction using online software.

Reference:

1. Dinakaran Michael R, Immunological Techniques Using Fish Model- A Laboratory Manual, Year, Notion Press.

22BT2073	CHEMINFORMATICS AND MEDICINAL CHEMISTRY	L	T	P	C
		2	1	0	3

Course Objectives:

1. To introduces the small molecule-ligand-oriented in silico physico-chemical aspects of rational drug design.
2. To represent of chemical information, chemical databases and data mining, molecular drawing and interactive visualization can able to understand the novel concept of new drug discovery.
3. To build ligand ab initio or from similar ligands, with and without known macromolecules, assessing activity and toxicity and drugability.

Course Outcomes:

At the end of course student will be able to

1. Investigate chemicals and materials that are not practical for laboratory analysis
2. Develop individual model molecules or the behaviors of chemical compounds within the natural world
3. create a catalog, categorize, organize, and search the structures of chemicals
4. Describe the computational chemistry to simplify problems and make calculations that are used in laboratory experimentation.
5. Understand the concepts of rational drug discovery on medicinal chemistry.
6. Create the skills on basics of biophysical properties and biological activity parameters of anti-inflammatory drugs.

Module 1: Chemistry and Information technology (8hrs)

Overview of pharmaceutical chemistry , Ligands and Targets, in-silico representation of chemical information.

Module 2: Chemical Databases (7hrs)

Data Mining, Chemical/biochemical data collation, retrieval, analysis and interpretation.

Module 3: Computer-Aided Drug Design (8hrs)

Overview, Structural Homology Modelling Tools, Docking Tools and Screening Tools, Artificial intelligence in chemistry, Simulation methods for molecules and materials.

Module 4: Structural molecular mechanism (7hrs)

Stereochemistry and mechanism, coordination chemistry for drug design, in silico tools for medicinal chemistry (docking, MD, de novo drug design), Organic reaction mechanism, Logic in organic synthesis, QSAR, pharmacological screening, chemistry of drug action, Pharmaceutical Preformulation, Solid State Pharmaceutics, Drug metabolism, pharmacokinetics, pharmacodynamics.

Module 5 : Medicinal chemistry (8 hrs)

History and development of medicinal chemistry, Physicochemical properties in relation to biological action Ionization, Solubility, Partition Coefficient, Hydrogen bonding, Protein binding, Chelation, Bioisosterism, Optical and Geometrical isomerism, Drug metabolism, Drug metabolism principles- Phase I and Phase II. Factors affecting drug metabolism including stereo chemical aspects

Module 6: Anti-inflammatory agents (7 hrs)

Sodium salicylate, Aspirin, Mefenamic acid*, Meclofenamate, Indomethacin, Sulindac, Tolmetin, Zomepriac, Diclofenac, Ketorolac, Ibuprofen*, Naproxen, Piroxicam, Phenacetin, Acetaminophen, Antipyrine, Phenylbutazone.

Text Book:

1. Muthukumarasamy Karthikeyan and Renu Vyas. Practical chemoinformatics. Springer, soft-cover ISBN 9788132234913, 2014.
2. Silverman, Richard B., and Mark W. Holladay. The organic chemistry of drug design and drug action. Academic Press, 2014.

Reference Book:

1. Bajorath, Jurgen. Chemoinformatics for Drug Discovery. John Wiley & Sons, 2013.
2. Cramer, C.J., Essentials of Computational Chemistry, 2nd Ed., John Wiley & Sons Ltd., 2004.

Essentials of Foye's Principles of Medicinal Chemistry – 2016. An Introduction to Medicinal Chemistry, by Graham L. Patrick.

20BT2068	PRINCIPLES OF PLANT BIOTECHNOLOGY AND APPLICATIONS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To recall the plant tissue culture techniques and its applications.
2. To examine the plant transformation and breeding techniques
3. To employ the drug production strategies in plant biotechnology

Course Outcomes:

1. Summarize cell and tissue culture techniques.
2. Illustrate the knowledge on plant genetic engineering tools.
3. Enumerate the different vectors used in plant transformation

4. Employ different methods of in vitro drug production techniques
5. Examine the principles of plant breeding and protection
6. Assess the different bioreactors and its applications in plant biotechnology

Module 1: Plant Tissue Culture (8 hrs)

History-tissue culture lab - establishing aseptic conditions -types of media and their preparation plant hormones -organogenesis–direct and indirect (meristem/shoot apex culture, callus and suspension culture), Significance and application of anther culture, ovule culture, embryo culture-somatic embryogenesis-protoplast fusion-somaclonal variation-artificial seeds-micropropagation. Hardening and acclimatization of tissue cultured plants

Module 2: Plant Genetic Engineering Tools (8 hrs)

Biology of Agrobacteriumtumefaciens-plant transformation methods-stable and transient-Agrobacterium-mediated,biolistic,PEG/liposome-mediated,electroporation,chloroplast Transformation, protoplast transformation, site directed integration of transgene (zinc finger).

Module 3: Vectors in plant transformation (8 hrs)

Binary and co-integrate vectors-gateway vectors-promoters-selectable and screenable markers-marker free transgenics-significance and applications. Plant as Bioreactors- edible Vaccines; Germplasm conservation; Gene Banks; Crop improvement; legume symbiosis, N_2 Fixation; Regulation of NIF and NOD Genes.

Module 4: Secondary metabolite production in tissue culture: **(6 hrs)**

Callus culture initiation, biotransformation, elicitation, hairy root culture, immobilization, permeabilization.

Module 5: **Plant Breeding and Protection (6 hrs)**

Sexual hybridization Mutagenesis – Polyploidy, Genetic resources for breeding, Germplasm conservation, Marker assisted selection, cultivar release and commercial seed production, Biotic stress factors and natural disease resistance pathways, Abiotic stress factors - tolerance mechanisms.

Module 6: **Bioreactors for drug production (9 hrs)**

Bioreactors: In-Process control (IPC), determination of plant cell growth: Illumination, Types of bioreactors for plant cell suspension culture, Re- and multi usable bioreactors for plant cell suspension culture, Single-use and disposable bioreactors for plant cells and tissue cultures, Re- and multi usable bioreactors for root culture, Single use vs re- and multiusable bioreactors. Advantages and disadvantages.

Total Hours: 45

Text Books:

1. Adrian Slater, Nigel W. Scott, Mark R. Fowler,"Plant Biotechnology-TheGenetic Manipulation of Plants"third edition, Oxford University Press, 2008.
2. Mantal S.H., Mathew J.A.,Mickee R.A., Principles of Plant Biotechnology. An Introduction to Genetic Engineering in Plants, Blackwell Scientific Publication, 2006.

Reference Books:

1. Dodds J.H., Plant Genetic Engineering, Cambridge University Press, 2005.
2. C Neil Stewart Jr. "Plant Biotechnology and Genetics "- John Wiley & Sons, Inc., New Jersey 2008

20BT2069	ADVANCES IN ANIMAL BIOTECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

1. To impart technical knowledge in cell culture techniques and development of skills for *In vitro* culture of cells and its products
2. To conceptualize tissue engineering techniques for organ transplantation
3. To acquaint learners with the development of transgenic animals, and debate on the boon and bane of Genetically Modified Organisms

Course Outcomes:

Students will be able to:

1. Demonstrate the cell culture techniques for maintenance of cell lines

2. Recognize the importance of scaling up of cell culture for development of cell culture products
3. Interpret the applications of tissue engineering and 3D cell culture techniques
4. Relate the need of genetic screening for *In vitro* fertilization
5. Apply the knowledge of livestock improvement using transgenesis
6. Assess the scope, applications and ethical issues in animal biotechnology

Module 1: Cell Culture, Cell Separation and Characterization (12 hrs)

Layout of cell culture laboratory, Introduction to culture techniques, chemically defined media, serum and serum free media. Primary cell culture and types, Establishment of cell lines, maintenance and preservation, Cell separation by density gradient, Fluorescent activated cell sorting, Characterization: Morphology, Chromosome analysis, Isoenzymes, Cell Banks.

Module 2: Scaling up of Cell Cultures and Product Development (6hrs)

Scaling up of adherence and suspension cultures, Continuous flow culture, Cell culture as a source of various products-Vaccines, Enzymes and Hormones.

Module 3: Tissue Engineering :(7hrs)

3D culturing, protocols for 3D culturing of cells, Scaffolds as biomaterials for tissue engineering, Stem cells in tissue engineering, Organs for transplantation protocols (Skin, Bone, Nerve and Cardiovascular Tissue)

Module 4: Nutritional Biotechnology (5hrs)

Bio conservation of lignocellulose (high quality dietary fiber), Genetic manipulation of microbes for improved feed utilization and health, Fermentation process of milk and meat

Module 5: Micromanipulation of Embryos (7hrs)

Micromanipulation technology, Enrichment of X and Y bearing sperms from semen samples of animals, Artificial insemination and germ cell manipulation, *In vitro* fertilization and embryo transfer technology.

Module 6: Transgenic Animals and Live Stock Improvement (8hrs)

Molecular diagnosis of animal diseases, Concepts of transgenic animal technology: Strategies for the development of transgenic animals and their importance in Biotechnology, Stem cells in the development of transgenic animals, Marker assisted selection, Gene knock out in animals, gene banking, Use of Artificial Intelligence in Animal monitoring, Ethical and Regulatory issues in Animal Biotechnology.

Total Hours: 45

Text Books:

1. Ranga M.M. Animal Biotechnology. 3rd ed., Agrobios. 2007.
2. *R. Ian Freshney. Introduction to Culture of Animal Cells:* A Manual of Basic Technique and Specialized Applications, 6thed.,.*Publisher*, John Wiley & Sons, 2011.
3. Birbal Singh, Gorak Mal, Sanjeev K Goutam. Advances in Animal Biotechnology, 1st ed. Springer, 2019.

Reference Books:

1. Animal Biotechnology 1**. Niemann,** Heiner, **Wrenzycki**, Christine .ed., Springer Publishing. 2018.
2. Levine MM, Kaper JB, Rappuoli R, Liu MA, Good MF. *New Generation Vaccines*. 3rd Ed. Informa Healthcare. 2004.
3. Animal Cell Culture by John R.W. Masters 3rd ed., Oxford University Press, 2009.

20BT2052	PLANT AND ANIMAL TISSUE CULTURE LAB	L	T	P	C
		0	0	4	2

Course Objectives:

1. To learn the basic techniques of animal cell culture
2. To impart the technical skills of plant tissue culture
3. To develop the knowledge of preservation and conservation techniques in cell culture

Course Outcomes:

1. Gain knowledge in Animal cell culture technique

2. Understand the sterilization techniques and its importance
3. Analyze and determine the growth of cells in *in vitro*conditions
4. Evaluate the viability cells in animal cell culture
5. Apply the propagation methods for commercially important plants
6. Adapt *in vitro* techniques in animal and plant cell cultures for product development

List of Experiments:

1. Basics of tissue culture laboratory design and maintenance.
2. Packing and Sterilization of glass and plastic wares for cell culture.
3. Passaging of cell line
4. Cryopreservation
5. Membrane integrity assay- Trypan Blue Staining
6. Metabolic activity assay- LDH assay
7. Media preparation and sterilization techniques.
8. Callus induction from explant
9. Shoot induction by axillary bud breaking method
10. Establishment of hairy root culture from explant
11. Cell Suspension Culture for metabolite production and growth kinetic studies
12. Preparation of synthetic seeds.

References:

1. Plant Tissue Culture: Theory and Practice Satish Kumar Sinha Oxford Book Company 2012
2. Bojwani, S.S. "Plant Tissue Culture: Applications and Limitations", Elsevier science publishers, 2001.
3. R. Ian Freshney. Introduction to Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, Sixth Edition. Publisher, John Wiley & Sons, 2011.

22BT2097	COMPREHENSIVE PRACTICES	L 0	T 0	P 3	C 1.5

Course Objective

1. To understand the recent literature on cutting edge technologies
2. To integrate the learning in different domains of biotechnology
3. To develop a holistic view on the different domains of biotechnology

Course Outcome

1. To acquire knowledge on cutting edge technologies from published literature
2. To understand the recent developments in Biochemistry, Microbiology, Cell biology
3. To apply logical skills to adapt concepts learnt in classroom
4. To apply analytical skills to assimilate the concepts learnt in classroom
5. To analyze the concepts in Bioprocess Principles, Bioprocess Engineering
6. To evaluate the recent developments in Bio-analytical Techniques, Metabolic Engineering

Comprehensive Practices will be conducted in a lab mode with 10 evaluation components, viva voce and end semester examination. Various cutting edge technologies or recent trends in the different courses would be identified and discussed.

20BT2023	DOWNSTREAM PROCESSING	L 3	T 0	P 0	C 3

Course Objectives:

1. To know characteristics of cell types and their disruption methods.
2. To understand the principles of isolation, separation and purification of bioproducts
3. To analyze the different polishing methods available for bioproducts.

Course Outcome:

1. Understand the fundamentals of product isolation and separation techniques.
2. Distinguish various techniques for product recovery and isolation.
3. Explain operating principles across different solid(liquid)-liquid separation process
4. Analyze product recovery in solid-liquid separation processes.
5. Compare the performances of different extraction techniques
6. Apply separation techniques for bio product recovery.

Module 1:Overview Of Bioseparations (6)

Broad classification of bio products, characteristics of fermentation broths and bio products. Cell disruption and pretreatment: Analysis of various physical, chemical, enzymatic and mechanical methods for release of intracellular products, case studies related to choose cell-disruption techniques

Module 2:Product Recovery (10)

Filtration: Equipments for conventional filtration- filter media, pretreatment methods, general filtration theory- Darcy's law, compressible and incompressible filter cakes, filtration cycle. Continuous filtration equipments in industries, Sedimentation: Mechanisms of theory, thickeners, classifiers, applications in downstream processing. Centrifugal bio separations: Theory of Tubular-bowl centrifuges- maximum efficiency, centrifuge selection-RCF, scale up of centrifuges- sigma factor analysis, equivalent time, efficiency.

Module 3:Isolation of Bioproduct (11)

Adsorption: Adsorption kinetics, isotherm, assessment of adsorption capacity, Extraction, aqueous two-phase extraction, Extraction efficiency in multi-stage extractor, NH_4SO_4 based protein fractionation, Membrane separation processes: Membrane, materials and fabrication, reverse osmosis

Module 4:Purification (7)

Chromatographic separations, Classification of techniques, elution chromatography- retention theory, Ion exchange chromatography, gel permeation chromatography, gel filtration techniques for molecular weight determination, affinity chromatography, Reverse phase, hydrophobic interaction chromatography

Module 5: Product Polishing and Stabilization (5)

Crystallization: Basic principles- nucleation and crystal growth- supersaturation theory- commercial crystallizers Product drying: Heat and mass transfer in drying- types of commercial dryers- vacuum dryers, freeze dryers, spray dryers

Module 6: Process Simulation and Case Study (6)

Insulin Case Study: State-of-the-art in downstream processing of monoclonal antibodies, citric acid, penicillin, lactic acid, Process trends in design and validation

Total Hours: 45

Text Books

1. Paul A Belter, EL Cussler, Wei-shou Hu, Bioseparations: Downstream Processing for Biotechnology - Wiley Interscience, 2011.
2. Sivasankar B, Bioseparations: Principles and Techniques, Prentice-Hall of India Pvt. Ltd., 2008.

Reference Books

1. Roger G. Harrison, Paul Todd, Scott R. Rudge, Demetri P. Petrides, "Bioseparations science and Engineering" Oxford University Press, 2015.
2. Krishna Kant Prasad, Nooralabettu "Downstream Process Technology: A new Horizon in Biotechnology" PHI learning Private Limited, 2010.
3. Coulson JM and Richardson JF, Chemical Engineering, Volume 2: Particle technology and separation processes" Butterworth Heinemann, 2006.
4. Christie john Geankoplis "Transport Processes and Separation Process Principles: Includes Unit Operations" prentice hall of India private limited, 2006.

20BT2054	ENVIRONMENTAL BIOTECHNOLOGY	L	T	P	C

		3	**0**	**0**	**3**

Course Objectives:

1. To acquire the knowledge of environmental problems and develop technologies
2. To develop skills in bioreactors and biotreatment methods of industrial wastewater
3. To find solution to create green and clean environment

Course Outcomes:

1. Infer the biotechnological solutions to address environmental issues including pollution, mineral, renewable energy and water recycling
2. Appraise the opportunities for incorporating environmental quality into products, processes and projects.
3. Develop technologies for bioremediation and biodegradation
4. Acquaint oneself with the pertinent legislation and methodology of pollutants
5. Demonstrate the professional responsibility towards protecting the environment
6. Apply scientific solutions for the development of environmental sustainable products

Module1: Environmental Monitoring (8 hrs)

Major types of environmental pollutants, Sampling, physical, chemical and biological analysis, Removal of toxicants from contaminated sources by bioadsorption techniques.

Module2: Wastewater Treatment (9 hrs)

Characteristics of wastewater, Primary treatment by sedimentation, Secondary treatment by suspended growth reactors - Activated sludge process, Aerobic – digestion, Anaerobic processes and Lagoons. Attached growth reactors - Trickling filter, Rotating Biological Contactor, Fluidized bed biological reactors, up flow anaerobic sludge blanket reactor, Biological nutrient removal and Sequential batch reactor. Tertiary treatment- Polishing operations: Sand filtration, adsorption by activated carbon and chlorination.

Module3: Air Pollution and Control Technology (7 hrs)

Classification of pollutants, Effects of air pollution, Control devices for particulate and gaseous contaminants: Settling chambers, Cyclone separator, Venturi scrubber, Biofiltration, Fabric filters, Electrostatic precipitators, absorption, adsorption, condensation and flaring.

Module4: Solid Waste Treatment and Management (8 hrs)

Types, sources and properties of solid waste, Collection of solid wastes, Transfer and transport, solid waste treatment methods: incineration, vermicomposting, land filling, conversion of solid waste into useful products: *in situ and ex situ* bioremediation, Reuse, Recycle and Recovering (3Rs).

Module5: Hazardous Waste Treatment and Biowaste Management (6 hrs)

Types of hazardous waste, Xenobiotic compounds, recalcitrance, biodegradation of xenobiotics and oil spills, biological detoxification, Genomic tools for bioremediation

Module6: Development of Bio products and Technologies (7 Hrs)

Bioleaching, Bio pesticide, Bio fertilizer, Biodegradable plastics, integrated bio-digester for biogas and electricity generation, biosensor for environmental monitoring, quorum sensing.

Total Hours: 45

Text Books:

1. Jogdand, S.N. Environmental Biotechnology Himalaya Publishing House, New Delhi,2012
2. Prescott, Harley and Klein, "Microbiology", 5th edition, McGraw Hill, 2014.

Reference Books:

1. Karnely D. Chakrabarty K. Ovnen G.S. Biotechnology and Biodegradation, Advances in Applied Biotechnology series, Vol. Gulf Publications Co. London, 2009.
2. Graty. C.P.L., Daigger, G and Lim, H.C, Biological Wastewater Treatment. 3rd Edition, Marcel Dekker, 2008
3. Piasecki, B.W., Fletcher, K. A. and Mendelson, F. J. 2010. Environmental Management and Business Strategy John Wiley & Sons, 2010.

20BT2030	CONCEPTS OF BIOINFORMATICS	L	T	P	C
		2	0	2	3

Course Objectives:

1. To learn and understand specific databases and perform effective database searches.
2. To learn and perform various *Insilco* analysis for gene and protein structure and function identification
3. To learn and perform target identification for drug-designing and to have a platform for interchange and exchange of knowledge with academia and industry.

Course Outcomes:

Students are able to

1. Gain knowledge on Biological databases and tools.
2. Understand the significance of biological databases and their utilization.
3. Apply the knowledge of Bioinformatics skill to solve the biological problems in Genomics and Proteomics
4. Analyse different types of Biological databases and resources.
5. Evaluate the vital role drugs interacting to the target.
6. Constructphylogenetic tree based on Molecular data

Module 1: Introduction to Bioinformatics (5)

Introduction to Bioinformatics, Importance and uses of Bioinformatics Scope of Bioinformatics. Genebank file format, SwissProt File format, Protein Databank file format

Module 2: Biological Databases (5)

Introduction to Biological databases, organization and management of databases, Primary sequence databases, Secondary databases- nucleic acid sequence databases - Protein sequence data bases.

Module 3:Sequencing Alignment and Dynamic Programming (5)

Sequence Alignment, Local alignment, Global alignment, pairwise Alignment, multiple sequence alignments. Dynamic programming in sequence alignment: Needleman-Wunsch Algorithm, Smith Waterman Algorithm, Amino acid Substitution matrices (PAM, BLOSUM).

Module 4: Applied Bioinformatics Tools and Data Resources (5)

Entrez, ExPASy, EMBL-EBI tools and Data Resources: DNA/RNA Sequence Analysis tools, Gene Expression, Protein Sequence Analysis, Primer Design, Tools for Primer Design, Primer Design Application.

Module 5: Computational Genomics and Proteomics (6)

Genomics databases, Proteomics databases, Comparative genomics and Proteomics; Understanding DNA microarrays and protein arrays, Gene and protein prediction strategies, Molecular Evolution and Phylogeny, Molecular data of Phylogenetic Tree, Distance Based Treen Reconstruction Methods, UPGMA, Neighbor Relation, Neighbor joining, Character based Tree Reconstruction method, Maximum Parsimony Method, Maximum Likelihood method.

Module 6: Molecular Modeling and Simulation (4)

Basic concepts of Homology, threading, ab-initio protein structural modeling, Energy Minimization methods and Applications, Molecular simulation methods and applications, target identification and validation.

Total Hours: 30

Text Books:

1. Dan Gusfield, "Algorithms on Strings Trees and Sequences", Cambridge University Press, Cambridge, 2017.
2. David Mount W., "Bioinformatics sequence and genome analysis", CBS Publishers, New Delhi, 2nd Edition, 2013.
3. D.W. Mount. Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbour Laboratory Press, New York, 2012.

References Books:

1. Andreas D. Baxevanis, B. F. Francis Ouellette, Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, 3rd Edition, Wiley and Sons, 2012
2. S.C. Rastogi and N. Mendiratla and P.Rastogi. Bioinformatics methods and applications-Genomics, Proteomics and Drug Discovery. Prentice Hall India, 2013
3. A.M. Lesk. Introduction to Bioinformatics. Oxford University Press India, 2017.

List of experiments:

1. NCBI Database
2. ExPASy Database
3. EMBOSS pairwise Sequence Alignment
4. Freiburg RNA Tools Smith-Waterman
5. Swiss-Prot Database
6. Gene Prediction
7. Protein Familes –SCOP,Pfam and CATH
8. Secondary Structure prediction
9. EMBL-EBI database
10. Analysing the geometry of protein and visualize the protein using protein databank and swiss-pdb viewer.
11. Homology Modelling Using Modeller Protein
12. Tree Reconstruction based on Molecular Phylogeny Data

Reference Books:

1. Andreas D. Baxevanis, B. F. Francis Ouellette, Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, 3rd Edition, Wiley and Sons, 2012
2. Rastogi S.C. and N. Mendiratla and P.Rastogi. Bioinformatics methods and applications-Genomics, Proteomics and Drug Discovery. Prentice Hall India, 2013
3. Lesk A.M. Introduction to Bioinformatics. Oxford University Press India, 2017.

20BT2057	BIOETHICS, IPR AND BIOSAFETY	L	T	P	C
		3	0	0	3

Course Objectives:

1. To understand Biosafety regulations and IPR

2. To know ethical reasons behind transgenics and human genome projects
3. To know ethical issue of organ transplantation and transgenic animals

Course Outcomes:

1. Recall different rDNA technology of transgenic in animals, humans and microorganisms
2. Understand the various biosafety regulations in transgenics
3. Illustrate IPR and patent procedures
4. Comprehend on various techniques of genome, stem cells and organ research in humans
5. Aware of modern rDNA research and its ethical procedures
6. Comprehend on recent ethical, legal and social economic impacts of rDNA research in biotechnology and its applications

Module 1: Biosafety (6 hrs)

Introduction – biosafety issues in biotechnology - historical background. Biological Safety Cabinets, Primary Containment for Biohazards. Biosafety Levels - Levels of Specific Microorganisms, Infectious Agents and Infected Animals.

Module 2: Biosafety Guidelines(8 hrs)

Guidelines and regulations (National and International including Cartegana Protocol) – operation of biosafety guidelines and regulations of Government of India; Definition of GMOs & LMOs. Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture. Environmental release of =GMOs - Risk - Analysis, Assessment, management and communication

Module 3: Intellectual Property Rights (9 hrs)

Introduction to IPR, Types of IP - Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge and Geographical Indications. Importance of IPR – patentable and non patentables, patenting life, legal protection of Biotechnological inventions. Agreements and Treaties - History of GATT & TRIPS Agreement; Madrid Agreement; Hague Agreement; WIPO Treaties; Budapest Treaty; PCT; Indian Patent Act 1970 & recent amendments. IPR and WTO regime - Consumer protection and plant genetic resources

Module 4: Patents and Patent Laws (9 hrs)

Objectives of the patent system - Basic, principles and general requirements of patent law. Biotechnological inventions and patent law - Legal development - Patentable subjects and protection in Biotechnology. Patent Filing Procedures - National & PCT filing procedure, Time frame and cost, Status of the patent applications, Precautions while patenting, disclosure/ nondisclosure, financial assistance for patenting, introduction to existing schemes. Patent licensing and agreement. Patent infringement - meaning, scope, litigation, case studies

Module 5: Bioethics (9 hrs)

Bioethics: Introduction to ethics and bioethics, framework for ethical decision making. Ethical, legal and socioeconomic aspects of gene therapy, germ line, somatic, embryonic and adult stem cell research. Ethical implications of GM crops, GMO's, human genome project, human cloning, designer babies, biopiracy and biowarfare. Eugenics and its possible approaches. Animal right activities - Blue cross in

India- society for prevention of cruelty against animals. Ethical limits of Animal use. Green peace - Human Rights and Responsibilities

Module 6: Organs Transplantation in Human Beings (5 hrs)

Organs Transplantation in Human Beings, Ethics in Xenotransplantation, Bioethical Issues.

Total Hours: 45

Text Books:

1. Sree Krishna. Bioethics and Biosafety in Biotechnology. New Age International Publishers, New Delhi, 2007
2. Sateesh, M.K., Bioethics and Biosafety, IK International Publishers (2008)

Reference Books:

1. Jonathan, Y.R., Anthology of Biosafety (Vols. 1-4), American Biological Safety Association (2005).
2. Encyclopedia of Ethical, Legal and Policy issues in Biotechnology, John Wiley & Sons Inc. (2005).

20BT2024	DOWNSTREAM PROCESSING LAB	L	T	P	C
		0	0	3	1.5

Course Objectives:

1. To strengthen principles of the unit operations involved in the separation and purification of a biological product
2. To learn on cell disruption techniques, solid liquid separation
3. To learn about product isolation, purification and polishing

Course Outcome

After successful completion of the course, the students will able to

1. Remember cell disruption techniques for intracellular product recovery.
2. Understand the separation methods to recover microbial cells from aqueous suspensions
3. Apply techniques of bulk product isolation.
4. Design purification strategy based on product characteristics.
5. Evaluate finishing operations.
6. Analyze scale up operations.

List of Experiments

1. Calculation of area of thickener using batch sedimentation data.
2. Estimation of Sigma-factor in batch centrifuge.
3. Calculation of specific cake-resistance in batch Filtration process
4. Estimation of degree of cell disruption in physical techniques (sonication, homogenizer)
5. Estimation of protein recovery involving solvent precipitation technique.
6. Determination of partition coefficient of organic acid between water-chloroform
7. Estimation of protein recovery in ammonium sulfate precipitation technique
8. Determination of equilibrium moisture content in batch drying technique.
9. Separation of phytochemicals using column Chromatography
10. Analysis of isotherm parameters for citric acid adsorption onto charcoal
11. Effect the coagulant dose in flocculation efficiency
12. Determination of theoretical plates equivalent in packed-bed distillation.

Text Books:

1. Paul A Belter, EL Cussler, Wei-shou Hu, Bioseparations: Downstream Processing for Biotechnology - Wiley Interscience, 2011.
2. Sivasankar B, Bioseparations: Principles and Techniques, Prentice-Hall of India Pvt. Ltd., 2008.

Reference Books:

1. Roger G. Harrision; Paul W. Todd; Scott R. Rudge, "Bioseparations Science and Engineering" Oxford University Press, 2015.
2. Don W. Green; Nooralabettu Krishna Prasad "Downstream Process Technology: A New Horizon in Biotechnology" phi learning private limited, 2010.
3. Richardson J.F.; Harker J.H.; Backhurst J.R. "Coulson and Richardson Chemical Engineering volume 2: Particle Technology and Separation Processes" Butterworth-Heinemann, 2006

22BT2076	DATA ANALYSIS AND SIMULATIONS	L	T	P	C
		2	1	0	3

Course Objectives:

1. To understand and implement the principles and methods of statistical analysis for a range of real-world data sets.
2. To provide a basic understanding of data analysis using statistics and to use computational tools on problems of applied nature.
3. To apply data science techniques such as machine learning, deep learning to biological data.

Course Outcomes:

At the end of course student will be able to

1. Evaluate the correlation among data sets and adapt data visualization
2. Apply relevant statistical analysis to real-time data
3. Analyze associations, or causal structures from data sets
4. Apply machine learning techniques to healthcare and biological data
5. Adapt ANN based models for biological data
6. Evaluate quality of models developed using machine learning tools

Module 1: Data preprocessing and visualization (7 hours)

Types of data, dealing with missing data, data visualization: Scatter Plot, histogram, group plots, box plots etc., dimensionality reduction.

Module 2: Data analysis (7 hours)

Statistical analysis, hypothesis testing, significance of p-value, chi-square, T-test, Interval, Estimation for the Comparison of Means, tutorials using softwares such as SPSS, Stata, SAS.

Module 3: Mining Frequent Patterns (7 hours)

Associations and correlations, classification: decision tree classifiers, Bayesian classifiers, and rulebased classifiers , cluster analysis : Fuzzy clustering and probabilistic model-based clustering, outlier detection.

Module 4: Machine learning (9 hours)

Supervised learning, unsupervised learning, logistic regression, Support Vector Machines (SVMs), decision trees, clustering and model evaluation.

Module 5: Artificial neural networks (ANN) (8 hours)

Introduction to ANNs, Types of ANN: feedforward neural networks, recurrent neural network, convolutional neural network, case studies for the application of deep learning in biology and health care research.

Module 6: Model selection and validation (7 hours)

Model class selection, Overfitting, Cross-validation, Information Criteria (AIC, BIC)

Total hours: 45

Text Books:

1. Introduction to Machine Learning using Python, Jeeva Jose, Khanna Publishing House, 2019.
2. Data Mining: Concepts and Techniques, Jiawei Han, Micheline Kamber, and Jian Pei, Elsevier; Third Edition, 2012

References:

1. Data Visualization – A Practical Introduction by Kieran Healy, Princeton University Press, 2019.
2. Deep Learning – Rajiv Chopra, Khanna Publishing House, 2019.
3. Deep Learning by Ian Goodfellow, Yoshua Bengio, MIT Press 2017.

22BT2077	BIG DATA ANALYTICS	L	T	P	C
		2	1	0	3

Course Objectives:

1. To inculcate critical thinking to carry out scientific investigation objectively without being biased with preconceived notions.
2. To equip the student with skills to analyze problems, formulate an hypothesis, evaluate and validate results.
3. To prepare students for pursuing research or careers in industry in mathematical sciences and allied fields.

Course Outcomes:

The student should be able to:

1. Understanding of basic characteristics application and challenge of bigdata analytics.
2. Describe the traditional about storage, organization, and manipulation of structured data.
3. Understand the challenges associated with modified enzyme systems using big data computing.
4. Able to analyse learn the risk, safety, and ethics of gene editing tools.
5. Develop the perspective of the complexity to establish models through Hadoop.
6. Illustrate and implement the concepts by taking an application problem.

Module 1: Introduction (8hrs)

Data Storage and Analysis - Characteristics of Big Data – Big Data Analytics - Typical Analytical Architecture – Requirement for new analytical architecture – Challenges in Big Data Analytics – Need of big data frameworks

Module 2: Traditional methods (7hrs)

Overview of traditional methods: homologues recombination for gene knockout. RNAi system, Cre-LoxP and Flp-FRT systems.

Module 3: Engineered enzyme systems (8hrs)

Zinc finger nucleases (ZFNs), transcription-activator like effector nucleases (TALEN), meganucleases and the clustered regularly interspaced short palindromic repeats (CRISPR/Cas9) system.

Module 4: Gene editing (8hrs)

Design of sgRNA. Multiplex Automated Genomic Engineering (MAGE). Applications in Targeted gene mutation, Gene therapy, creating chromosome rearrangement

Module 5: Hadoop Ecosystem (7hrs)

Introduction to Hadoop ecosystem technologies: Serialization: AVRO, Co-ordination: Zookeeper, Databases: HBase, Hive, Scripting language: Pig, Streaming: Flink, Storm

Module 6: Application of Big data analysis (7hrs)

Application in biofuel production and in bioremediation. Ethics, safety and risk of targeted gene editing.

Text Books:

1. Foundations of Systems Biology, Hiroaki Kitano (Editor),MIT Press, 2001
2. Computational Modeling of Genetic and Biochemical Networks, James M. Bower, Hamid Bolouri, MIT Press,2000.
3. Gene Regulation and Metabolism: Postgenomic Computational Approaches, Julio Collado-Vides (Editor), Ralf Hofestadt (Editor),MIT Press,2002

Reference Books:

1. Uri Alon, An Introduction to Systems Biology: Design Principles of Biological Circuits, 2/e, CRC Press, (2006).
2. Kitano et al., Systems Biology: A Brief Overview, Science, (2002), 295, 1662-1664.
John Ross et al., Complex Systems: From Chemistry to Systems Biology, PNAS, (2009), 106, 6433–6434.

22BT2078	BIOSIMILARS TECHNOLOGY	L	T	P	C
		3	0	0	3

Course objective:

1. To describe biotechnologies used for biologics production and delivery.
2. To explain the specific aspects of biologics in pharmacodynamics and pharmacokinetics.
3. To describe the advancements and challenges for using gene therapy to treat various disorders.

Course Outcomes:

Students completing this class will be able to:

1. Demonstrate appropriate depth and breadth of knowledge in Biologics.
2. Understand the concept and characteristics of biologics, biosimilars, and bioequivalence.
3. Distinguish the differences and similarity between biologics and chemical drugs.
4. Describe and apply the principles of the biotechnologies
5. Describe the procedure and techniques for target identification and validation for biologics
6. Compare/contrast the pharmacodynamics and pharmacokinetics of biologics versus chemical drugs.

Module 1: Introduction to Biopharma (8hrs)

Generics in Biopharma, definition of biologics, biosimilars, super biologics, differences between chemical genetics and biosimilars, The developmental and regulatory challenges in biosimilar development, Prerequisites for Biosimilar development, Biosimilar market potential.

Module 2: Types of biosimilar drugs (8hrs)

Peptides, proteins, antibodies, Enzymes, Vaccines, Nucleic acid based therapies (DNA, RNA, etc), Cell based therapies (including stem cells)

Module 3: Characterization methods (7hrs)

Aggregation- precipitation, floccule strength, precipitate ageing & kinetics, adsorption of proteins & peptides on surfaces, effect of temperature on protein structure, hydration & thermal stability of proteins - solid powders, suspension on non-aqueous solvents, reversed micelles, aqueous solution of polyols, analytical and spectrophotometric characterization of proteins, protein sequencing and structure determination

Module 4: Bioequivalence studies (8hrs)

Immunogenicity & allergenicity of biosimilars; factors affecting immunogenicity - structural, post-translational modifications, formulations, impurities, manufacturing and formulation methods for biosimilars; types of bioequivalence (average, population, individual), experimental designs & statistical considerations for bioequivalence studies (Non-replicated designs – General Linear Model, Replicated crossover designs), introduction to "ORANGE BOOK" & "PURPLE BOOK".

Module 5: Case studies (7hrs)

Indian companies working in this space & their product pipeline (Biocon, Intas, Dr Reddy's, Reliance, Bharat Biotech, Lupin, Cipla, Shanta, etc); products - Erythropoietin, growth hormone, granulocyte stimulating factors, interferons, streptokinase, monoclonal antibodies.

Module 6: Therapeutic Biologic Applications (BLA) (7hrs)

Biological products, like other drugs, are used for the treatment, prevention or cure of disease in humans. Public Health Service (PHS) Act, FDA's Center for Drug Evaluation and Research (CDER) and Center for Biologics Evaluation and Research (CBER)

Text Books:

1. Laszlo Endrenyi, Paul Declerck and Shein-Chung Chow, Biosimilar Drug Development, Drugs and Pharmaceutical Sciences, Vol 216, CRC Press.
2. Cheng Liu and K. John Morrow Jr., Biosimilars of Monoclonal Antibodies: A Practical Guide to Manufacturing, Preclinical and Clinical Development, Wiley, Dec 2016.

Reference Books:

1. Schoenwald, R.D., "Pharmacokinetics in Drug Discovery and Development", CRC Press,2002.
2. Niazi, Sarfaraz K. "Handbook of Biogeneric Therapeutic Proteins: Regulatory,Manufacturing, Testing, and Patent Issues". CRC Press, 2006.

3. Glick B.R. and Pasternak J.J. "Molecular Biotechnology: Principles and applications ofrecombinant DNA" 3rdEdition., ASM Press, 2003.

20BT2079	WASTE MANAGEMENT AND UPCYCLING	L 3	T 0	P 0	C 3

Course Objectives:

1. To understand the basic concept of waste and its sustainable management.
2. To inculcate knowledge and skills in the collection, transport, treatment, disposal and recycling process for solid and liquid wastes.
3. To acquire knowledge on how waste can be converted to wealth in a sustainable way.

Course Outcomes:

The students will be able to:

1. Categorize different types of wastes and develop concepts in the field of waste management.
2. Relate the characteristics features of different wastes and influencing factors.
3. Analyze suitable techniques to transport and disposal of wastes.
4. Compare among various waste processing technologies.
5. Formulate treatment process of wastewater and sludge disposal.
6. Develop sustainable technologies for waste conversion into value-added products.

Module 1: Classification of Wastes and it's Management (8 hrs)

Types and sources of solid and hazardous wastes; Need for solid and hazardous waste management; Salient features of Indian legislations on management and handling of municipal solid wastes, nuclear wastes, electronic wastes, plastics and fly ash; Financing and public private participation for waste management; Induction of 5R's in waste management-Refuse, reduce, reuse, repurpose, recycle.

Module 2: Waste Characterization and Source Reduction (7 hrs)

Waste generation rates and variation; composition, physical, chemical and biological properties of solid wastes; Hazardous characteristics-TCLP tests; Waste sampling and characterization plan; Source reduction of wastes, waste exchange, extended producer responsibility; Collection of municipal solid wastes, Handling and segregation of wastes at source-storage.

Module 3: Transport and Disposal of Wastes (7 hrs)

Transfer stations optimizing waste allocation; Compatibility, storage, labelling and handling of hazardous waste; Hazardous waste manifests and transport; Waste disposal options; Disposal in landfills, landfill classification, types and methods; Site selection; Design and operation of sanitary landfills, secure landfills and landfill bioreactors; Leachate and landfill gas management; Landfill closure and environmental monitoring.

Module 4: Waste Processing Technologies (9 hrs)

Material separation and processing technologies; Biological and chemical conversion technologies; Methods and controls of composting; Thermal conversion technologies and energy recovery; Incineration, solidification and stabilization of hazardous wastes; Treatment of biomedical wastes; Health considerations in the context of operation of facilities, handling of materials and impact of outputs on the environment.

Module 5: Wastewater Reuse and Residual Management (8 hrs)

Individual and Common effluent treatment plants; Joint treatment of industrial and domestic wastewater; Zero effluent discharge systems; Quality requirements for wastewater reuse; Industrial reuse, present status and issues; Disposal on water and land; Residuals of industrial wastewater treatment; Quantification and characteristics of sludge; Thickening, digestion, conditioning, dewatering and disposal of sludge; Management of RO rejects.

Module 6: Sustainable Technologies for Waste Conversion into Value-added Products (6 hrs)

Waste biomass into bioenergy, Liquid form of biofuels-Bioethanol, Gaseous form of biofuels-Biohydrogen; Conversion of waste into nanoparticles, Application of waste nanomaterials into the environmental sectors; Textile waste upcycling; Upcycling of chicken wastes into fibers; Circular bioeconomy.

Text Books:

1. M.J. Rogoff, “Solid Waste Recycling and Processing” Elsevier, 2nd Edition, 2013.
2. Jonathan W. C. Wong; Rao Y. Surampalli; Tian C. Zhang; Rajeshwar D. Tyagi; and A. Selvam “Sustainable Solid Waste Management, ASCE, First edition, 2016.

Reference Books:

1. A.Virginia, “Industrial wastewater management, treatment & disposal”, Water Environment Federation, 3rd Edition, 2008.
2. O.P. Gupta, “Elements of Solid & Hazardous Waste Management”, Khanna Publishing House, New Delhi, 2019.

22BT2080	GENE EXPRESSION AND TRANSGENICS	L	T	P	C
		3	0	0	3

Course Objectives:

1. Provide the technical details and use of different gene expression systems for overexpression of recombinant proteins.
2. Develop technical skills in purification of proteins expressed in different expression systems.
3. Impart knowledge about the use transgenic animals in research.

Course Outcomes:

The students will be able to

1. Define the concepts in gene expression system
2. Relate and evaluate the use of cloning vectors and promoters in genetic engineering.
3. Understand and analyze the process of purification of proteins
4. Discuss and appraise the strategy and applications of gene cloning
5. Analyze the importance of transgenesis in biotechnological research.
6. Comprehend the current status of genome sequencing projects

Module 1: Recombinant protein expression vectors and protein purification (8 hrs)

Vectors with tags -His, GST, MBP. Cleavable tag and non-cleavable tags. Vectors for tag free protein expressions. Over-expression of integral membrane proteins. Plasmid vectors for expression in plants.

Module 2: Over expression for protein production in various organisms (9 hrs)

Overexpression in E. coli, B. subtilis, Corynebacterium, Pseudomonas fluorescens, yeasts like S. cerevisiae and Pichia pastoris, insect cell lines like Sf21 and Mammalian cell line like Chinese Hamster ovary (CHO) and Human embryonic kidney (HEK), Plant single cell.

Module 3: Cell free protein Expression systems (7 hrs)

Cell free protein Expression-Cell free extracts from *E. coli*, rabbit, wheat germ, insect. Purification of tagged and tag-free proteins.

Module 4: Methods for creation of transgenic organisms (7 hrs)

Microinjection, Embryonic stem cell-mediated gene transfer, Retrovirus-mediated gene transfer. Microprojectile bombardment, electroporation, Agrobacterium mediated gene transfer.

Module 5: Application of Transgenic Organisms (7 hrs)

Transgenic plants in crop improvement, transgenic products in plants, transgenic animals in medical research, in toxicology, in mammalian developmental genetics, in the pharmaceutical industry, in biotechnology, in aquaculture and in xenografting. Humanized animal models

Module 6: Functional genomics (7 Hrs)

Introduction to Functional genomics, Microarrays, EST, Serial Analysis of Gene expression (SAGE), Subtractive hybridization, TOGA, Proteogenomics and relevant Web resources.

Total: 45 hrs

Text Books

1. Desmond S. T. Nicholl, “An Introduction to Genetic Engineering”, 3rd Edition Cambridge University Press; South Asian edition, 2010.
2. Gene Cloning and DNA Analysis, 6th Edition, Blackwell Publishing Ltd 2010
3. Barry R. Schaller "Understanding Bioethics and the Law: The Promises and Perils of the Brave New World of Biotechnology" Praeger Publishers Inc, 2007.

Reference Books

1. Sandy B. Primrose, Richard Twyman “Principles of Gene Manipulation and Genomics” Backwell Scientific Publications 2010.
2. Sandhya Mitra, “Genetic Engineering Principles and Practice”, Macmillan Publications, 2008.
3. Richard Sherlock, John D. Morrey "Ethical Issues in Biotechnology" Rowman & Littlefield Publishers, 2002.
4. Regulation of Gene Expression, By Perdew, Gary H., Vanden Heuvel, Jack P., Peters, Jeffrey M. Springer 6th Edition 2007.

22BT2081	RATIONAL DRUG DISCOVERY	L	T	P	C
		2	1	0	3

Course Objectives:

1. To explore the process of drug development, from target identification to final drug registration.
2. To provide the knowledge in drug development as a process involving target selection, lead discovery using computer-based methods and combinatorial chemistry/high-throughput screening.
3. To develop skills in specialized areas related to bioavailability, clinical trials, and the essentials of patent law

Course Outcomes:

The students will be able to

1. Understand the process of drug discovery and development
2. Discuss the challenges faced in each step of the drug discovery process
3. Classify the computational methods used in drug discovery
4. Organize information into a clear report
5. Demonstrate their ability to work in teams and communicate scientific information effectively
6. Construct, review and evaluate preclinical and clinical pharmaceutical studies.

Module 1: Drug and their Interaction (8 Hours)

Introduction to Drugs: Drug nomenclature, Routes of drug administration and dosage forms, Principles of Pharmacokinetics and Pharmacodynamics: ADME, Bioavailability of drugs -Lipinski’s rule; how drugs work -Drug targets, drug-target interaction and dose-response Relationships.

Module 2: Drug design pipeline (8 Hours)

New Drug Discovery & Development: Overview of new drug discovery, development, cost and time lines. Target Identification & Validation. Lead Discovery: Rational and irrational approaches -Drug repurposing, Natural products, High-throughput screening (HTS), Combinatorial chemistry and computer aided drug design (CADD).

Module 3: Fundamental of Drug Actions (8 Hours)

Inter and intramolecular interactions: Weak interactions in drug molecules; Chirality and drug action; Covalent, ion, ion-dipole, hydrogen bonding, C-H hydrogen bonding, dihydrogen bonding, van der waals interactions and the associated energies. Cation-and-OH interactions. Receptorology: Drug-receptor interactions, receptor theories and drug action; Occupancy theory, rate theory, induced fit theory, macromolecular perturbation theory, activation-aggregation theory. Topological and stereo chemical consideration.

Module 4: Drug toxicity, Assays and testing (7 Hours)

Preclinical Testing of New Drugs: Pharmacology -In vitro/in vivo Pharmacokinetics and Pharmacodynamics testing; Toxicology-Acute, chronic, carcinogenicity and reproductive toxicity testing; Drug formulation testing. Clinical Trial Testing of New Drugs. Good clinical practice (GCP) guidelines -Investigators brochures, Clinical trial protocols and trial design; Ethical issues in clinical trials -How are patient rights protected?

Module 5: Drug Regulatory Agencies (7 Hours)

US Food & Drug Administration (US FDA) and Central Drugs Standard Control Organization (CDSCO), India. Regulatory Applications & New Drug Approval: Investigational new drug (IND) application & New drug application (NDA); Regulatory review and approval process. Regulatory Requirements for

Drug Manufacturing: Current Good manufacturing practice (cGMP) and GMP manufacturing facility inspection & approval.

Module 6: Drug review intellectual rights (IPR) (7 Hours)

IPR Definition and implications for discovery & development. Forms of IPR Protection-Copyright, Trademark and Patents. International organization and treaties for IPR protection –World Trade Organization (WTO) & Trade Related Aspects of Intellectual Property Rights (TRIPS) Agreements. Controller General of Patents, Designs & Trade Marks, India (CGPDTM), World Intellectual Property organization (WIPO)-Patent Cooperation Treaty (PCT).

Text Books:

1. Rick NG. Drugs: From discovery to approval 2nd Ed Wiley Blackwell (2009)
2. TripathiKd. Essentials of Medical Pharmacology, 6th Edition, Publisher: Jaypee Brothers (2013)
3. Burger's Medicinal Chemistry and Drug discovery. Volume 2, Wiley-Interscience; Volume 2 edition (2003)

Reference Books:

1. Prankrishna Pal. Intellectual Property Rights In India: General Issues And Implications Publisher: Deep & Deep Publications Pvt.Ltd (2008)
2. Stromgaard, Kristian, PovlKrogsgaard-Larsen, and Ulf Madsen. Textbook of drug design and discovery. CRC Press, (2009).
3. Katzung, Bertram G., Susan B. Masters, and Anthony J. Trevor. Basic and Clinical Pharmacology (LANGE Basic Science). McGraw-Hill Education,(2012).
   Spriet, Alain, et al. Methodology of clinical drug trials. Basel: Karger, (2004).

22BT2082	PRECISION MEDICINE AND WELLNESS	L	T	P	C
		3	0	0	3

Course objective:

1. The course will teach the students about use of modern omics techniques and systems biology in providing personalized medicine and preventive health care.
2. To explore the the possibilities, promises, and pitfalls of precision medicine, using real-world examples.
3. To provide students with knowledge about prolonging health and treating disease that will empower them to make shared informed decisions with their physicians

Course Outcomes:

The students will be able to

1. Explain how the HGP has advanced technology in biomedical research.
2. Understand how the diversity of life evolves over time by processes (leading to) of genetic change, particularly the role of genetic and genomic variation throughout the genome in health and disease.
3. Describe recent advances in disease risk prediction, molecular diagnosis and progression of diseases, and targeted therapies for individuals.
4. Understand how to translate research findings and technology into healthcare delivery that benefits the general public.
5. Discuss the ethical, legal, and social implications of health privacy and policy laws for precision medicine.
6. Critically evaluate primary and secondary precision medicine research.

Module 1: Omics application for clinical practice (8hrs)

Use of genomics, transcriptomics, proteomics and metabolomics in understanding disease condition. Biomarker identification and validation of a disease state.

Module 2: Concept of Immunotherapeutics (7hrs)

Introduction to Immunology, Molecular mechanisms in immune cell differentiation and function, Transplant, autoimmunity and tumour immunology, Inflammation and cell migration, Basic concept of cancer treatment and immune response, Chimeric antigen receptor engineering and clinical studies.

.**Module 3: Pharmacogenomics (7hrs)**

Pharmacogenomic testing for drug selection, dosing and predicting adverse effects of commonly prescribed drugs, Tumor profiling, Patient data and clinical decisions.

Module 4: Precision Oncology (8hrs)

Pharmacogenomic testing for drug selection, dosing and predicting adverse effects of commonly prescribed drugs, Tumor profiling, Patient data and clinical decisions.

Module 5: Artificial Intelligence Applications in Precision Health (8hrs)

Concepts and ideas in artificial intelligence (AI) and machine learning -- including statistical approaches, visualization, and human-computer interactions. Applications of AI techniques and software tools.

Module 6: Indian traditional medicine and formulation (7hrs)

Indian traditional medicine history and natural formulations, Ayurveda system of Prakriti and Agni.

Text Books:

1. Genomic and Precision Medicine, 3rd Edition, Geoffrey Ginsburg and Huntington Willard, 2016
2. The Language of Life: DNA and the Revolution in Personalized Medicine, Francis S. Collins, 2010

Reference Books:

1. Genetics and Genomics in Medicine: Tom Strachan, Judith Goodship, Patrick Chinnery ISBN: 9780815344803, 2014, 1st edition
2. Ferryman, Kadija, and Mikaela Pitcan. "Fairness in precision medicine." Data & Society 1 (2018).
3. The Language of Life: DNA and the Revolution in Personalized Medicine, Francis S. Collins.

22BT2083	NANO-BIOTECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objective:

This course will make the students

1. To get familiarized with the chemistry of biological molecules
2. To learn biophysical principles and dynamics involved in biological systems
3. To apply knowledge on basic techniques involved in the study of biological systems, biotechnology and culturing techniques

Course Outcome:

The students will be able to

1. Learn the basic Properties of Nano composites.
2. Gain knowledge on structural and functional principles of biomolecular motors.
3. Recognize the structural and functional principles of bio-nanotechnology.
4. Acquire knowledge on basic techniques involved in the study of biological systems, biotechnology and culturing techniques
5. Distinguish the biomedical applications of bio-anotechnology.
6. Apply adequate knowledge in nano composites food materials.

Module I Nanobiomaterials and Biocompatibility (9 hours)

Surface and Bulk of bio-materials, Nano Biomaterials, Nano Ceramics, Nano Polymers, Nano Silica, Hydroxy apatite, Carbon Based Nanomaterials, Surface modification, Textured and porous Materials, Surface immobilized biomolecules, Cell -biomaterial interactions, immune response, In Vitro and In Vivo assessment of tissue compatibility.

Module II Structural & Functional Principles of Bio Nanotechnology. (9 hours)

Lipid Bilayers, Liposomes, neosomes, Polysaccharides, Peptides, Nucleic acids, DNA scaffolds, Enzymes, Biomolecular Motors: linear, rotary motors, immunoconjugates, limitations of natural biomolecules.

Module III Protein and DNA Based Nanostructures (9 hours)

Nanocircuitry – S-layer proteins: structure, chemistry and assembly, lipid chips, S-layer as Templates, engineered nanopores, DNA -protein Nanostructures, DNA-templated Electronics, DNA- based Metallic Nanowires and Networks, DNA-Gold-Nanoparticle Conjugates, DNA-templated Electronics, DNA Nanostructures for Mechanics and computing.

Module IV Nanobio-Analytics (9 hours)

Luminescent Quantum Dots for biological Labelling, Nanoparticle Molecular Labels, Surface Biology: Analysis of Biomolecular Structure by Atomic Force Microscopy and Molecular Pulling, Force Spectroscopy, Biofunctionalized Nanoparticles for Surface, Enhanced Raman Scattering and Surface Plasmon Resonance, Bio-conjugated Silica Nanoparticles for Bioanalytical Applications.

Module V Techniques in Biomedical Imaging and Nano Structuring (9 hours)

Immuno Fluorescent Biomarker Imaging- Immuno gold labeling- Nanoprobes- Bio- Photonics- Diagnostic Biosensors- Catalyst- Functionalized Metallic Nanoparticle and their Applications in Colorimetric Sensing- Dip stick Tests- Nanoparticles as Catalysts for Signal Generation and Amplification- Iron Oxide Nanoparticles in Magnetic Resonance Imaging- Optical nanoparticles sensors for quantitative intracellular imaging. Cancer imaging- Nano photonics. Design aspects of Nanostructures-Lithographic techniques- Nanoimprinting- Near Field Optical Methods of fabrication- Nano polishing with diamond and etching of nanostructures- Nano indendation Focused Ion beam.

Module VI Nanotechnology in Food, Medicine, and Health Science (9 hours)

Nano particle Based Drug Delivery System, Ultra sound triggered Nano/Microbubbles, Regenerated Medicine, Biosensors -optical Biosensors based on Nano-plasmonics, Nano biosensors, Nano medicinal Foods and cosmetics, Bioavailability and delivery of Nutraceuticals and functional foods Using Nanotechnology, Polymer -Based Nanocomposites for Food Packaging, Toxicity and environmental risks of Nanomaterials.

Text Books

1. C. M. Niemeyer, "Nanobiotechnology: Concepts, Applications and Perspectives", Wiley – VCH, 2006.
2. David S Goodsell, "Bionanotechnology", John Wiley & Sons, 2004.

Reference Books.

1. Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons, "Biomaterials Science: An Introduction to Materials in Medicine", Academic Press, 2012.
2. Debasis Bagchi, Manashi Bagchi, Hiroyoshi Moriyama, Fereidoon Shahidi, "Bio-Nanotechnology: A Revolution in Food, Biomedical and Health Sciences" Wiley- Blackwell, 2013.
3. Jain K.K, Nanobiotechnology in Molecular Diagnostics – Current Techniques and Applications, Taylor and Francis Publications 2006.

22BT2084	STRUCTURAL BIOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

1. To understand the principles of protein structural elucidation and validity
2. To ensure students to have a strong knowledge on the Biomolecular atomic configuration and structural analysis
3. To provide facts on structural dynamics and simulations.

Course Outcomes:

The students will be able to

1. Explain the relationship between protein sequence and protein structure and experimental techniques.
2. Describe protein purification and structural characterization.
3. Estimate the validity of information in macromolecular structure using various high throughput technologies.
4. Understand the Use on-line structural databases and tools to predict the properties, structure and function of proteins.
5. Describe mechanisms of protein folding and the roles of natively unstructured proteins in biology.
6. Understand the evolution of protein structural modification and simulation associate this with function.

Module 1: Protein structural biology (8 hrs)

Structural features of biomolecules; techniques used to determine the structure of biomolecules; Methods for single crystal X-ray Diffraction of macromolecules; molecular replacement method and direct method – Fiber diffraction; analysis of structures and correctness of structures; submission of data to PDB; atomic coordinates and electron density maps

Module 2: Protein structure and analysis (7 hrs)

Principles of soluble and membrane protein purification, Phase diagram and separation, crystallization, Use of robotics in crystallization, Space groups and symmetry, structure determination; NMR sample preparation, Sample preparation for Cryo EM, Structure validation and best practices on the use of protein structures from protein data bank; Protein fold-function relationships, Protein Data Bank (PDB) and EM Data Bank, BioMagResBank (BMRB)

Module 3: Methods for atomic-resolution structure determination (8 hrs)

Solution- and solid-state NMR spectroscopy, Single particle Cryo Electron Microscopy, XRay Free-Electron Laser (XFEL). Anisotropy? Use of Circular Dichroism, Steady-state and time-resolved fluorescence spectroscopy, FRET, Single molecule fluorescence, Electron Paramagnetic Resonance spectroscopy.

Module 4: DNA and RNA structure prediction (8 hrs)

DNA and RNA secondary structures (duplex, triplex, quadruplexes and aptamers), RNA secondary structure prediction.

Module 5: Structural dynamics: (7 hrs)

Forces that determine protein and nucleic acid structure, basic problems, polypeptide chains geometrics, potential energy calculations, observed values for rotation angles, hydrogen bonding, hydrophobic interactions and water structures ionic interactions, disulphide bonds.

Module 6: Structural simulations (7 hrs)

Protein functional dynamics, Protein dynamics studies by MD simulations; Protein dynamics studies by biophysical techniques.

Total Hours: 45

Text Book

1. Biophysical Chemistry vol I, II and III by Charles R. Canter and Paul R. Shimmel. 1980
2. Introduction to Protein Structure by Branden and Tooze, Garland Science; 2nd edition 1999.

Reference Book:

1. The Art of Molecular Dynamics Simulation by D. C. Rapaport Cambridge University Press; 2nd edition 2004.
2. Cantor R., Schimmel P.R., Biophysical Chemistry, Vol. I, II, W.H. Freeman & Co., 1985. RNA Sequence, Structure, and Function: Computational and Bioinformatic Methods by Walter L. Ruzzo, Jan Gorodkin, Springer 2014.

22BT2085	SYNTHETIC AND SYSTEMS BIOLOGY	L	T	P	C
		2	1	0	3

Course Objectives:

1. To know large-scale methods used in systems biology research and their basic data types
2. To Compare different systems biology approaches in their advantages and disadvantages
3. To make students understand dynamical modeling techniques used in contemporary Systems Biology research.

Course Outcomes:

The student should be able to:

1. Describe how naturally system organisms regulate the expression of their genes
2. Understand the regulation of the genes and properties
3. Infer synthetic biology alters the properties of the cell or the organism
4. Apply a algorithm for sensitivity analysis and parameter fitting
5. recognize, exemplify and explain typical network motifs for signaling pathways
6. Develop synthetic cell model to recognize the cell-cell communications.

Module 1: Introduction of systems biology (8hrs)

Introduction - System-level Understanding of Biological Systems - Advanced Measurement Systems Modeling Genetic Networks

Module 2: systems modeling (8hrs)

Modeling the Activity of Single Gene - A Probabilistic Model of a Prokaryotic Gene and its Regulation.Modeling Biochemical Networks - Atomic-Level Simulation and Modeling of Biomacromolecules

Module 3: Recognition cell regulation model (7 hrs)

Kinetic Models of Excitable Membranes and Synaptic Interactions - Stochastic Simulation of Cell Signaling Pathways -Analysis of Complex Dynamics in Cell Cycle Regulation

Module 4: Cell to cell communication in development of embryos (7 hrs)

Induction and competence, paracrine factors, Signal transduction pathways, Juxtacrine signaling, crosstalk pathways.

Module 5: Synthetic model simulation (7 hrs)

Modeling Large Biological Systems from Functional Genomic Data: Parameter Estimation - Cellular Simulation - Towards a Virtual Biology Laboratory - Computational Cell Biology : The Stochastic Approach

Module 6: Computation tools for cell model (8 hrs)

Computer Simulation of the Whole Cell - Computer Simulation of the Cell: Human Erythrocyte Model and its Application - Software for Modeling and Simulation – E-CELL, V-CELL and GROMOS

Text Books:

1. Foundations of Systems Biology, Hiroaki Kitano (Editor),MIT Press, 2001
2. Computational Modeling of Genetic and Biochemical Networks, James M. Bower, Hamid Bolouri, MIT Press,2000.
3. Gene Regulation and Metabolism: Postgenomic Computational Approaches, Julio Collado-Vides (Editor), Ralf Hofestadt (Editor),MIT Press,2002

Reference Books:

1. Uri Alon, An Introduction to Systems Biology: Design Principles of Biological Circuits, 2/e, CRC Press, (2006).
2. Kitano et al., Systems Biology: A Brief Overview, Science, (2002), 295, 1662-1664.
3. John Ross et al., Complex Systems: From Chemistry to Systems Biology, PNAS, (2009), 106, 6433–6434.

20BT2043	STEM CELL TECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

1. This course will take students on a journey into the stem cell biology and biotech revolution.
2. This course will provide details regarding social implications associated with stem cell technology.
3. The course offers an opportunity to understand the basics of stem cells, embryonic stem cells, adult stem cells and genetic engineering of stem cells and their applications.

Course Outcomes:

The students will be able to

1. Explore the technique and the pros and cons of animal cell culture.
2. Understand the definition of stem cell and the features that distinguish it from other cells.
3. Recognize the different types of stem cells and their properties.
4. Analyze the residence of the stem cells and the factors that affect its function.
5. Learn the isolation and application of stem cells.
6. Explores the ethical aspects of stem cell technology.

Module 1: Introduction (4)

Overview of Stem cell technology; Introduction to Cell Culture; Pros & Cons of Cell culture; Primary and Secondary cultures & Hayflicks limit, telomerase;

Module 2: Techniques (5)
Aseptic Technique and Cell culture Lab equipments & etiquette.
Module 3: Types of Stems Cells (9)
Totipotency, Pleuripotency**,** Types of Stems Cells; Embryonic stem cells; Pleuripotent Stem Cells; Adult Stem cells; Induced Pleuripotent Stem Cells
Module 4: Isolation of Stem Cells (9)
Growth factors; chord cells; Derivation & differentiation of ES Cells; Derivation & differentiation of Pleuripotent Cells; Induced Pluripotent cell-Methods; Genetic & epigenetic reprogramming. iPSC vs Trans-differentiation, FACS
Module 5: Applications of Stem Cell Technology (9)
Use of stem cells in Neurological disorders; Use of stem cells in cardiac disease; Use of stem cells in Cancer; Stem cells for organ generation; Use of stem cells in tissue engineering & Gene therapy.
Module 6: Ethical Concerns of Stem Cell Technology (9)
Problems and perspectives in stem cell technology; Alternatives to stem cells; Deeper concerns in stem cell technology-, longevity, ageing & Immortality.

Total Hours: 45

Text Book

1. Robert Lanza Handbook of Stem Cells edited by Anthony Atala,. (Vol-1) Second edition. Academic press, 2013.

References Books:

1. Stem Cell Biology - edited by Daniel R Marshak, Richard L Gardener, David Gottlieab, Cold Spring Harbor Press.
2. Kursad and Turksen, "Embryonic Stem cells", Humana Press, 2002.

20BT2058	TISSUE ENGINEERING	L	T	P	C
		3	0	0	3

Course Objectives:

1. Provide knowledge about cell culture, cell signaling and growth factors
2. Inculcate the importance of characterization in cell culture for the identification
3. Impart technical skills in tissue implants and tissue engineering

Course Outcomes:

1. Recall the fundamental concepts about types of cells and culturing procedures
2. Analyze the cellular interaction and molecular aspects of cell differentiation.
3. Design scaffolds, tissue implants and its use in tissue engineering
4. Apprise about 3D culture mechanism and cell interactions
5. Evaluate the tissue engineering applications in the field of medicine
6. Adapt the regulatory and ethical issues in tissue Engineering

Module 1: Introduction to Tissue Culture :(9)
Introduction, Cell Culture Media, Quantification of Cells, Cell cycle Time, Cell Migration, Microbial Contamination
Module 2: Characterization and Differentiation: (9)
Characterization: Morphology, Chromosome Analysis, Enzyme Activity. Differentiation: Proliferation, Lineage, Markers of Differentiation, Genetic Instability
Module 3: Biomaterials and Organs for Transplants (9)
Scaffolds, Biomaterials for Tissue Engineering, Collagen, Silk and Polylactic Acid, Engineering tissues for replacing bone, cartilage, tendons, ligaments, skin and liver. Basic transplant immunology, stems cells in tissue engineering
Module 4: Specialized cells and 3D Culturing (9)
Epithelial Cells, Mesenchymal Cells, Neuroectodermal cells, Hematopoietic cells, 3D cell culture of different types of cells, cell transplantation for liver, musculoskeletal, cardiovascular, neural, visceral tissue engineering.

Module 5: Applications in Medical Fields (5)
Product development using tissue Engineering, Current scope of development of tissue engineering in therapeutics and in-vitro testing, Artificial blood vessel, Artificial Liver tissue engineering.
Module 6: Regulatory Issues (4)
Ethical, FDA and regulatory issues of tissue engineering,

Total Hours:45

Text Books:

1. R. *Ian Freshney*. Introduction to Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, Sixth Edition. *Publisher*, John Wiley & Sons, 2011.
2. Bernhard Palsson, Jeffery A. Hubbell, Robert Plonsey, Joseph D. Bronzino, Tissue Engineering, CRC Press, 2019**.**

Reference Books:

0. Robert. P.Lanza, Robert Langer & William L. Chick, Principles of tissue engineering, , Academic press, 2002
1. Joseph D. Bronzino, The Biomedical Engineering –Handbook, CRC press, 4th ed. 2014
2. B. Palsson, J.A. Hubbell, R.Plonsey& J.D. Bronzino, Tissue Engineering, CRC- Taylor & Francis, 2006.

22BT2095	BIOMATERIALS IN BIOTECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:
The students will be able to

1. Understand the basic concepts in biomaterials.
2. Understand the use of implants and cell-interfacing materials.
3. Demonstrate the application of biomaterials in field of Biotechnology.

Course Outcomes:
The Student will be able to

1. Classify the structural distinctions in biomaterials.
2. Categorize the various properties of biomaterials and Immunology.
3. Appraise the methods for using implants and testing.
4. Recognize the Interfacing materials and biomimetics.
5. Understand the nuances of lab organs and prosthetics.
6. Evaluate manufacturing processes of biomaterials in biotechnology and their Ethical implications.

Module-I: Structural Distinctions in Biomaterials (9 Hours)
Structure of bio materials and bio compatibility- Mechanical properties, Physical characterization, Surface characterization, Thermal characterization. Definition and Classification of Biomaterials, Function of Biomaterials, Biocompatibility and Biomaterials, Properties of Biomaterials, Body response to implants.
Module-II: Immune response and Inflammation (7 Hours)
Wound-healing, Implant Response resolution, Blood compatibility – Skin Regeneration, Inflammatory Response, Interaction of Biomaterials with Blood, Circulatory System
Module-III: Implants used in Biotechnology (9 Hours)
Metallic Implant materials – Types, Characteristics and Functions, Biodegradable polymers; Natural polymers, Polymeric Implant materials – Types, Polyurethanes and Polythenes, Soft Tissue and Hard Tissue replacement, Soft Tissue and Hard Tissue replacement, smart materials for medical applications-tissue replacement implants-Sutures, Surgical tapes, Adhesive, Percutaneous and skin implants, Maxillofacial augmentation, Joint replacements.
Module-IV: Interfacing Materials in Biotechnology and Biomimetics (8 Hours)
Blood interfacing materials, Methods of testing implants for biological performance, Biocompatibility – Toxicology, Biocompatibility, Biomimetic synthesis, Direct molding Technique, Advanced 3D fabrication techniques.

Module-V: Artificial Organs and Entrepreneurship (6 Hours)

Artificial organs - Introduction to Artificial Organs, Artificial Organs - The Future, Artificial Heart Vs Natural Heart, Heart valves – Types, Characteristics Features, Functions, Durability, Oxygenators and Dialysers, Dental implants. Entrepreneurship and Bio technocrats, Biomaterials market in India.

Module 6: Manufacturing Biomaterials for Biotechnological Applications (6 Hours)

Basic principles of engineering manufacturing, methods and applications of common manufacturing processes, milling, grinding, finishing, rolling, forging, Biomaterials for the 21st Century, Biomaterial and Biocompatibility Testing Laboratory Setup according to India Human Resources, Layout and Controls, Equipment and Instruments.

Text Books:

1. Biomaterials: An Introduction- J. Bo. Park.
2. Sujata V. Bhatt, "Biomaterials" Second Edition ,Narosa Publishing House,2005.

Reference Books:

1. Biomaterials Science - An Introduction to Materials in Medicine, Buddy Ratner Allan Hoffman Frederick Schoen Jack Lemons, ISBN: 9780080470368, Academic Press, 2004.
2. Michael Lysaght and Thomas Webster, "Biomaterials for artificial Organs", Woohead Publishing series in biomaterials, 2010.
3. Research Papers:
    a. Prosthesis and Intersection of Biology and Engineering - George M.Whitesides and Amy P.Wong,.
    b. Foreign Body Reaction To Biomaterials - James M.Anderson, Analiz Rodriguez, and David T. Chang,

22BT2096	BIOTERRORISM AND NATIONAL SECURITY	L 3	T 0	P 0	C 3

Course Objective:

1. To understand terrorism employing biological pathogens
2. To familiarize issues involved and threats facing society due to bioterrorism
3. To impart knowledge on various approaches to tackle bioterrorism

Course Outcome:

1. Formulate security policy in relation to disease-related security challenges.
2. Categorize different agents and phases of bioterrorisms in public health
3. Analyze infectious diseases affecting man, animal and agriculture
4. Evaluate epidemiological aspects of bioterrorism
5. Mitigate the threats due to bioterrorism
6. Manage the ethical issues pertaining to bioterrorism

Module 1: Terrorism and Bioterrorism (7 Hours)

Definition-Traditional terrorists-New terrorists-Nuclear, chemical, and radiological weapons-Psychology of Bioterrorism-Historical perspective

Module 2: Microbes and Immune System (6 Hours)

Primary classes of Microbes-bacteria, virus, and other Agents-Immune system- Interaction between microbes and the immune system.

Module 3: Bioterrorism and Public Health (6 Hours)

Classification of bioterrorism agents- Category A, B and C, Clinical syndromes caused by bioterrorism agents, Phases of bioterrorist attack- preparedness phase, early morning phase, notification phase, response phase and recovery phase

Module 4: Bioterrorism Weapons and Techniques (10 hours)

Characteristics of microbes and the reasons for their Use-Symptoms-Pathogenicity Epidemiology-natural and targeted release-Biological techniques of dispersal, case studies of Anthrax, Plague-Botulism, Smallpox, and Tularemia and Viral Hemorrhagic Fevers (VHF); Biological attack on Agriculture-Animals as sentinels of bioterrorism agents

Module 5: Prevention and Control of Bioterrorism (9 Hours)

Surveillance and detection- equipment and sensors –Diagnosis-Treatment Vaccinations-Supplies-Effectiveness-Liability-Public Resistance-Response-First Responders-Infectious Control-Hospital-Prevention- Protection-Decontamination Notification-Role of Law Enforcement-Economic impact

Module 6: Bioterrorism Management **(7 Hours)**

Ethical issues: personal, national, the need to inform the public without creating fear, cost-benefit analysis-Information Management-Government control and industry Support-Microbial forensics.

Text Books:

1. Donald A. Henderson, Thomas V., M.D. Inglesby, Tara O'Toole, Bioterrorism: Guidelines for Medical and Public Health Management, American Medical Association, 1st Edition, 2002.
2. Lederberg J, Biological Weapons: Limiting the Threat (BCSIA Studies in International Security), MIT Press, 1999.
3. Fong IW, and Kenneth A, Bioterrorism and Infectious Agents: A New Dilemma for the 21st Century (Emerging Infectious Diseases of the 21st Century), , Springer,2005.

Reference Books:

1. Richard Preston, The Demon in the Freezer: A True Story, Fawcett Books, 2003.
2. Leonard A Cole, The Anthrax Letters: A Medical Detective Story, Joseph Henry Press, 2003.
3. Biotechnology research in an age of terrorism: confronting the dual use dilemma, National Academies of Science, 2003.
4. Das S and Kattaria VK, Bioterrorism: A public health perspective, , Medical Journal of Armed forces India, 66 (3) 255-260; 2010

22BT2086	MOLECULAR PHARMACEUTICS	L 3	T 0	P 0	C 3

Course Objective:

Students can be understand

1. The various approaches for development of novel drug delivery system
2. The criteria for selection of drugs and polymers for the development of NTDS
3. The formulation and evaluation of novel drug delivery

Course Outcome:

The students will be able to

1. Acquire knowledge on Drug delivery systems and understanding.
2. Describe the characterization and preparation of various drug targeting methods with liabilities.
3. Utilize enterprise-wide information assets in support of various pharmaceutical micro capsules and spears.
4. Explain concepts of nasal drug delivery systems and physiological mechanism.
5. Elaborate the Bimolecular based drug delivery methods and function
6. Describe functional principle of enzyme inhibitors

Module I Targeted Drug Delivery Systems **(8 hrs)**

Concepts, Events and biological process involved in drug targeting. Tumor targeting and Brain specific delivery.

Module II Targeting Methods: **(7 hrs)**

Introduction preparation and evaluation. Nano Particles & Liposomes: Types, preparation and evaluation.

Module III Micro Capsules / Micro Spheres **(7 hrs)**

Types, preparation and evaluation , Monoclonal Antibodies ; preparation and application, preparation and application of Niosomes, Aquasomes, Phytosomes, Electrosomes.

Module IV Pulmonary Drug Delivery Systems **(7 hrs)**

Aerosols, propellents, Containers Types, preparation and evaluation, Intra Nasal Route Delivery systems; Types, preparation and evaluation.

Module V Nucleic acid based therapeutic delivery system **(8 hrs)**

Gene therapy, introduction (ex-vivo & in-vivo gene therapy). Potential target diseases for gene therapy (inherited disorder and cancer). Gene expression systems (viral and nonviral gene transfer). Liposomal gene delivery systems. Biodistribution and Pharmacokinetics. knowledge of therapeutic antisense molecules and aptamers as drugs of future.

Module VI Rational Design of Enzyme Inhibitors (8 hrs)

Enzyme kinetics & Principles of Enzyme inhibitors, Enzyme inhibitors in medicine, Enzyme inhibitors in basic research, rational design of non-covalently and covalently binding enzyme inhibitors.

Text Books

1. Y W. Chien, Novel Drug Delivery Systems, 2nd edition, revised and expanded,Marcel Dekker, Inc., New York, 1992.
2. S.P.Vyas and R.K.Khar, Controlled Drug Delivery - concepts and advances, Ballabh Prakashan, New Delhi, First edition 2002.
3. N.K. Jain, Controlled and Novel Drug Delivery, CBS Publishers & Distributors, NewDelhi, First edition 1997 (reprint in 2001)

Reference Books :

1. An Introduction to Medicinal Chemistry, Graham L.Patrick, III Edition 2017, Oxford University Press, USA.
2. Biopharmaceutics and pharmacokinetics, DM.Brahmankar, Sunil B. Jaiswal II Edition, 2014, Vallabh Prakashan, New Delhi.
3. Peptidomimetics in Organic and Medicinal Chemistry by Antonio Guarna and Andrea Trabocchi, First edition 2016, Wiley publishers.

22BT2087	COMPUTER AIDED DRUG DESIGN	L 3	T 0	P 0	C 3

Course Objectives:

At completion of this course it is expected that students will be able to

1. understand rRole of CADD in drug discovery, Techniques and their application
2. Various strategies to design and develop new drug like molecules
3. Working with molecular modeling software's to design new molecule and virtual screening protocols

Course Outcomes:

The students will be able to

1. Explain the various stages of drug discovery
2. Demonstrate the concept modern drug discovery process and validation
3. Describe physicochemical Properties and the techniques involved in QSAR
4. Learn introduction to Bioinformatics and Cheminformatics role in molecular docking studies
5. Contrast the methods in molecular and quantum mechanics in molecular properties
6. Explain various structure based drug design methods in denova virtual ligands screening

Moldule I Introduction to Computer Aided Drug Design (CADD) (8 hrs)

History, different techniques and applications. Quantitative Structure Activity Relationships: Basics History and development of QSAR: Physicochemical parameters and methods to calculate physicochemical parameters: Hammett equation and electronic parameters (sigma), lipophilicity effects and parameters (log P, pi-substituent constant), steric effects (Taft steric and MR parameters) Experimental and theoretical approaches for the determination of these physicochemical parameters.

Moldule II An overview of modern drug discovery process: **(7 hrs)**

Target identification, target validation, lead identification and lead Optimization. Economics of drug discovery. Target Discovery and validation-Role of Genomics, Proteomics and Bioinformatics. Role of Nucleic acid microarrays, Protein microarrays, Antisense technologies, siRNAs, antisense oligonucleotides, Zinc finger proteins. Role of transgenic animals in target validation.

Moldule III Quantitative Structure Activity Relationships: **(8 hrs)**

Applications Hansch analysis, Free Wilson analysis and relationship between them, Advantages and disadvantages; Deriving 2D-QSAR equations. 3D-QSAR approaches and contour map analysis. Statistical methods used in QSAR analysis and importance of statistical parameters.

Moldule VI Molecular Modeling and Docking (8 hrs)

a) Molecular and Quantum Mechanics in drug design. b) Energy Minimization Methods: comparison between global minimum conformation and bioactive conformation c) Molecular docking and drug receptor interactions: Rigid docking, flexible docking and extraprecision docking. Agents acting on enzymes such as DHFR, HMG-CoA reductase and HIV protease, choline esterase (AchE & BchE)

Moldule V Molecular Properties and Drug Design (7 hrs)

a) Prediction and analysis of ADMET properties of new molecules and its importance in drug design. b) De novo drug design: Receptor/enzyme-interaction and its analysis, Receptor/enzyme cavity size prediction, predicting the functional components of cavities, Fragment based drug design. c) Homology modeling and generation of 3D-structure of protein.

Moldule VI Pharmacophore Mapping and Virtual Screening (7 hrs)

Concept of pharmacophore, pharmacophore mapping, identification of Pharmacophore features and Pharmacophore modeling; Conformational search used in pharmacophore mapping. In Silico Drug Design and Virtual Screening Techniques Similarity based methods and Pharmacophore based screening, structure based In-silico virtual screening protocols.

Text Books:

1. Computational and structural approaches to drug discovery, Robert M Stroud and Janet. F Moore, RCS Publishers.
2. Introduction to Quantitative Drug Design by Y.C. Martin, CRC Press 2010, Taylor & Francis group..
3. Drug Design by Ariens Volume 1 to 10, Academic Press, 1975, Elsevier Publishers.

Reference Books

1. Principles of Drug Design by Smith and Williams, CRC Press 2017, Taylor & Francis.
2. The Organic Chemistry of the Drug Design and Drug action by Richard B. Silverman, Elsevier Publishers 2013.
3. Computational and structural approaches to drug design edited by Robert M Stroud and Janet. F Moore 2012
4. Wilson and Gisvold‟s Text book of Organic Medicinal and Pharmaceutical Chemistry, Ippincott Williams & Wilkins 2011.

22BT2088	DRUG FORMULATION AND DEVELOPMENT LAB	L 0	T 0	P 3	C 2

Course Objectives:

At completion of this course it is expected that students will be able to understand

1. The various physica and physicochemical properties of drug pharmulations
2. The bioorganic principles involved in dosage forms/formulations
3. The Theory and practical components of the subject help the student to get a better insight into various areas of formulation research and development

Course Outcomes:

The students will be able to

1. Understand various physicochemical properties of drug molecules in the designing the dosage forms
2. Know the principles of chemical kinetics & to use them for stability testing nad determination of expiry date of formulations
3. Demonstrate use of physicochemical properties in the formulation development and evaluation of dosage forms.
4. To perform various processes involved in pharmaceutical manufacturing process.
5. To know various unit operations used in Pharmaceutical industries.

6. To appreciate the various preventive methods used for corrosion control in Pharmaceutical industries.

List of Experiments

1. Formulation development of compressed tablets.
2. Formulation development of topical preparations.
3. Formulation development of oral liquids.
4. Formulation development of stable suspensions and dry suspensions.
5. Formulation development of emulsions.
6. Formulation development of small volume parenterals.
7. Formulation development of ophthalmic preparations.
8. Assessment of stability studies according to ICH guidelines.
9. Evaluation of packaging materials.
10. Product development of sustained release dosage forms.
11. Preparation of 4-chlorobenzhydrylpiperazine. (an intermediate for cetirizine HCl).
12. Calculation of ADMET properties of drug molecules and its analysis using softwares Pharmacophore modeling
13. Identification of organic compounds using FT-IR, NMR, CNMR and Mass spectra

Reference Books:

1. Fahr, Alfred. Voigt's pharmaceutical technology. John Wiley & Sons, 2018.
2. Armstrong, N. Anthony. Pharmaceutical experimental design and interpretation. CRC Press, 2006.
3. Gibson, Mark, ed. Pharmaceutical preformulation and formulation: a practical guide from candidate drug selection to commercial dosage form. CRC Press, 2016.
4. Roy, Jiben. An introduction to pharmaceutical sciences: Production, chemistry, techniques and technology. Elsevier, 2011.

22BT2089	GENOME ENGINEERING IN LIVESTOCK AND AGRICULTURE	L	T	P	C
		3	0	0	3

Course Objectives:

1. To provide insights into Genome Engineering.
2. To impart knowledge in animal and plant breeding employing genome engineering technology.
3. To equip students with advancement in livestock enhancement and crop improvement.

Course outcomes:

The student will be able to

1. Describe the basic concepts in Genome Engineering.
2. Relate and identify the areas of improvement in livestock through molecular techniques.
3. Explain the role of genetic engineering and genome engineering.
4. Identify strategies for crop improvement.
5. Demonstrate a capacity for understanding the social impact of genome engineering.
6. Relate the ethical implications of genome engineering.

Module I: Introduction to Genome and Genome Engineering (6 hrs)

Organization and Structure of Genomes; Nuclear genes, mitochondrial genes, plastid genes; Construction of recombinant DNA; Preparation of cDNA and genomic libraries in vector systems; Genome Engineering; Gene modification in animals and plants – Practical applications.

Module II: Genetic Characterization and Gene Transfer Methods in Animals (6 hrs)

Genetic characterization of livestock breeds, Marker assisted breeding of farm animals; Gene transfer methods in Animals: Microinjection, ES cell mediated gene transfer, Retroviral gene transfer, Gene transfer by sperm vector method.

Module III: Gene Targeting And Transgenic Animals (9 hrs)

Gene targeting - Homologous recombination and Conditional targeting; Genome editing in livestock - Transgenic technology - Milk modification, Meat production (composition and quality), Disease

resistance; Transgenic Cattle, sheep, goat, pig and chicken; Molecular pharming - production of recombinant proteins.

Module IV: Genetic Modification in Plants (8 hrs)

Genetic Modification in plants – Transgenic, Cisgenic, Subgenic and Multiple trait integration; Pyramiding of genes; Gene editing tools in plants –PTGS, ZFNs, TALENs, and CRISPR/Cas9; Progress and challenges of gene editing in plants.

Module V: Strategies for Plant Improvement (9 hrs)

Engineering plants for drought tolerance, salt tolerance and freeze tolerance; Targeted approaches to engineer stress tolerance; Improving the nutritional quality and functional properties of seed proteins, carotenoids and flavonoids; Improvement of shelf life of fruits and flowers; Insect and Herbicide resistance in plants; Improving photosynthesis, growth, taste and color; Reducing the effect of Viral disease in plants: VIGS - Virus Induced Gene Silencing.

Module VI: Ethical Implications and Biosafety Regulations (7hrs) Impact of genome engineering on livestock breeding and agriculture; Ethical issues related to Livestock cloning; Public perspective on GM foods; Terminator Technology; Patenting Biological Material; Biosafety measures and regulation.

Total hours: 45

Text Books:

1. Primrose S.B and Twyman R.M. "Principles of Gene Manipulation and Genomic", Blackwell Publishing Company, Oxford, UK Third Edition (2006).
2. Ausubel F.M, Brent R, Kingston R.E and Moore D.D. "Current Protocols in Molecular Biology" John Wiley & Sons, New York, First Edition (1987).

Reference Books:

1. Slater A, Scott N.W and Fowler M.R. "Plant Biotechnology: The Genetic Manipulation of Plants", Oxford University Press, Third Edition (2008).
2. Voytas D.F and Gao C (2014) Precision Genome Engineering and Agriculture: Opportunities and Regulatory Challenges, Plos One. 12, e1001877.
3. Guimaraes et. al, "Marker-Assisted Selection: Current Status and Future Perspectives In Crops-Livestock- Forestry and Fish", FAO Publication, (2007).
4. Collard et al (2008) Rice Molecular Breeding Laboratories in the Genomics Era: Current Status and Future Considerations, International Journal of Plant Genomics, 2008: 524847.

22BT2090	GENOME EDITING FOR THERAPY	L	T	P	C
		3	0	0	3

Course Objectives:

1. To provide understanding of the technology of Genome Engineering.
2. To equip students with the knowledge of the tools employed in genome engineering.
3. To make aware the ethical considerations of genome editing.

Course outcomes:

The student will be able to

1. Describe the basic concepts in human genome organization and genetic diseases.
2. Understand the tools used in genome editing.
3. Identify various strategies in genome editing for therapy.
4. Understand thoroughly the technique of CRISPR in therapeutics.
5. Demonstrate a capacity for understanding the social impact of genome engineering.
6. Perceive the ethical implications of genome editing.

Module I: The Human Genome and Genetic Analysis (6 hrs)

Genome and genome organization; Genetic Diseases; Types of genetic variations and analysis; PCR and its types - Real Time PCR. Genome editing – Introduction; Genome Analysis - DNA sequencing and its types.

Module II: Gene Editing Tools (6 hrs)

Transgenesis and site-specific recombination: Lentiviral system, Cre-Lox, Phi31 integrase; Genome editing: ZFNs, TALENs, Multi-gene assemblies and high-throughput DNA assembly techniques.

Module III: CRISPR-Based Gene Therapy (9 hrs)

Origin of CRISPR; Mechanism of the classical CRISPR/Cas9 system; CRISPR Knock-out Basics (Experimental Design, Guide RNA design, Delivery into Cells, Genotyping, Validation); CRISPR Knock-in (Inserting or Mutating DNA Sequences in the Genome); CRISPR Editing in Bacteria, Yeast and Animal Models (Knockout and Knock-in Strategies); CRISPR Screens (High throughput applications of CRISPR); CRISPR Interference (dCas9 Fusions Inhibition or Activation).

Module IV: RNA Therapeutics (7 hrs)

Silencing of gene expression by small RNAs, RNAi, long noncoding RNAs, siRNA, Role of non-coding RNAs in gene regulation and therapy; shRNA, miRNA, microRNA, snoRNA & siRNA,

Module V: Gene Editing and Diseases (10 hrs)

Gene editing and delivery strategies: ex vivo editing therapy (HIV); in vivo editing therapy (Haemophilia B); Gene editing technique in basic research, diagnosis, and therapy of cancer; Using CRISPR/Cas9 library for screening functional genes in cancer cells; Gene editing in hematologic disorders; Gene editing in brain diseases; Factors Influencing Therapeutic Efficacy; Fitness of Edited Cells; Challenges to Clinical Translation.

Module VI: The Future of Gene Editing Tools and Ethical Considerations (7 hrs)

Gene editing tools - Applications, Limitations, and Implications for the future; Gene editing and ethics; CRIPSR in the Clinic; CRISPR Babies; Case-Studies; WHO recommendations on human genome editing for the advancement of public health.

Total hours: 45

Text Books:

1. Brown T.A. “Gene Cloning and DNA Analysis an Introduction”, Wiley Blackwell, UK. Seventh Edition (2016).
2. Gardner A and Davies T. “Human Genetics” Viva Books, Second Edition (2012).

Reference Books:

1. Young I.D. “Medical Genetics” Oxford University Press, UK. First Edition (2005).
2. Arsham M.S and Barch M.J. “The AGT Cytogenetics Laboratory Manual” Wiley- Blackwell”, New Jersey, USA, Fourth Edition (2017).
3. Donnai D and Read A. “New Clinical Genetics”, Scion Publishing Limited, Oxford, UK, Third Edition (2015).
4. Nussbaum R.L, McInnes R.R, Willard H.F and Hamosh A. “Genetics in Medicine”, Elsevier, USA, Eighth Edition (2016).

22BT2091	GENETIC MANIPULATION LAB	L	T	P	C
		0	0	3	1.5

Course Objective:

1. To impart technical knowledge on genetic manipulation.
2. To enable the students to understand the principles of Genome editing.
3. To impart the knowledge on various techniques and methods in Genome engineering.

Course Outcome:

The student will be able to

1. Understand the handling of biomolecules such as nucleic acids.
2. Demonstrate the principles, techniques and applications of gene manipulation
3. Describe the instrumentation and techniques for qualitative and quantitative analysis of nucleic acids.
4. Design primers, siRNA, lentiviral vectors and CRIPR Guide RNA.
5. Explain the determination of pH and their applications in buffer preparations
6. Demonstrate the applications of CRISPR/CAS technology in prokaryotes and eukaryotes.

List of Experiments

1. Isolation of Plasmid DNA.

2. RNA isolation.
3. Quantification of nucleic acids using Nanodrop.
4. Primer design and analysis.
5. Reverse transcriptase PCR for cDNA synthesis.
6. Polymerase Chain Reaction
7. Agarose gel electrophoresis of Plasmids and PCR products
8. Analysis of gene expression using Real-time PCR.
9. CRISPR Guide RNA design.
10. Lentiviral vectors design.
11. Demonstration of CRISPR/Cas technology in bacteria.
12. Demonstration of CRISPR/Cas technology in yeast.

Reference:

1. Michael R. Green, Joseph Sambrook, Molecular Cloning: A Laboratory Manual (Fourth Edition), 2012
2. Web resources

20BT3001	ADVANCES IN BIOPOLYMER AND APPLICATIONS	L	T	P	C
		3	0	0	3

Course Objectives:

To improve knowledge on

1. Application of biopolymers in the field of pharma and food industries.
2. Interaction of biopolymers and their structure – function relationship
3. Recent trends in biopolymers research

Course Outcomes:

The students will be able to

1. Recall the basic structure, composition and functions of biopolymers.
2. Demonstrate the applications of biopolymers in medical, pharma, food and agro industries
3. Apply technologies such as protein engineering, glysosylation engineering, enzyme engineering, antibody engineering to study the biomolecules
4. Compare and contrast the structure functional relationship of different biomolecules
5. Appraise the applications of biomolecules as biomarkers in diagnosis of diseases and as biosensors
6. Compile, discuss and critically review the recent updates / progress in biopolymers research and their applications

Module 1: Glycans and Glycobiology (10 Hours)

Glycoconjugates – glycoproteins, glycolipids and lipopolysaccharides; Glycans and blood groups, Lectins use and interaction with glycoconjugates; Glycans in biotechnology and pharmaceutical industry: as components of vaccines and small molecule drugs, glycosylation engineering, therapeutic glycans.

Module 2: Protein and Enzyme technology (10 Hours)

Structure- function relationship in fibrous and globular proteins, industrially significant peptides; Protein Engineering Methods - Applications of proteins: Food industry, Environmental, Medical. Enzyme markers in disease diagnosis – hepatobiliary diseases, myocardial disorders, atherosclerosis, renal dysfunction. Oxidative stress and cancer; Enzyme based biosensors; Enzymes in food, and pharmaceutical industries. Enzyme immobilization techniques and its applications.

Module 3: Hormones and Antibodies (6 Hours)

Mechanism of actions of chemically diverse hormones, Hormone therapy, Applications of hormones in anti-ageing medicine. Antibody engineering, Abzymes

Module 4: Lipid Technology and Applications (7 Hours)

Industrial applications of fatty acids and lipids, role of lipids in pharmaceutical industry, Structured Lipids for Food and Nutraceutical Applications

Module 5: Nucleic Acid Biopolymer (6 Hours)

Applications of nucleic acid polymer in diagnosis and therapy - nucleic acid probes in clinical laboratory; Review on current status of gene therapy research.

Module 6: Recent trends in Biopolymer applications (6 Hours)

Applications of biopolymers in food and packaging industry, Biopolymer scaffolds and tissue engineering, Biopolymers and bioremediation, Liposomes and their novel applications in nanobiotechnology and medicine.

Text book:

1. Lehninger A. L, Nelson D. L. and CoxM. M. "Principles of Biochemistry" Seventh Edition (Freeman Publishers), New York, 2017.

Reference Books:

1. Varki A, Cummings R.D, Esko J.D, Freeze H.H, Stanley P, Bertozzi C.R, Hart G.W,Etzler M.E., " Essentials of Glycobiology", Second edition; Published by Cold Spring Harbor Laboratory Press, New York, 2009
2. Murray R.K, Granner B.K, Mayes P.A, Rodwell V.W. "Harper's Biochemistry", Prentice Hall International, 2015.
3. Donald Voet and Judith G. Voet . "Biochemistry" – Volume 1, Biomolecules, Mechanisms of Enzyme Action and Metabolism, John.Willey and sons, 2010.
4. BurcuTuranli-Yildiz, CerenAlkim and Z. PetekCakar (2012). Protein Engineering Methods and Applications, Protein Engineering, Prof. Pravin Kaumaya (Ed.), ISBN: 978-953-51-0037-9

20BT3002	GENETIC ENGINEERING AND RECOMBINANT PRODUCTS	L	T	P	C
		3	0	0	3

Course Objectives:

To gain knowledge about

1. The history and future of genetic engineering
2. The techniques employed in Genetic Engineering in the field of medicine and the biotech industry.
3. The techniques involved in generating transgenic microbes, plants and animals.

Course Outcomes:

The students will be able to

1. Understand the basic concepts in Genetic engineering.
2. Recognize the usage of the tools of genetic engineering.
3. Choose the techniques employed in genetic manipulation of microbes.
4. Analyze the techniques employed in the genetic manipulation plants for crop improvement
5. Illustrate the techniques employed in the genetic manipulation animals for commercial purposes.
6. Discuss the genetic manipulation techniques employed in the production of therapeutics.

Module1: Introduction to Genetic engineering and the market of r-DNA products (4 Hours)

Impact of r-DNA products in food, drug, agriculture, and industry.

Module2: Tools employed in Genetic engineering: Vectors & Enzymes (7 Hours)

Properties of ideal vectors, Cloning vectors & Expression Vectors. Vectors for Bacteria; plasmids, cosmids and Phagemids, BAC and YAC. Shuttle vectors, Expression vectors for bacteria, yeast, animal/mammalian cells and plants.

Module3: Polymerase Chain Reaction (6 Hours)

Types of PCR, Inverse PCR, Nested PCR, RACE PCR, Reverse Transcriptase PCR, Real Time PCR, Nucleic acid sequencing methods.

Module4: Construction & Analysis of recombinant DNA (10 Hours)

Construction of Genomic DNA libraries & cDNA libraries, PCR Cloning of DNA for Expression in E.coli, Yeast, Plant & Mammalian cells. Physical, chemical and biological methods of transferring recombinant DNA into target cells. Restriction analysis, Probe preparation and labeling methods, hybridization methods

Module5: Protein and Nucleic Acid products of rDNA technology (9 Hours)

Production of hormones, enzymes for therapeutics and diagnostics. Recombinant enzymes for industrial applications.DNA oligonucleotides for Antigene applications, Gene editing tools: Meganuclease, CRISPER-CAS. ZFN, TALEN; RNA decoys, siRNA, micro RNA

Module6: Application of Genetically Modified Organisms (9 Hours)

Improved crop varieties GMOs: drought resistant, pest resistant, virus resistant salinity tolerant, Terminator technology, Biofortified crops, Plantibodies and Vaccines production in plants. Genetically enhanced animals, hypoallergenic cows.

Text Books:

1. Berhard R. Glick, Chery L. Patten, Molecular Biotechnology: Principles and Applications of Recombinant DNA, 5th edition, 2010
2. James D. Watson, Amy A. Caudy, Richard M. Myers, Jan A. Witkowski, Recombinant DNA: Genes and Genomes, W.H. Freeman, 2007

Reference Books:

1. GodbeyW T, **An Introduction to Biotechnology** ,AP, 2014
2. Kadema Carter, Biomedical Applications of DNA Recombinant Technology, Koros, 2014
3. Lilia Alberghina, **Protein Engineering For Industrial Biotechnology**, Hardwood Academic Press, 2000
4. Nigel W. Scott, Mark R. Fowler, Adrian Slater, **Plant Biotechnology**: **The genetic manipulation of plants**,2nd Edition, 2008
5. Carl A. Pinkert, **Transgenic Animal Technology**: A Laboratory Handbook, 2012.

20BT3003	BIOPROCESS MODELLING & SIMULATION	L	T	P	C
		3	0	0	3

Course Objectives:

To improve knowledge on

1. Principles and frameworks of data driven modeling
2. Mathematical models relevant to industrial and environmental bioprocess systems
3. Basics of MATLAB required for formalization of Bioprocess models and its simulation

Course Outcomes:

The students will be able to

1. Recognize the different stages and their inter-relationship in bioprocess modelling
2. Relate modelling, simulation and parameter estimation
3. Develop bioprocess system models from experimental data using Matlab tool
4. Examine the suitability of developed models in a quantitative manner
5. Interpret the bioprocess modelling outcome for refinement of model structure
6. Formulate simplification strategies and simulate bioprocess models with relevant examples

Module 1: Introduction to Bioprocess modelling (**7 Hours)**

Basic modeling principles – Purpose of modelling transient or steady state behavior – deterministic, stochastic, population based, mechanistic and empirical models. Fundamental laws guiding modelling framework – mass and energy balance, charge balance, equilibrium states and chemical kinetics, continuity equation.

Module 2: Mathematical formalization of Bioprocess **(7 Hours)**

Representation of Bioprocess (with examples) in terms of key mathematical expression, Data availability and designing data collection. Identifying key variables, parameters, number of equations, Kinetic expression, Conversion of algebraic to differential form for mass balance equations. Numerical modelling algorithm – initial value problem.

Module 3: Matlab basics for modelling **(10 Hours)**

Basics of Matlab environments, import from web, xls, txt file, variables, vector-matrices operations, Matlab functions, Numerical integration, Euler and fourth order Runge-Kutta method, Matlab ODE solver, choice of numerical solvers ode45, ode15s, ode23. Curve fitting toolbox for kinetic models simulating a bioprocess with known process parameters

Module 4: Matlab application in bioprocess modelling **(5 Hours)**

Solving problems by numerical integration. Modelling simple microbial growth, substrate consumption and product formation kinetics in batch Process. Incorporating substrate and product inhibition, multi-substrate growth models

Module 5: Parameter Estimation and sensitivity analysis, model fitness **(11 Hours)**

Parameter estimation from experimental and modelled data, least square regression, Use of local and global optimization tool for parameter estimation (Genetic algorithm). Cross-validation test for over-fitting, external validation, parameter Sensitivity and confidence interval estimation using boot-strapping

Module 6: Advanced Bioprocess Modelling examples **(5 Hours)**

Modelling and Simulation of Citric Acid Production from Corn Starch Hydrolysate, Mathematical modelling of ethanol production, Dynamic Modelling of Complex Enzymatic Reactions, Dynamic modeling of nutrient removal

Text Books:

1. Verma, Ashok Kumar, Process Modelling and Simulation in Chemical, Biochemical and Environmental Engineering, CRC Press, (2014).
2. Dunn, Irving J. Biological reaction engineering: dynamic modelling fundamentals with simulation examples, Wiley-VCH, (2003).

Reference Books:

1. Nicoletti, Maria Carmo, Computational Intelligence Techniques for Bioprocess Modelling, Supervision and Control. Springer, (2009)
2. Snape, Jonathan B. Dunn, Irving J., Ingham John, Prenosil Jiri E. ,Dynamics of Environmental Bioprocesses: Modelling and Simulation, John Wiley & Sons, (2008)

20BT3004	BIOCHEMICAL ANALYSIS LAB	L	T	P	C
		0	0	4	2

Course Objectives:

To improve knowledge on

1. Clinical role of biochemical metabolites in biological sample.
2. Importance of biochemical metabolites and their assays
3. Advanced biochemical characterizationand structure prediction techniques

Course Outcomes:

The students will be able to

1. Recall the basic concepts and principles of different assays
2. Understand the protocol for extraction of biomolecules from various sources
3. Experiment with the assay procedures of acid phosphatase. Glucose, hexosamine, and antioxidants assays
4. Infer the results and draw conclusion
5. Compare the different methods of extraction of phytochemicals, and exposed to latest techniques on determination and structure prediction using advanced techniques
6. Propose and apply the above learnt experimental skills in their project work

List of Experiments:

1. Assay of acid phosphatase
2. Assay of lipid peroxidation (LPO) in plasma
3. Estimation of glucose by glucose oxidase and peroxidase (GOD – POD) method
4. Estimation of serum hexosamine by Wagner method
5. Determination of peroxide value of oil
6. Isolation and preparation of lecithin from egg
7. Determination of total antioxidant capacity by phosphomolybdenum method
8. Modified hydroxyl radical scavenging assay
9. Solvent extraction of phytochemicals and qualitative screening
10. Separation of phytochemicals by HP-TLC
11. Determination of molecular mass of phytochemicals by Mass spectrometry
12. Biomolecular structure prediction using X-Ray diffraction

Reference Books:

1. S.Sadasivam and A.Manickam, Biochemical Methods. 2nd edition, New Age International publishers, New Delhi, 2005
2. S.K. Sawhney and Randhir singh, Introductory Practical Biochemistry, Narosa Publishers, 2005

20BT3005	ANIMAL AND PLANT TISSUE CULTURE LAB	L	T	P	C
		0	0	4	2

Course Objectives:

1. To know Plant tissue culture and transformation techniques
2. To know Animal tissue culture and assays
3. To carryout Sterilization techniques on Plant and Animal Tissue Culture

Course Outcomes:

1. Demonstrate media preparation on Plant and Animal Tissue Culture
2. Comprehend on sterilization techniques
3. Experiment plant transformation techniques
4. Performin vitro animal cell culture techniques

5. Demonstrate cell viability assays using different types of animal cells
6. Analyze the cell toxicity of drugs

List of Experiments:

1. Media preparation and Axillary bud breaking method
2. Establishment of banana explant and Multiplication
3. Cell Suspension Culture for secondary metabolite production and growth kinetic studies
4. Establishment of hairy root culture for secondary metabolite production
5. Agrobacterium mediated gene transfer in *in vitro* plantlets
6. Passaging of cell line
7. Cryopreservation
8. Membrane integrity assay- Trypan Blue Staining
9. Metabolic activity assay- LDH assay
10. Functional assay- MTT/XTT
11. DNA assay- COMET
12. Micropropagation of medicinal plant

References:

1. Plant Tissue Culture: Theory and Practice Satish Kumar Sinha Oxford Book Company 2012
2. Bojwani, S.S. "Plant Tissue Culture: Applications and Limitations", Elsevier science publishers, 2001.
3. R. Ian Freshney. Introduction to Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, Sixth Edition. Publisher, John Wiley & Sons, 2011.

20BT3006	ADVANCED PROCESS EQUIPMENT DESIGN AND DRAWING LAB	L	T	P	C
		0	0	4	2

Course Objectives:

1. To design safe and dependable processing facilities.
2. To design plant layout and selection using AutoCAD.
3. To provide the basic knowledge to carry out process equipment design and cost effect.

Course Outcomes:

1. Understand the unit operation symbol, letters and plant layout
2. Summarize the effect of heat exchangers and evaporators
3. Recognize batch reactor
4. Evaluate the efficiency of distillation
5. Analyze the process of filtration and absorption
6. Comprehend the uses of valves in flow measuring devices

List of Experiments:

1. Engineering Letters, Lines and numbers.
2. Basics of various unit operation symbols
3. Design of Pharmaceutical Industry Plant layout
4. Design of Chemical Industry Plant layout
5. Design of Shell and tube heat exchanger
6. Design of Single effect evaporator
7. Design of Batch reactor
8. Design of Airlift Fermentor
9. Design of Fractional distillation column
10. Design of Rotary drum filter
11. Design of Absorption column
12. Design of Venturi meter

Reference Books:

1. Donald Q.Kern, "ProcessHeatTransfer",TataMcGrawHill, New Delhi, 2007.

2. Mccabe, W. L.,Smith, J. C., and Harriott,P., "Unit Operations of Chemical Engineering", McGraw Hill,NewYork,6th Edition,2004

Course Code	Genetic Engineering Lab	L	T	P	C
20BT3007	(Version 1.1)	0	0	4	2

Co-requisite: Lab in Molecular Biology

Course Objectives:

To impart knowledge on

1. Isolation of nucleic acids and proteins.
2. Qualitative and Quantitative analysis of nucleic acids.
3. Genetic manipulation of nucleic acids for protein production.

Course Outcomes:

After completing the course the students will be able to

1. Isolate the nucleic acids
2. Perform electrophoresis of nucleic acids and proteins.
3. Interpret DNA manipulation and transformation techniques.
4. Evaluate RNA expression by reverse transcription
5. Analyze nucleic acid amplifications using PCR
6. Illustrate the purification of recombinant proteins

List of Experiments

1. Isolation of plasmid DNA and restriction digestion to estimate molecular weight by Agarose Gel electrophoresis
2. Isolation of total RNA from E.coli
3. Isolation of total RNA from Yeast
4. Isolation of RNA from mammalian cells.
5. Reverse Transcriptase PCR of target gene & Agarose Gel electrophoresis to estimate molecular weight.
6. RAPD- PCR
7. Restriction Analysis - RFLP
8. Preparation of competent E.coli and transformation of the cloned plasmid and selection of recombinant clones.
9. Extraction and purification of target protein using column chromatography.
10. Analysis of expressed protein using SDS-PAGE.
11. Western blotting analysis for confirmation of purity and quality of expressed protein
12. Spectrometric quantification of nucleic acids.

Reference:

1. Michael R. Green, Joseph Sambrook, Molecular Cloning: A Laboratory Manual (Fourth Edition), 2012

20BT3008	ENZYME TECHNOLOGY AND INDUSTRIAL APPLICATIONS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To understand the mechanism of biocatalyst
2. To learn the kinetics of enzymatic reaction
3. To learn about applications of enzymes

Course Outcomes:

The students will be able to

1. Understand the concept of kinetics of immobilization
2. Understand molecular understanding of enzymes
3. Apply enzymes in sterospecific reactions
4. Evaluate application of enzymes

5. Analyze commercial production of enzyme
6. Create inhibition kinetics of the enzymatic reactions

Module 1: Introduction to enzymes (7 hours)

Brief history of enzyme engineering, quantification of enzyme activity and specific activity, Enzyme in action & specificity, Enzyme stability, monomer & oligomeric enzymes. Structure of enzymes-ray crystallography of enzymes, control of Enzyme activity

Module 2: Enzyme kinetics &modeling of enzymatic systems (7 hours)

Kinetics of multisubstrate enzyme catalyzed reaction, relation of kinetic parameters, microenvironmetal effects on enzyme kinetics, Enzyme Inhibition – Substrate, Product and Toxic compound inhibition, types and derivation. Enzyme deactivation kinetics. Allosteric regulation of enzymes, Monod changeuxwyman model

Module 3: Immobilized enzymes (7 hours)

Introduction, kinetics of immobilized enzymes, Analysis of film and Pore diffusion, Reactor systems and Engineering considerations

Module 4: Industrial enzymes (9 hours)

Few industrial nzymes like glucose-isomerase, cellulases, Pectinases, protease etc. Their importance, source production, optimization of fermentation medium, assay, extraction and purification, Characterization, genetic manipulation etc. Applications of enzymes in analysis; Design of enzyme electrodes

Module 5: Molecular Understanding of Enzymes (7 hours)

Enzyme catalysis- mechanism of enzyme activity, enzyme dynamics and flexibility; specificity of enzymes- substrate specificity, enantioselectivity of enzymes; thermodynamics and stability

Module 6: Enzyme in Organic Synthesis (8 hours)

Enzymes like DHAP aldolase, pyruvate aldolase, tyrosine kinase & their uses, Uses of mutagenesis to increase substrate specificity. Producing catalytic antibodies.

Text Books:

1. Palmer, T., & Bonner, P. L. *Enzymes: biochemistry, biotechnology, clinical chemistry*. Elsevier, 2007
2. Punekar, N. S. *Enzymes*. Springer, 2018

Reference Books:

1. Guisan, J. M. (Ed.). *Immobilization of enzymes and cells* (Vol. 22). Totowa, NJ: Humana Press, 2006
2. Price and Lewis Stevens. Fundamentals of Enzymology, Oxford, United Kingdom, 2000
3. Yoo, Y. J., Feng, Y., Kim, Y. H., &Yagonia, C. F. J. *Fundamentals of enzyme engineering*. Springer, 2017
4. Liu, S. *Bioprocess engineering: kinetics, sustainability, and reactor design*. Elsevier, 2020

20BT3009	MICROBIAL BIOTECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

1. To study the role of microorganisms in medicine, agriculture, and the environment.
2. To impart knowledge concerning genomics and proteomics in biotechnology
3. To develop value added microbial based products for commercialization

Course Outcomes:

The students will be able to

1. Gain knowledge about recent advances in microbial biotechnologies
2. Apply the concept of genomics and proteomics in biotechnology with regard to microorganisms
3. Acquire practical exposure to recombinant DNA technologies in microbes to enhance animal health and production
4. Demonstrate and evaluate the interactions between microbes, hosts and environment.
5. Give an account of important microbial/enzymatic industrial processes in food and fuel industry.
6. Critically analyze any microbial products from an economics/market point of view

Module 1: Introduction to microbial technology (5 Hours)

Microbial technology in human welfare; Isolation and screening of microbes important for industry – advances in methodology and its application; Strain improvement to increase yield of selected molecules, e.g., antibiotics, enzymes, biofuels

Module 2: Microbial Genomics (9 Hours)

Introduction to Microbial genomes -Genome sequencing of different microbes; Microbial genomics for discovery of novel enzymes, drugs/ antibiotics-Multi Drug Resistance, Metagenomics and metatranscriptomics – their potential, methods to study and applications/use (animal and plant health, environmental clean-up, global nutrient cycles & global sustainability), Phylogenetic relationships between various genera of microbes; Global metagenomics initiative - surveys/projects and outcome

Module 3: Microbial Proteomics (8 Hours)

Introduction to microbial proteomics, 2D gel profiling, MALDI – ToF, Protein purification work station of various microbes, Microbial pathogenesis at the proteome level, Structural proteomics and computational analysis, Proteome research for novel drug targets, High throughput proteomic screening for novel enzymes

Module 4: Microbial interactions (6 Hours)

Interactions of microorganisms with plants, animals and humans- The gut microbiota; Bacteriophages in control of bacteria, Thermal adaptation of decomposer communities to global warming, Gene manipulation of useful microbes, Microbial communication system- Quorum sensing

Module 5: Microbes in food and agriculture (9 Hours)

Food processing and food preservation- Temperature, Food additives, Irradiation, Food Borne Intoxications- Clostridium botulinum, Staphylococcus aureus, Listeria monocytogenes, Mycotoxins, Production of bacteriocins from lactic acid bacteria and their applications in food industry; Non-recombinant ways of introducing desirable properties in Generally recognized as safe (GRAS) microbes to be used in food (e.g., Yeast); Bioinsecticides, biofertilizers, Mycorrhiza

Module 6: Production of Microbial Metabolites (8 Hours)

Production, recovery, stability and formulation of bacterial and fungal enzymes-penicillin acylase, glucose isomerase and Cell based biotransformations of steroids, antibiotics, alkaloids, enzyme/cell electrodes; Microbial fuel cells; Prebiotics and Probiotics; Microbiologically produced food colours and flavours; Biofuel production from microalgae, Production of recombinant bacterial/ viral vaccines against important animal diseases

Textbooks:

1. Ian Humphery-Smith and Michael Hecker, Microbial Proteomics: Functional Biology of Whole Organisms by Publisher: Wiley-Interscience; 1st edition, 2010.
2. Thomas J. Dougherty and Steven J. Projan, Microbial Genomics and Drug Discovery by Publisher: CRC; 1st ed. 2013.
3. Stanbury, P. F., Whitaker and Hall, A. S. J., Principles of Fermentation Technology. Butterworth-Heinemann, 2009.

References:

1. Shuler, M.L. and Karg, I F., Bioprocess Engineering Basic Concepts, 2010.
2. Crueger W. and Crueger, A., Biotechnology. A Textbook of Industrial Microbiology, Sinauer Associates, 2008.
3. El-Mansi, M., & Bryce, C. F. (2007). Fermentation Microbiology and Biotechnology.
4. Boca Raton: CRC/Taylor & Francis.
5. Glazer AN, Nikaido H. 2007. Microbial Biotechnology: Fundamentals of Applied Microbiology. Cambridge University Press
6. Lin YK, Microbial Biotechnology: Principles and Applications. 3rd Ed. World Scientific

20BT3010	AGRICULTURE AND FOOD BIOTECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

1. To enhance knowledge on principles of Agriculture and plant breeding

2. To analyze the biotechnology processing of food and packaging
3. To elaborate the understanding of marketing of agricultural produce.

Course Outcomes:

The students will be able to

1. Acquire knowledge on basics of biotechnology in Agriculture
2. Outline the applications of microbes in Agriculture
3. Understand the concept of industrial Biotechnology processes
4. Relate the technological applications in food processing
5. Evaluate the advances in Food processing and Packaging
6. Analyze Marketing and Export of Food Products

Module 1: Agriculture Biotechnology (8 Hours)

Plant derived Biotechnological Products, Plant tissue culture and Genetic engineering, integrated pest and nutrient management, poly house technology, Scenario of Biotech industries & Institutes, Concepts of Biotech Park. Entrepreneurship biotechnology

Module 2: Microbes in Agriculture (7 Hours)

Microbes of agricultural importance, Microbe based biofertilizers, Soil microbes and plant growth substances, biocontrol agents, Induced systemic resistance (ISR), Plant growth promoting rhizobacteria (PGPR)

Module 3: Industrial Perspectives (7 Hours)

Screening of microorganisms for new products. Fermentation process development. Shake flask, Scale up of process and bioreactors. Genetically engineered microbes (GEMs). Production of secondary metabolites. Process and types of bioreactors. Various methods of fermentation.

Module 4: Technological Applications in Food Processing (8 Hours)

Recent trends in food processing. Techniques and applications of immobilized enzymes in food industry. Single cell proteins for human food consumption. Biotechnology for natural and artificial flavor and fragrance production. Safety issues related processed foods, bio-preservation/ Natural preservation. Aseptic packaging/ vaccum packaging, biodegradable plastics, extrusion cooking.

Module 5: Food processing and Packaging (8 Hours)

Scope and importance of food processing. National and international perspectives. Principles and methods of food preservation, Storage of food, Packaging operations, shelf life of packaged foodstuff, methods to extend shelf-life, Food packages and containers

Module 6: Marketing and Export of Food Products (7 Hours)

Food spoilage causes and prevention, Food borne infections and intoxication, immobilization of microbial and cultured plant cells. External trade in Agricultural products, Present status, policy and prospects under WTO regime. Quality parameters and quarantine procedures of export

Text Books:

1. Chawla H S, Introduction to Plant Biotechnology, 3Ed Oxford & IBH Publishing 2020
2. AkhilMathur, Food processing packaging by Anmol publisher (2012)
3. Acharya S.S., Agricultural marketing in India by Oxford & IBH publishing; 6th revised edition edition (2019)
4. William C. Frazier, Dennis C. Westhoff, N.M. Vanitha, Food Microbiology by. McGraw Hill Education; Fifth edition (2017)

Reference Books:

1. Megh R. Goyal, Hafiz AnsarRasul Suleria, Shanmugam Kirubanandan, Technological Processes for Marine Foods, From Water to Fork: Bioactive Compounds, Industrial Applications, and Genomics (Innovations in Agricultural & Biological Engineering) by Apple Academic Press; 1 edition (25 June 2019)
2. Byong H. Lee, Fundamentals of Food Biotechnology (2015).
3. Jeyabalan Sangeetha, DevarajanThangadurai, SomboonTanasupawat, PradnyaPralhadKanekar,Biotechnology of Microorganisms: Diversity, Improvement, and

Application of Microbes for Food Processing, Healthcare, Environmental Safety, and Agriculture by Apple Academic Press; 1 edition (2019).

4. Philip E. Nelson, Principles of Aseptic Processing and Packaging, Purdue University Press, (2010)

20BT3011	BIG DATA ANALYTICS	L	T	P	C
		3	0	0	3

Course Objectives:

To improve knowledge on

1. Fundamental concepts and methods of Big data analysis.
2. Data exploration, visualization and statistical analysis for given data set.
3. Managing big data analytics for Biological data set.

Course Outcomes:

The students will be able to

1. Know various types of big data platform and cloud computing model.
2. Understand the fundamentals of big data technologies
3. Apply the big data tools and software in handling the biological data.
4. Evaluate variety of big data analytics tools.
5. Explore use of R platform for biological big data analysis.
6. Design and develop Biological models based on big data techniques.

Module 1: Introduction (8 Hours)

Big data analytics overview, Data life cycle, Traditional Data mining Life cycle, CRISP, Big Data life cycle methodologies

Module 2: Data Exploration and Visualization (7 Hours)

Problem Definition, Data Collection, Data Pre-processing, Data Cleaning – Homogenization, Heterogenization, Summarizing data, Data Exploration and Visualization.

Module 3: Big Data Methods (9 Hours)

Introduction to R programming, Data Frames, Atomic vectors, Factors, Data types, Variables, Functions, working with excel files, Data interface.

Module 4: Charts & Graphs (6 Hours)

Develop pie chart, 3D pie chart, Histograms, Bar chart, Group bar chart, Stacked Bar chart, Line graph, Multiline graph and Box plot.

Module 5: Statistical Methods (9 Hours)

Regression models, Linear Regression, Multiple regression, Logistic regression, Mean, Median, Mode, Chi-Square test, T-Test.

Module 6: Big data analytics for Health care (6 Hours)

Big data analytics in bioinformatics, Health care, Data mining using RNA seq data, Text mining on complex biomedical literature, Biological sequence motifs and patterns.

Text Books:

1. VenkatAnkam, "Big Data analytics", Packt publishing 2016
2. Parag Kulkarni, Sarang Joshi, "Big Data analytics", PHI learning 2016
3. Wang, Baoying, Big Data Analytics in Bioinformatics and Healthcare, IGI global edition, 2014

Reference Books:

1. Mark Gardener. Beginning R: The Statistical Programming Language. John Wiley & Sons, 2012.
2. Avril Coghlan, A Little Book of R For Bioinformatics, Release 0.1, 2017
3. Robert Gentleman, R Programming for Bioinformatics, CRC press, Taylor & Francis,2008

20BT3012	BIOETHICS AND BIOSAFETY	L	T	P	C
		3	0	0	3

Course Objectives:

1. To Understand Biosafety regulations and IPR
2. To discuss environmental containments of GMO and ethics of stem cell research

3. To appraise ethical issue of transgenics in plant, animal and microorganisms

Course Outcomes:

1. Recall different rDNA technology of transgenic in animals, humans and plants
2. Understand the various biosafety regulations in transgenics
3. Illustrate IPR and patent procedures
4. Comprehend on various techniques of genome, stem cells and organ research in humans
5. Aware of modern rDNA research and its ethical procedures
6. Comprehend on recent ethical, legal and social economic impacts of rDNA research in biotechnology and its applications

Module 1: Legal Impacts of Biotechnology - Biosafety Regulations and Bioethics (7 hrs)

National and International Level Biosafety Regulations, Trials On-field, Upscaling of Field Trials, Coordination and Capacity Establishment, Screen–A Newsletter on Biosafety, Hazardous Materials Used in Biotechnology—Handling and Disposal, Good Manufacturing Practices, Good Laboratory Practices, Good Laboratory Practice Principles. Bioethics: Introduction to ethics and bioethics, framework for ethical decision making. Ethical, legal and socioeconomic aspects of gene therapy.

Module 2: Intellectual Property Rights (9 hrs)

Introduction to IPR, Types of IP - Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge and Geographical Indications, Filing of a patent application; Precautions before patenting-disclosure/non-disclosure; Procedure for filing a PCT application, Patenting and the Procedures Involved in the Application for Grading of a Patent, Steps to a Patent, Examples of Patents in Biotechnology

Module 3: Environmental containments of GMO and Farmers rights (9 hrs)

The GM-food debate and biosafety assessment procedures for biotech foods & related products, including transgenic food crops, case studies of relevance. Key to the environmentally responsible use of biotechnology. Environmental aspects of biotech applications. Use of genetically modified organisms and their release in environment. Discussions on recombinant organisms and transgenic crops, with case studies of relevance. Plant breeder's rights. Legal implications, Biodiversity and farmers rights. Ethical implications of GM crops and GMO's.

Module 4: Stem Cell Research (8hrs)

Introduction**,** Applications of Stem Cells, Ethics Involved in Stem-cell Research, Use of Cell-cultures as Alternatives to Use of Animals, Replacement, Use of Animals for Research and Testing, Animal Cloning, Ethics and Animal Cloning, Human Cloning, Why Cloning Humans is Ethically Unacceptable?, Controlling Someone Else's Genetic Makeup, Instrumentality, Infertility–An Exception to Instrumentality.

Module 5: Organs Transplantation in Human Beings (8 hrs)

Organs Transplantation in Human Beings, Ethics in Xenotransplantation, Bioethical Issues, Transgenesis, Informed Consent, Allocation of Health Care Resources, Patentability and Xenotransplantation, Organ Culture, Ethical Issues.

Module 6: Transgenic guidelines (5 hrs)

DBT - rDNA guidelines and regulatory affairs for transgenics- plants, animals and microorganisms

Total Hours: 45

Text Book:

1. Sree Krishna. Bioethics and Biosafety in Biotechnology. New Age International Publishers, New Delhi, 2007

.**Reference Books:**

1. Jonathan, Y.R., Anthology of Biosafety (Vols. 1-4), American Biological Safety Association (2005).
2. Encyclopedia of Ethical, Legal and Policy issues in Biotechnology, John Wiley & Sons Inc. (2005).

20BT3013	CHEMICAL PROCESS TECHNOLOGY	L	T	P	C
		3	0	0	3

Course objectives:

1. To address designing new process and product development.
2. To understand the processes technologies of various organic and inorganic process industries for manufacturing chemicals.
3. To associated troubleshoot.

Course Outcomes:

1. Remember the process flow diagram for various chemical process
2. Understand the steps in manufacturing process of organic and inorganic chemicals
3. Classify various chemical, agrochemical and fermentation products
4. Illustrate the process flow diagram of carbohydrates, oils, fats etc.
5. Analyze various chemical process to solve engineering problems during production
6. Evaluate major engineering problems and in order to provide technological solutions in chemical process industries.

Module 1:Process Flow Diagram (8 hrs)

Basic philosophy of a process flow diagram (PFD). Elements of a PFD. General discussion on Influence of various parameters on deciding process for a product and method of drawing PFD. Nitric acid, sulphuric acid, phosphoric acid and urea

Module 2: Industrial Production (8 hrs)

Caustic chlorine industry - membrane and diaphragm cells. Hydrochloric acid and important chlorine compounds sodium bicarbonate, cement , Glass & ceramic industries

Module 3: Oils and Fats (7 hrs)

Process description and flowsheet of extracting vegetable oils. Hydrogenation of oils, major engineering problems and recent technology.

Module 4: Sugar Derivatives (8 hrs)

Manufacturing process with flow diagram for Sugar and starch industries and their different by-products; Glucose, Pulp and paper Industries

Module 5: Fermentation Products (7 hrs)

Fermentation industries: Industrial Alcohol, Absolute Alcohol; their production process with flow diagram.

Module 6: Agrochemical Industries (7 hrs)

Elementary ideas on Pesticides, Insecticides, Fungicides, Herbicides, DDT manufacturing process with flow sheet.

Total Hours: 45

Text Book:

1. Dryden, C. E., and Rao, M.G. (Ed.), Outlines of Chemical Technology Affiliated East West Press.2010

Reference Books:

1. Austins, G.T., Sherve's Chemical Process Industries, MGH,2012.
2. Venkateswarlu, S. (Ed.) Chemtech (II) Chemical Engineering Development Centre, IIT, Madras, 2009.
3. S. K. Ghoshal, S. K. Sanyal and S. Datta, Introduction to Chemical Engineering, Tata McGraw Hill, New Delhi, 2010.
4. Kirk &Othmer (Ed.), Encyclopedia of Chemical Technology, 2011.

20BT3014	**IMMUNOTECHNOLOGY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Objectives:

1. This course aims to impart basic knowledge in Immunology,
2. To help the students familiarize with the organs and cells of the immune system, the immune response and molecular interactions involved in immune response.
3. To make the students aware of the applications of immunology such as, immunodiagonosis and immunotherapy.

Course Outcomes:

1. Account for the structure and function of the immune system both at the molecular and cellular level.
2. Account for polyclonal, monoclonal and humanized antibodies and production of these.
3. Describe immunization/vaccination, immunological disease and immunotherapy.
4. Plan, carry out and present achieved results of immunological serum analyses by means of different immunotechniques.
5. Discuss immunological techniques and their applications in biotechnical industry.

Module 1:Immune System(9)

Introduction and an overview of immunology, History of immunology, Types of Immunity - Innate and acquired immunity, Cell mediated and humoral immunity; Organs of the immune system: Lymphoid organs - primary and secondary.

Module 2:Immune Response(9)

Granulocytes and Agranulocytes, haematopoiesis, extravasation, phagocytosis. T and B Lymphocytes & NK cells. Major histocompatibility complex; antigen processing and presentation, T-Cell activation and the cellular immune response.

Module 3:Antigen Antibody Reactions(9)

Antigens- chemical and their molecular nature; Haptens; Adjuvants. Antibody – structure, Classes, Genes and Antibody diversity. Antigen Antibody reactions; Neutralization, Opsonization. Complement, Cytokines. Vaccines.

Module 4: Autoimmunity, Hypersensitivity(4)

Tolerance and Autoimmunity, Types and mechanism of autoimmune diseases, Hypersensitive reactions, Primary and secondary immunodeficiency, AIDS

Module 5:New Generation Antibodies (5)

New Generation Antibodies; Multigene organization of immunoglobulin genes, Ab diversity; Chimeric antibodies, Antibody engineering; Phage display libraries; Antibodies as in vitro and in vivo probes. Large scale manufacture of antibodies for immunodiagnostics.

Module 6:Immunotechniques (9)

Diagnostics; immunodiffusion, Haemagglutination, ELISPOT assay, immunofluorescence, Surface plasmon resonance, flow cytometry and immunoelectron microscopy. PCR based technology for Antibody generation, Plamsa based therapy, Monoclonal Antibody production, Vaccine development and case studies on Immuno compromising and treatment.

Total Hours: 45

Text Book

1. Roitt I, Male, Brostoff, "Immunology", Mosby Publishers, 2002.

Reference Books:

1. Tizard, "Immunology", Saunders college publication, 5th Edition. 2004.
2. Kuby J, "Immunology", WH Freeman & Co., 2000.
3. Ashim K. Chakravarthy, "Immunology", TataMcGraw-Hill, 2001

20BT3015	COMPUTATIONAL BIOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

1. To understand the fundamental concepts, tools and resources in Computational Biology.
2. To improve knowledge on machine learning and data mining concepts and techniques relevant to biological data along with practical implementation of machine learning techniques.
3. To facilitate the specialized areas related to Computational Biology which will enable high throughput data processing and analysis.

Course Outcomes:

The students will be able to

1. Understand the principles of, biological data and interpretation.

2. Demonstrate high throughput biological data and perform statistical analysis.
3. Make use of advanced data mining and machine learning techniques
4. Create skills on molecular modeling and simulation, whole cell modeling, drug discovery, and Systems Biology
5. Clarify the implementation of algorithms which may help them design their own.
6. Explain the theory and practical aspects of important computational experimental techniques.

Module 1: Biomolecular Computing (10 Hours)

DNA Structure, and Processing , Computational operations and Step involve in DNA computing, Bio-soft Computing Based on DNA Length, Beginnings of Molecular ComputingAdelman Experiment. RNA secondary structure prediction: Base pair maximisation and the Nussinov folding algorithm, Energy minimisation and the Zuker folding algorithm, Design of covariance models, Application of RNA fold.

Module 2: MolecularMechanics:(7 Hours)

Introduction, The Morse Potential, The Harmonic Oscillator Model for Molecules, Comparison of Morse and Harmonic Potential, Two atoms connected by a bond, Poly atomic Molecules, Energy due to Stretch, Bend, Stretch-Bend, Torsional strain, van der Waals and Dipole-Diploe interactions. Types of Potentials: Lennard-Jones, Truncated Lennard-jones. Types of Force Fields: AMBER, CHARMM, Merck Molecular Force Field, Consistent Force Field, MM2, MM3 and MM4 force fields.

Module 3: Molecular Dynamics Simulation (7 Hours)

Introduction, Radial distribution functions, Pair Correlation function, Newtonian dynamics, Integrators-Leapfrog and Verlet algorithm, Potential truncation and shifted-force potentials, Implicit and explicit Solvation models, Periodic boundary conditions, Temperature and pressure control in molecular dynamics simulations.

Module 4: Next generation sequencing (7 Hours)

NGS Platforms: Introduction to NGS, Roche/454 FLX, Illumina/Solexa Genome Analyzer, Applied Biosystems SOLiD system, HelicosHeliscope, Pacific Biosciences/single molecule real time (SMRT) sequencing. Biological applications of NGS: Whole-genome sequencing, Exome sequencing, Transcriptome sequencing, Epigenome sequencing, Interactome sequencing, methylome sequencing.

Module 5: Data Mining and Data warehousing (7 Hours)

Need for data warehouse, definition, goals of data warehouse, Data Mart, Data warehouse architecture, extract and load process, clean and transform data, Designing fact tables, partitioning, Data warehouse and OLAP technology. Importance of Data Mining, Relational Databases, Data Warehouses, Transactional Databases, Advance Database Systems and Applications, Data Mining Functionalities, Classification of Data Mining Systems, Major issues in Data Mining.

Module 6: Systems Biology and protein network analysis (7 Hours)

Systems Biology Networks- basics of computer networks, Biological uses and Integration. Basic properties of Network: Degree, average degree and degree distribution. Adjacency matrix, weighted and unweighted networks, Bipartite network, Paths and distances. Metabolic reconstruction, Application.

Text Books:

1. An introduction to bioinformatics algorithms by Neil C. Jones, Pavel Pevzner. MIT Press ,(2011)
2. Molecular Modelling for Beginners, (2nd Edition) by Alan Hinchliffe, John Wiley & Sons Ltd. (2008)
3. Next-generation DNA sequencing Informatics by Stuart M. Brown, Cold Spring Harbor Laboratory, (2013).

Reference Books:

1. Andrew R. Leach, Molecular Modeling Principles and Applications, Second Edition, Prentice Hall. (2001)
2. Jonathan Pevsner. Bioinformatics and Functional Genomics, 2nd Edition. John Wiley & Sons Inc (2015)
3. Computational systems biology by A.Kriete, R.Eils, Academic Press. (2005)
4. Systems Biology and Synthetic Biology by Pengcheng Fu, Sven Panke, Wiley InterScience. (2009)

5. Greg Gibson and Spencer V. Muse. A Primer of Genome Science, Third Edition. Sinauer Associates, Inc; 3 edition (2009)

20BT3016	METABOLIC REGULATION AND ENGINEERING	L	T	P	C
		3	0	0	3

Course Objectives:

1. Impart skills to amend the existing metabolic pathways through metabolic engineering and synthetic biology
2. Enable the students to use molecular techniques to enhance the yield of industrially important product
3. Understand the quantitative basis of metabolic networks

Course Outcomes:

The students will be able to

1. Identify the appropriate metabolic pathways to produce a desired product
2. Characterize the metabolic pathways and propose relevant metabolic engineering strategies to enhance an economically viable products
3. Construct metabolic flux models using available tools
4. Design 13C-labeling strategies and perform metabolic flux analysis to determine metabolic pathway
5. Construct a mathematical representation of a metabolic network, and calculate the internal fluxes based on external measurements.
6. Adapt suitable synthetic biology tools to build and design new pathways, cells and systems

Module 1: Metabolic Pathways and integrated database (6 Hours)

Metabolic pathways database, KEGG, Roche Biochemical Pathways, Pathway of Cellular respirations, Glycolysis, Krebs Cycle, Fermentative Pathways, Metabolism of Proteins and Lipids, Stoichiometry of cellular reactions, reaction rate and flux, dynamic mass balance

Module 2: Regulation of Metabolic Pathways (5 Hours)

Feedback control systems, alteration of feedback regulation for enhanced production of primary metabolites, Regulation of enzyme concentration-lac operon- Metabolic networks-branch point classification

Module 3: Metabolic Flux and Control Analysis (12 Hours)

Flux Analysis basics, Dynamic steady state, Estimation of intracellular metabolic flux, Determined, over determined and under determined system, use of linear programming; Isotopic substrate composition, 13C MFA experimentation, Detection of 13C labelling patterns, Construction of a metabolic model for 13C flux analysis; Coefficients of control analysis, elasticity coefficient, Flux control coefficients, Summation theorem, FC connectivity theorems

Module 4: Synthesis and Engineering Tools in Synthetic Biology (9 hours)

Introduction to Synthetic Biology- New Tools for Cost-Effective DNA Synthesis- Oligonucleotide Synthesis- microarray oligonucleotide synthesis, Microfluidic and fluidic systems; Quality Control-hybridization selection; 'BioBricks: a standard for physical DNA composition; Protein Engineering Methods- Site directed diversification, Screening and selection, high throughput screening in microtitre plates

Module 5: Pathway Engineering as Enabling Synthetic Biology Tool (7 hours)

Introduction-Design and construction of pathways- Pathway design tools; Pathway optimization-strategies for optimizing a metabolic pathway based on gene expression, strategies for optimizing a metabolic pathway based on protein level Ex E.coli*

Module 6: Applications of Metabolic Engineering and Synthetic Biology (6 Hours)

Product over-production examples: polyhydroxyalkanoic acids, Extension of substrate utilization range for organisms such as *S. cerevisae* and *Z. mobilis* for ethanol production, metabolic engineering of *Enterobacter aerogenes*; metabolic engineering of microalgae for biofuel production

Textbooks:

1. Christina Smolke*ed.*, The Metabolic Pathway Engineering Handbook: Fundamentals, CRC Press, 2009.
2. Gregory N. Stephanopoulos, Aristos A. Aristidou & Jens Nielsen, "Metabolic Engineering: Principles and Methodologies", Academic Press, An Imprint of Elsevier India Pvt.Ltd., 1st edition, 1998.

Reference Books:

1. S. Cortassa, M.A.Aon, A.A.Iglesias and D.Llyod, "An Introduction to Metabolic and Cellular Engineering", 2nd Edition, World Scientific Publishing Co. Pte. Ltd, 2012.
2. Peter F. Stanbury, Stephen J. Hall & A. Whitaker, "Principles of Fermentation Technology", Butterworth – Heinemann An Imprint of Elsevier India Pvt. Ltd., 2nd edition, 2005
3. Eva-Kathrin Ehmoser-Sinner, Cherng-Wen Darren Tan Lessons on Synthetic Bioarchitectures: Interaction of Living Matter with synthetic structural analogues, Springer International Publishing, 2018
4. *Molecular Systems Biology 7; Article number 515; doi:10.1038/msb.2011.46

20BT3017	CLINICAL TRIALS AND BIOETHICS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To Explain key concepts in the design of clinical trials
2. To identify key issues in data management for clinical trials.
3. To describe the roles of Regulatory Affairs in clinical trials.

Course Outcomes:

The students will be able to

1. Understands the principles and methodology of clinical trials
2. Comprehend the theory and practical aspects of important techniques
3. Develop analytical skills and expertise to formulate and implement a research oriented real time problem.
4. Asses in major high throughput statistical methods in clinical research.
5. Evaluate experimental component to undertake interdisciplinary work.
6. Equips skills to pursue a career either in academia or industry.

Module 1: Introduction to Drug Discovery and Development (9Lecture Hours)

Origin and History of Clinical Research, Introduction to Drug Discovery and drug Development, Clinical Trials in India–The National Perspective, Clinical Trial Phase I, Clinical Trial Phase II, Clinical Trial Phase III, Clinical Trial Phase IV –methods, Principles of sampling -Inclusion and exclusion criteria, Methods of allocation and randomization, Termination of trial.

Module 2: Ethical Regulation (8Lecture Hours)

Historical guidelines in Clinical Research -Nuremberg code, Declaration of Helsinki, Belmont report, Research ethics and Bioethics –Principles of research ethics; ethical issues in clinical trials; Use of humans in Scientific Experiments; the informed consent; Introduction to ethical codes and conduct; Introduction to animal ethics; Animal rights and use of animals in the advancement of medical technology

Module 3: Regulation in clinical research (7 Lecture Hours)

International Conference on Harmonization (ICH) Brief history of ICH, Structure of ICH, ICH Harmonization Process, Responsibilities of Stakeholders: Sponsors, Investigators, CROs, Monitors, Institutional ethics committee

Module 4: Clinical trial important documentation (7 Lecture Hours)

Essential Documents in Clinical Trials: SOP, Clinical Trial Protocol and 95Protocol Amendment(S), Investigator Brochure, Master Files, Informed Consent Forms, Consort statement, Case Record Form

Module 5:Clinical trial data management (8 Lecture Hours)

Project management in clinical trials -principles of project management; Application in clinical trial management; Risk assessment Pharmacovigilance, Project Auditing, Inspection.

Module 6: Clinical data monitoring (7 Lecture Hours)

CRF Review & Source Data Verification, Drug Safety Reporting, Drug Accountability Work, Routine Site Monitoring, Site Close Out Visit.
Case study in recent epidemics-clinical trials.

Text Books:

1. Lee, Chi -Jen; etal.,"Clinical Trials or Drugs and Biopharmaceuticals." CRC / Taylor &Francis, (2011)
2. Matoren, Gary M. "The Clinical Research Process in the Pharmaceutical Industry" Marcel Dekker, (2001).
3. Methodology of Clinical Drug Trials, 2ndEdition.Spriet A., Dupin-Spriet T., Simon P. Publisher: Karger. (1997)

Reference Books:

1. Design and Analysis of Clinical Trials: Concepts and Methodologies, 3rdEdition.Shein-Chung Chow, Jen-Pei Liu. Publisher: Wiley. (2014)
2. Principles and Practice of Pharmaceutical Medicine, 3rdEdition. Lionel D. Edwards, Anthony W. Fox, Peter D. Stonier. Publisher: Wiley-Blackwell. (2011)
3. Oxford Handbook of Clinical Medicine, 9th Edition. Murray Longmore, Ian Wilkinson, Andrew Baldwin, and Elizabeth Wallin.Oxford Medical Handbooks.(2014)

20BT3018	SUSTAINABLE BIOPROCESS DEVELOPMENT	L	T	P	C
		3	0	0	3

Course Objectives:

1. To impart knowledge on design and operation of fermentation processes with all its prerequisites.
2. To familiar the students with the basics of microbial kinetics and reactor design
3. To develop bioengineering skills for the production of value added product using integrated biochemical processes

Course Outcomes:

The students will be able to

1. Develop growth model based on the microbial characteristics
2. Understand working procedure of bioprocess industries
3. Analyze the diversity and nature of bio-products
4. Evaluate enzyme reaction and its kinetics
5. Understand different configurations of bioreactors
6. Understand the sustainability assessment methods

Module 1: Bioprocess and nature of bio-products (6 Lecture Hours)

Microbial diversity, Major products of biological processing, Component parts of fermentation process, Concept of Upstream, downstream processing and scale up

Module 2: Bioreactor Design (8 Lecture Hours)

Mixing, Mixing Equipment, Flow pattern, Mechanism of Mixing, Power requirement for mixing, Bioreactor Configurations (Different Bioreactors), Membrane bioreactor

Module 3: Modeling and Simulation of Bioprocesses (9 Lecture Hours)

Microbial growth model, Problem Structuring, Process Analysis, and Process Scheme, leudeking-piret models, Models with growth inhibitors, oxygen transfer model, volumetric mass transfer coefficient, Uncertainty Analysis- Sensitivity Analysis, error analysis, Application-cellulase based catalysis process

Module 4: Sustainability Assessment (7 Lecture Hours)

Sustainability, Economic Assessment- Capital-Cost Estimation, Operating-Cost Estimation, Profitability Assessment, Environmental Assessment, case study

Module 5: Reactor Operation (8 Lecture Hours)

Batch Operation of a Mixed Reactor, Fed-Batch Operation of a Mixed Reactor, Continuous Operation of a Mixed Reactor, Chemostat Operation, Operation of Plug-Flow reactor

Module 6: Advanced Bioprocessing (5 Lecture Hours)

Bioprocess Consideration in plant cell cultures, Bioprocess Consideration in animal cell cultures, Industrial Bioprocess, Advanced Membrane bioreactor to facilitate both upstream and downstream processing simultaneously

Text Book:

1. Heinzle E, Biwer AP and Cooney CL, "Development of Sustainable Bioprocesses Modeling and Assessment" 2006 John Wiley & Sons, Ltd

Reference Books:

1. Shuler, M.L. and Kargi,F. " Bioprocess Engineering - Basic concepts" Prentice Hall of India Pvt. Ltd.,2nd edition, 2015.
2. Peter F. Stanbury, Stephen J. Hall & Whitaker. A, "Principles of Fermentation Technology", Butterworth – Heinemann an Imprint of Elsevier India Pvt.Ltd., 2nd edition, 2005.
3. *Pauline M. Doran*, Bioprocess Engineering Principles, Elsevier Science & Technology Books, 2nd edition, May 1995

20BT3019	ADVANCED ANIMAL BIOTECHNOLOGY AND TISSUE CULTURE	L	T	P	C
		3	0	0	3

Course Objectives:

1. To Provide insights into Animal Biotechnology
2. Impart knowledge in manipulation of embryos and animal breeding
3. To make students understand the significance of trangenesis and its importance in livestock improvement

Course Outcomes:

1. Define concepts in Animal Biotechnology
2. Describe the importance of Cryopreservation of embryos and embryo sexing in animals
3. Relate and evaluate the genetic defects in animal embryos through molecular diagnosis
4. Experiment the technology used for animal breeding
5. Comprehend the fundamental concepts of mammalian cell and generation of cell line and to demonstrate tissue engineering applications for implantable materials.
6. Design the strategies for livestock improvement through transgenesis with ethical concern.

Module 1: CryopreservationOf Embryos and Artificial Insemination (8 Hrs)

Introduction to Animal Biotechnology, Cryopreservation of Sperms, Ova of livestock, Artificial Insemination, Super Ovulation, In Vitro fertilization, Culture of embryos, Cryopreservation of Embryos, Embryo transfer, Embryo splitting, Embryo sexing,

Module 2: Germplasm Preservation and Genetic Diagnosis (7 HRS)

In situ and ex situ preservation of germplasm, In utero testing of foetus for genetic defects, Pregnancy diagnostic kits, Gene knock out technology and animal models for human genetic disorders, Mouse model for COVID 19.

Module 3: Transgenic Animals (7 HRS)

Transgenic manipulation of animal embryos, different applications of transgenic animal technology, Animal cloning from- embryonic cells and adult cells, cloning for conservation of endangered species, anti-fertility animal vaccines, Ethical, social and moral issues related to cloning

Module 4: Live Stock Improvement (8 HRS)

Genetic characterization of livestock breeds, Marker assisted breeding of livestock, Transgenic animals and application in expression of therapeutic proteins, Detection of meat adulteration using DNA based methods.

Module 5: Cell Culture (8 HRS)

Application of animal cell culture for *In vitro* testing of drugs, Cytotoxicity and viability assays, Characterization, Cell line preservation and authentication. Scaling up of cell culture - Adherence and suspension type, Cell culture products.

Module 6: Tissue Engineering (7 HRS)

Tissue Engineering: Biomaterials in tissue engineering and scaffold fabrication, Artificial blood vessel, Artificial pancreas and liver tissue engineering, 3D Culture with different type of cells with examples and protocols. Spheroid culture.

Total Hours: 45

Text Books:

1. R. Ian Freshney. Introduction to Culture *of* Animal Cells: A Manual of Basic Technique and Specialized Applications, Sixth Edition. *Publisher*, John Wiley & Sons, 2011.
2. Animal cell culture 3rd ed., by John R.W. Masters A Practical Approach Oxford University press New York 2009
3. Advances in Animal Biotechnology by Birbal Singh, Gorak Mal, Sanjeev K Goutam. Springer; 1st ed. 2019 edition

Reference Books:

1. Animal Biotechnology 1**.** Niemann, Heiner, Wrenzycki, Christine .ed., Springer Publishing. 2018.
2. Levine MM, Kaper JB, Rappuoli R, Liu MA, Good MF. 2004. New Generation Vaccines. 3rd Ed. Informa Healthcare
3. Animal Cell Culture by John R.W. Masters 3rd ed., Oxford University Press, 2009.

20BT3020	MOLECULAR DIAGNOSTICS	L	T	P	C
		3	0	0	3

Course Objectives:

To improve knowledge on

1. History and Traditional diagnostics in genetic disease.
2. Principles and performance of DNA and RNA isolation, amplification, hybridization, and analysis.
3. Applications in microbiology, diagnosis, cancer, transplantation, and forensic medicine.

Course Outcomes:

The students will be able to

1. Understand the basic principles of molecular diagnosis
2. Demonstrate the working mechanism of different traditional and molecular diagnostic methods
3. Categorize genetic diseases and metabolic disorders
4. Apply appropriate diagnostic methods for the diagnosis of genetic and molecular diseases
5. Develop a new diagnostic kit for the emerging diseases
6. Adapt ethical guidelines for molecular test results

Module 1: Introduction to Diagnostics (7 Lecture Hours)

Diseases- infectious, physiological and metabolic errors, genetic basis of diseases, inherited diseases, Infection – mode of transmission of infections, clinical sample - method of collection, transport and processing of samples and Interpretation.

Module 2: Traditional Diagnostic Methods (8 Lecture Hours)

Diagnosis of infections: Bacteria: *Staphylococcus, Streptococcus, Mycobacterium E.coli, Salmonella, Shigella, and Vibrio,* Fungal diseases: Dermetophytoses, Candidiosis and Aspergillosis. DNA and RNA viruses- Pox viruses, Rhabdo Viruses, Corona Viruses, and Retroviruses. Protozoan diseases: Amoebiasis, Malaria, Leishmaniasis. Helminthic diseases- Ascarislumbricoides, Filariasis- Wuchereriabancrofti.

Module 3: Major Metabolic and genetic disorders (7 Lecture Hours)

Traditional methods for the diagnosis, Inborn metabolic errors – Glucose, Lipid, Amino Acid, Protein. Genetics of cancer - chronic myeloid leukemia, colon, breast, and lung cancer. Genetic disorders- Sickle cell anemia, Duchenne muscular Dystrophy, and Cystic Fibrosis**.**

Module 4: Molecular Diagnosis (8 Lecture Hours)

Duchenne muscular Dystrophy (Creatine phosphokinase-CPK), PKU (phenylketoneurea) – Amino acid deficiency - Inborn error, G6PD deficiency syndrome (G6PD), PCR diagnosis of Sickle cell anemia, Tuberculosis and COVID-19, Prenatal screening of Cystic Fibrosis. RT-PCR based diagnosis of Cancer, Tumor Metabolome. Biomarkers – PSA and KRAS (Oncogene markers).

Module 5: Hybridization and Sequencing (8 Lecture Hours)

Southern, Northern, in-situ- FISH, Western Blot. Principles, Methods and Instrumentation- Advances in DNA sequencing- New Generation sequencing Methods, Pyrosequencing, Personalized Medicine-Pharmacogenomics (ADMET).

Module 6: New Trends in Diagnostics (7 Lecture Hours)

Lab on a Chip - DNA chips, Diagnosis of neonatal genetic disorders, human genome project, ethical implications. Different Levels of Biosafety and Containment. Molecular Forensics – DNA profiling RFLP, VNTR, STR and PCR. DNA fingerprinting - The CODIS concept, Ethical and legal issues in genetic counselling.

Text Book:

1. Bailey & Scott's Diagnostic Microbiology (2012), Betty A. Forbes , Daniel F. Sahm, Alice S. Weissfeld , Ernest A. Trevino, Published by C.V. Mosby

Reference Books:

1. Fundamentals of Molecular Diagnostics (2010). David E. Bruns, Edward R. Ashwood, Carl A. Burtis. Saunders Group.
2. Molecular Diagnostics: Fundamentals, Methods & Clinical applications (2007). Lele Buckingham and Maribeth L. Flaws
3. Molecular Diagnostics for the Clinical Laboratorian 2Ed. 2006, W.B. Coleman. Humana Press.

20BT3021	DRUG DESIGN AND DISCOVERY	L	T	P	C
		3	0	0	3

Course Objectives:

1. To explore the process of drug development, from target identification to final drug registration.
2. To provide the knowledge in drug development as a process involving target selection, lead discovery using computer-based methods and combinatorial chemistry/high-throughput screening.
3. To develop skills in specialized areas related to bioavailability, clinical trials, and the essentials of patent law

Course Outcomes:

The students will be able to

1. Describe the process of drug discovery and development
2. Discuss the challenges faced in each step of the drug discovery process
3. Classify the computational methods used in drug discovery
4. Oorganize information into a clear report
5. Demonstrate their ability to work in teams and communicate scientific information effectively
6. Construct, review and evaluate preclinical and clinical pharmaceutical studies.

Module 1: Drug and their Interaction (8 Hours)

Introduction to Drugs: Drug nomenclature, Routes of drug administration and dosage forms, Principles of Pharmacokinetics and Pharmacodynamics: ADME, Bioavailability of drugs -Lipinski's rule; how drugs work -Drug targets, drug-target interaction and dose-response

Relationships.

Module 2: Drug design pipeline (8 Hours)

New Drug Discovery & Development: Overview of new drug discovery, development, cost and time lines. Target Identification & Validation. Lead Discovery: Rational and irrational approaches -Drug repurposing, Natural products, High-throughput screening (HTS), Combinatorial chemistry and computer aided drug design (CADD).

Module 3: Fundamental of Drug Actions: (8 Hours)

Inter and intramolecular interactions: Weak interactions in drug molecules; Chirality and drug action; Covalent, ion, ion-dipole, hydrogen bonding, C-H hydrogen bonding, dihydrogen bonding, van der waals interactions and the associated energies. Cation-and-OH interactions. Receptorology: Drug-receptor interactions, receptor theories and drug action; Occupancy theory, rate theory, induced fit theory, macromolecular perturbation theory, activation-aggregation theory. Topological and stereo chemical consideration.

Module 4: Drug toxicity, Assays and testing (7 Hours)

Preclinical Testing of New Drugs: Pharmacology -In vitro/in vivo Pharmacokinetics and Pharmacodynamics testing; Toxicology-Acute, chronic, carcinogenicity and reproductive toxicity testing; Drug formulation testing. Clinical Trial Testing of New Drugs. Good clinical practice (GCP) guidelines - Investigators brochures, Clinical trial protocols and trial design; Ethical issues in clinical trials -How are patient rights protected?

Module 5: Drug Regulatory Agencies (8 Hours)

US Food & Drug Administration (US FDA) and Central Drugs Standard Control Organization (CDSCO), India. Regulatory Applications & New Drug Approval: Investigational new drug (IND) application & New drug application (NDA); Regulatory review and approval process. Regulatory Requirements for Drug Manufacturing: Current Good manufacturing practice (cGMP) and GMP manufacturing facility inspection & approval.

Module 6: Intellectual Property Rights (IPR) (8 Hours)

IPR Definition and implications for discovery & development. Forms of IPR Protection-Copyright, Trademark and Patents. International organization and treaties for IPR protection –World Trade Organization (WTO) & Trade Related Aspects of Intellectual Property Rights (TRIPS) Agreements. Controller General of Patents, Designs & Trade Marks, India (CGPDTM), World Intellectual Property organization (WIPO)-Patent Cooperation Treaty (PCT).

Text Books:

1. Drugs: From discovery to approval 2nd Ed by Rick NG. Wiley Blackwell (2009)
2. Essentials of Medical Pharmacology, 6the Edition, by TripathiKd. Publisher: Jaypee Brothers (2013)
3. Burger's Medicinal Chemistry and Drug discovery. Volume 2, Wiley-Interscience; Volume 2 edition (2003)

Reference Books:

1. Intellectual Property Rights In India: General Issues And Implications by Prankrishna Pal. Publisher: Deep & Deep Publications Pvt.Ltd (2008)
2. Stromgaard, Kristian, PovlKrogsgaard-Larsen, and Ulf Madsen. *Textbook of drug design and discovery*. CRC Press, (2009).
3. Katzung, Bertram G., Susan B. Masters, and Anthony J. Trevor. *Basic and Clinical Pharmacology (LANGE Basic Science)*. McGraw-Hill Education,(2012).
4. Spriet, Alain, et al. *Methodology of clinical drug trials*. Basel: Karger, (2004).

20BT3022	INTRODUCTORY ARTIFICIAL INTELLIGENCE IN BIOTECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

1. To Study the concepts of Artificial Intelligence.
1. To learn the methods of solving problems using Artificial Intelligence.
2. To introduce the concepts of Expert Systems and machine learning on various applications.

Course Outcome:

1. Infer problems that are amenable to solution by AI methods.
2. Demonstrate appropriate AI methods to solve a given problem.
3. Formalise a given problem in the language/framework of different AI method
4. Develop an understanding of Machine learning integration in knowledge inference

5. Acquire knowledge on advanced intelligence computing techniques.
6. Formulate AI based solutions for industrial and healthcare applications.

Module I: Introduction to al and production systems [9 Lecture hours]

Introduction to AI-Problem formulation, Problem Definition -Production systems, Control strategies, Search strategies. Problem characteristics, Production system characteristics -Specialized production system- Problem solving methods – Problem graphs, Matching, Indexing and Heuristic functions -Hill Climbing-Depth first and Breath first, Constraints satisfaction – Related algorithms, Measure of performance and analysis of search algorithms.

Module II : Representation of knowledge [9 Lecture hours]

Game playing – Knowledge representation, Knowledge representation using Predicate logic, Introduction to predicate calculus, Resolution, Use of predicate calculus, Knowledge representation using other logic-Structured representation of knowledge.

Module III: Knowledge inference [9 Lecture hours]

Knowledge representation -Production based system, Frame based system. Inference – Backward chaining, Forward chaining, Rule value approach, Fuzzy reasoning – Certainty factors, Bayesian Theory-Bayesian Network-Dempster – Shafer theory.

Module IV: Planning and machine learning [8 Lecture hours]

Basic plan generation systems – Strips -Advanced plan generation systems – K strips -Strategic explanations -Why, Why not and how explanations. Learning- Machine learning, adaptive Learning.

Module V: Expert systems [5 Lecture hours]

Expert systems – Architecture of expert systems, Roles of expert systems – Knowledge Acquisition – Meta knowledge, Heuristics. Typical expert systems – MYCIN, DART, XOON, Expert systems shells.

Module VI: AI for Health care and Industrial Applications [5 Lecture hours]

Maintaining medical records and other data,doing repetitive jobs,Treatment design,Digital Consultation,Virtual Nurses,Medication Management,Drug Creation,Precision Medicine,Health Monitoring,and Health Care System Analysis. Application of AI in Pharmaceutical industry- Biofuel industry- Food industry- Water technology-Bio fertilizers- Bio control. **Total Hours: 45**

Text books:

1. Kevin Night and Elaine Rich, Nair B., "Artificial Intelligence (SIE)", McGraw Hill- 2008.
2. Dan W. Patterson, "Introduction to AI and ES", Pearson Education, 2007.

References:

1. Peter Jackson, "Introduction to Expert Systems", 3rd Edition, Pearson Education, 2007.
2. Stuart Russel and Peter Norvig "AI – A Modern Approach", 2nd Edition, Pearson Education 2007.
3. Deepak Khemani "Artificial Intelligence", Tata Mc Graw Hill Education 2013.

20BT3023	TRANSPORT PHENOMENA	L	T	P	C
		3	0	0	3

Course Objectives:

1. To give an overview of mass, momentum and energy transport, present the fundamental equations and illustrate how to use them to solve problems.
2. To describe mass, Momentum and energy transport at molecular, microscopic and macroscopic level, to determine velocity, temperature and concentration profiles.
3. The study also focuses on how operations related with fluids and how temperature plays a pivotal role in a drug or a chemical plant.

Course Outcome:

The students will be able to

1. Understand the molecular transport of Momentum, Heat, and mass.
2. Interpret and solve shell momentum, Heat, and mass balances for one dimensional steady state problems.

3. Develop dimensional analysis and knowledge of the dimensional numbers that are important in Momentum, Heat, and mass transfer applications.
4. Analyse inter phase transport problems which involve friction factors, drag coefficients, heat and mass transfer coefficients.
5. Evaluate the problems related with diffusivities and convection.
6. Construct molecule energy related phases in bioengineering.

MODULE 1: Introduction to Transport Processes (9 Hours)

Basic Mass, Momentum and Energy transport processes; micro and macroscopic views; phenomenological laws; driving forces; transport coefficients. Definition of fluxes; conservation principles; differential elementary volumes and coordinate systems; boundary conditions; dimensionless numbers. Molecular mass transport – Fick's law of binary diffusion; binary gaseous diffusion coefficient – kinetic theory; diffusion in liquids and solids. Effective transport properties (diffusion in suspensions and through a pack of spheres). Steady and transient diffusion processes– examples and application to transport problems.

MODULE 2: Momentum Transport and Viscous Flows (7 Hours)

Newton's law of viscosity; molecular theory of viscosity of dilute gases and liquids; Couette and falling film flow; Momentum as a flux and as a force – viscous stress tensor; Shell momentum balance and laminar flows – principles; Poiseuille flow; flow in an annulus; creeping flow around a sphere.

MODULE 3: Macroscopic balances for momentum transport (7 Hours)

Turbulent flows, Reynolds experiment, drag forces; turbulence and eddy flow (similarities with molecular transport) and atmospheric fluxes (eddy covariance method).

MODULE 4: Energy Transport Heat, Radiation and Phase Change (7 Hours)

Fourier's law of heat conduction; thermal conductivity - molecular and effective; heat flow in one and multi-dimensional geometries; steady-state and transient analytical solutions to Heat conduction; heat flow and convection; nonlinear cooling, macroscopic energy balance. Radiative energy transport– Stefan-Boltzmann law; black body exchange, principles and examples ; radiation through the atmosphere and greenhouse effect.

Phase change and coupled heat and mass transport (falling film, evaporating water drop)

MODULE 5: Mass Transport in Solid and Laminar I (Film) (6 Hours)

Flow Shell mass balances: boundary conditions, diffusion through a stagnant gas film, diffusion with heterogeneous chemical reaction, diffusion with homogeneous chemical reaction, diffusion into a falling liquid film forced.

MODULE 6: Mass Transport in Solid and in Laminar-II (Porous Support) (6)

convection mass transfer, diffusion, and chemical reaction inside a porous catalyst: the "effectiveness factor". Analogies between Heat, mass and Momentum and transfer

Text Book

1. Christie John Geankoplis, "Transport Processes and Separation Process Principles", 4th Edition, PHI Learning Private Limited., 2013.
2. Bird R.B., Stewart, W. E. and Lightfoot, E. N., "Transport Phenomena", 2nd Edn.John Wiley and Sons, 2002.
3. Welty, J.R., Wicks, C. E. and Wilson, R. E., "Fundamentals of Momentum, Heat Mass Transfer", 5th Edn., John Wiley and Sons, 2007.

Reference Books

1. Brodkey, R. S. and Hershey, H. C., "Transport Phenomena – A Unified Approach", Brodkey Publishing, 2003.
2. John C Slattery, "Momentum, Energy and Mass transfer in continua", McGraw Hill, Co. (1972).
3. Robert S Brodkey and Harry C Hersing, " Transport Phenomena a Unified approach" McGraw Hill Book Co. (1988).

20BT3024	PHARMACEUTICAL BIOTECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

1. To provide the student well versed with recent advances in the field of Pharmaceutical Biotechnology.
2. To make foundation for understanding the various events at molecular level, keeping a balance between health and disease.
3. To enabling the student to gain in-depth knowledge in fundamental and applied aspects of Microbiology and Immunology.

Course Outcome:

The students will be able to

1. understand and evaluate different pharmaceutical parameters for the current and future biotechnology related products on the market.
2. Aanalyze Screening, isolation, characterization and scale-up of Biological products.
3. Understand the legal steps involved in progressing a new drug to market and their science
4. Develop skills in molecular immunotherapeutics and immunotherapy.
5. Expertise in pharmaceutical drug delivery methods and analysis.
6. Gain knowledge in physicochemical properties, pharmacology and the formulation

Module I: Introduction to Biopharmaceuticals and Biogenerics. (9 Hours)

Introduction to Biopharmaceuticals and pharmaceutical biotechnology, Biopharmaceuticals: current status and future prospects, generic and branded biopharmaceuticals, overview of life history for development of biopharmaceuticals. Discovery of protein or peptide based therapeutics: In-silico, pharmaco-informatics. Pre-clinical toxicity assessment, Clinical trial phases and design, clinical data management, concept of Pharmacovigilance

Module II: Impact of omics in Drug Discovery (7 Hours)

Pharmacogenetics, Pharmacogenomics and proteomics, structural, functional and comparative genomics, DNA & oligonucleotides microarrays, genetically engineered animals, Integration of personalized and systems medicines, pharmacogenomics in preclinical and clinical development of drugs

Module III: Pharmacokinetics and Pharmacodynamics of Biopharmaceuticals (7 Hours)

Definition, rationales, absorption, distribution and metabolism pathway. Factors governing absorption of drug. Pharmacokinetics and Pharmacodynamics of therapeutic peptides. Dose response relationship, interspecies scaling, and heterogeneity of therapeutic proteins.Chemical modification of therapeutic proteins

Module IV: Immunotherapeutic & Immunodiagnostics (7 Hours)

Overview of antibody based therapeutics, biologics for autoimmunity and inflammation, vaccine-adjuvant technology, genetically engineered vaccines. Principles of immunodiagnostic assay based on solid phase system: Malarial & HIV diagnostic kits as case study. Fluorescent ligands and radio-isotope tracers, principles and instrumentation for molecular diagnostics (Time resolved fluorescence immunoassay, light scattering principles), PCR and nucleic acid based diagnostics, imaging techniques.

Module V:Biopharmaceuticals Based Delivery Systems (7 Hours)

Novel drug delivery systems for biopharmaceuticals (rate controlled and site specific), Nanotechnology based miniaturization of biopharmaceuticals and therapeutics, peptides for intracellular targeting, delivery of nucleic acids and therapeutic peptides, concept of responsive or smart drug delivery system.

Module VI: Formulation of Biopharmaceuticals (7 Hours)

Rational for formulation of biotherapeutics, formulation recipients: solubility enhancers, anti aggregating agents, buffers, cryoprotectants, antioxidants and preservatives etc significance with relevant examples. Methods to enhance shelf life protein based therapeutics. Packaging techniques and quality analysis of product

Text Books

1. Gary Walsh (2003) Biopharmaceuticals: Biochemistry and Biotechnology, 2nd Edition, John Wiley & Sons, Inc. 2.Daan J A Crommelin (2010),
2. Pharmaceutical Biotechnology, 2nd Edition, Taylor & Francis Group. 3.Rodney J. Y. Ho (2013)
3. Biotechnology and Biopharmaceuticals: Transforming Proteins and Genes into Drugs, 2ndEdition, John Wiley & Sons, Inc. (2008)

Reference Books

1. Gary Walsh Pharmaceutical Biotechnology: Concepts and Applications. John Wiley & Sons, Inc., (2007).
2. Oliver Kayser, HeribertWarzecha Pharmaceutical Biotechnology: Drug Discovery and Clinical Applications, 2nd Edition. John Wiley & Sons, Inc.(2012)

20BT3025	BIOREACTOR ENGINEERING	L	T	P	C
		3	0	0	3

Course Objectives:

1. Aims to understand the principles and concepts of Bioreactor engineering.
2. To understand structured models of growth and product formation
3. To understand the oxygen transfer parameters to be monitored and controlled in bioreactors

Course Outcomes:

1. Develop knowledge on various bioreactors.
2. Classify modern biotechnological process in host vector systems.
3. Understand methods to calculate oxygen and mass transfer coefficients in bioreactors.
4. Assess on-line data analysis for measurement of important physico-chemical and biochemical parameters in bioreactors.
5. Analyze structured models for analysis of various bioprocesses.
6. Design of various instrumentation for monitoring and control of bioreactors.

Module 1: Design and Analysis of Bioreactors (7 hrs)

Design and operation of novel bioreactors-Air-lift loop reactors, Fluidized bed-bioreactors, packed bed reactor, Bubble column reactor, stability analysis of bioreactors

Module 2: Bioreactor Scale-Up (7 hrs)

Oxygen mass transfer in bioreactors - microbial oxygen demands; methods for the determination of mass transfer coefficients; mass transfer correlations. Scale up criteria for bioreactors based on oxygen transfer, power consumption and impeller tip speed, other scale up criteria

Module 3: Monitoring of Bioprocesses (7 hrs)

On-line data analysis for measurement of important physico-chemical and biochemical parameters; State and parameter estimation techniques for biochemical processes.

Module 4: Modern Biotechnological Processes (8 hrs)

Recombinant cell culture processes, guidelines for choosing host-vector systems, plasmid stability in recombinant cell culture, limits to over expression, Modelling of recombinant bacterial cultures; bioreactor strategies for maximizing product formation; Bioprocess design considerations for plant and animal cell cultures

Module 5: Modelling and Simulation of Bioprocesses (8 hrs)

Study of structured models for analysis of various bioprocess – compartmental models, models of cellular energetics and metabolism, single cell models, plasmid replication and plasmid stability model. Dynamic simulation of batch, fed batch, steady and transient culture metabolism.

Module 6: Mixing Effectiveness (8 hrs)

Mixing equipment, Types of Impeller based on solution viscosity, Mechanism of Mixing, Assessing Mixing Effectiveness, Power requirement in mixing, Improving mixing efficiency, Sparging, Stirring and Bubble, Parameters to be monitored and controlled during fermentation process.

Total Hours: 45

Text Book:

1. Michael Shuler, FikretKargi, “Bioprocess Engineering Principles”, Second edition, Prentice Hall, 2008.

Reference Books:

1. P.Stanbury, A.Whitaker,SJ Hall “Principles of fermentation technology”, Second edition, ElsvierPergamon Press,2010.
2. Pauline Doran,”Bioprocess Engineering Principles”, Academic Press, 2010.

3. ElmarHeinzle, Arno P.Biwer, "Development of Sustainable Bioprocess: Modelling and Assessment", Wiley, 2007.
4. Bjorn K.Lyderson, Nancy Ade'lia and Kim Nelson,"Bioprocess engineering *(handcover)",*Wiley Interscience, 2014.

20BT3026	STEM CELL THERAPEUTICS	L	T	P	C
		3	0	0	3

Course Objectives:

To gain awareness about

1. The history and future of the emerging field of Stem Cell Therapy
2. The impact of Stem Cell therapy in health care system.
3. The impact of Stem Cell Therapy in Human civilization.

Course Outcome:

The students will be able to

1. Understand the basic concepts in culturing animal and mammalian cells
2. Understand the aspects of cellular ageing
3. Understand the types of Stem cells, their development and function.
4. Learn the various methods to isolate and culture Stem cells
5. Learn the various therapeutic applications of stem cells
6. Appreciate the bigger picture of Stem Cell Technology and their impact of society and civilization.

Module 1: Culturing Cells in the laboratory (5 Lecture Hours)

Overview of Stem Cells. Introduction to Cell Culture, Pros & Cons of Cell culture, Primary and Secondary cultures, Aseptic Technique and Cell culture Lab equipments& etiquette

Module 2: Stem cell-Types (5 Lecture Hours)

Types of Stems Cells, Embryonic stem cells, Pleuripotent Stem Cells, Adult Stem cells, Induced Pleuripotent Stem Cells, Transit amplifying cells, Symmetry during cell division in Stem cells.

Module 3: Location, Nature & culturing of stem cells (10 Lecture Hours)

Stem Cell Niche, Isolation of Stem Cells, & Growth factors, chord cells, Derivation & differentiation of ES Cells, Derivation & differentiation of Pleuripotent Cells

Induced Pluripotent cell-Methods & Genetic & epigenetic reprogramming. Transdifferentiating, FACS

Module 4: Applications of Stem cell Technology (8 Lecture Hours)

Application of stem cells in disorders of nervous system, Stem cells of the skin- Wound healing & cosmetics, Application of Stem cells in Cancer, Application of stem cells in autoimmune disorders.

Module 5: Stem cell in tissue engineering & Regenerative medicine (7 Lecture Hours)

Scaffolds, types & topology and effect on tissues, Tissue regeneration and angiogenesis Organoids and organ generation, Organ on Chip, Body on Chip

Module 6: Ethical Implications of Stem cell therapeutics. (10 Lecture Hours)

Benefits, Problems and perspectives of stem cell therapy. Beginning of human life, legal, scientific, ethical, Religio-spiritual explanations. Treating infertility, multiple parents, Somatic Cell Nuclear Transfer & Human cloning, Extinction prevention, Stem cells and meat production, Alternatives to stem cells. Deeper concerns in stem cell technology- Ageing longevity, Immortality.

Text Book:

1. Robert Lanza, Handbook of Stem Cells edited by Anthony Atala,. (Vol-1) Second edition. Academic press, 2013.

Reference Books: (Years)

1. Paul Knoepfler, Stem Cells - An Insider's Guide "
2. Robert Lanza and Anthony Atala, Essentials of Stem Cell Biology"
3. Satish Totey and Kaushik D. Deb, Stem Cell Technologies: Basics and Applications
4. Warburton David, Stem Cells, Tissue Engineering an Regenerative Medicine

20BT3027	NANOBIOTECHNOLOGY	L	T	P	C

		3	**0**	**0**	**3**

Course Objective

1. To introduce the concepts and fundamentals of nanotechnology
2. To understand the synthesis and characterization of nanomaterials and their application in biomedical fields
3. To identify the risk assessments involved nanomaterials in biological application and the impact on environment.

Course Outcome

1. Understand the basic principles of nanotechnology
2. Understanding the application of various techniques characterization and interpreting the properties of nanomaterials as per required application.
3. Understand and apply the knowledge of nanomaterials and nanobiomaterials to enable health sector advancements.
4. Design devices and systems for various biological applications.
5. Conceptualize the design and development aspects in the domains like NEMS/BIOMEMS
6. Enlighten with comprehensive knowledge of toxicity associated with nanomaterials and Optimize the synthesis for better biocompatibility of Nanomaterials

Module 1 Fundamentals of Nanoscience and Engineering 6 Hrs

History, Types of nanomaterials: Fullerenes, Nanoshells, Quntum dots, Dendrimers, Nanocarriers, Nanofibers, Approaches of Fabrication: TopDown and Bottom-up methods of nanofabrication and Nanosynthesis, Biosynthesis of Nanoparticles, Microbial Nanoparticle production Biomineralization, Magnetosomes. Nanolithography: hard and soft lithography. Characterization of nanomaterials using spectroscopic (UV-Vis, FTIR and Raman) and microscopic methods (SEM, TEM, STM and AFM).

Module 2 Nanobiomaterials 8 Hrs

DNA and Protein based Nano structures. Biomaterial nanocircuitry; Protein based nanocircuitry; Neurons for network formation. DNA nanostructures for mechanics and computing and DNA based computation; DNA based nanomechanical devices. Function and application of DNA based nanostructures. Bionanomaterials in Nature: Lotus leaf as a model self cleansing system. Gecko foot as a case study for biological generation of adhesive forces. Diatoms as an example for silicon biomineralization. Mussel inspired nanofiber for tissue engineering. Biomechanical strength properties of Spider silk

Module3: Micro & Nano Electromechanical systems and Microfluidics 10 Hrs

BioMEMS/BioNEMS: Types of transducers: mechanical, electrical, electronic, magnetic and chemical transducers. Nano sensors: Types: Electronic nose and electronic tongue, magnetic nanosensors. mechanical nanosensors: Cantilever Nanosensors, Microfludics: Laminar flow, Hagen-Peouiselleequation, basic fluid ideas, Special considerations of flow in small channels, micro mixing, microvalves&micropumps, Body on a chip and lab on a chip.

Module 4 :Nanosensors 8 hrs

Nanofabricated devices to separate and interrogate DNA, Interrogation of immune and neuronal cell activities through micro- and nanotechnology based tools and devices. Types of Nanosensors and their applications. Electromagnetic nanosensors: Electronic nose and electronic tongue, Magnetic nanosensors. Mechanical nanosensors: Cantilever Nanosensors, NanoBiosensors: NanoBiosensors in modern medicine

Module 5: Medical Nano biotechnology: 9Hrs

Nanomaterials in Diagnostics, therapeutics, drug delivery, Nano Surgery and Tissue Engineering. Drug Delivery Applications, Bioavailability, Sustained and targeted release. Benefits of Nano drug delivery system. Use of Microneedles and nanoparticles for targeted and highly controlled drug delivery. Nano robots in drug delivery and cleaning system. Design of nanoparticles for oral delivery of peptide drugs. Nanotoxicity assessment: In-vitro laboratory tests on the interaction of nanoparticles with cells.

Module 6. Nano Safety Issues 4Hrs

Nanotoxicology: Toxicology health effects caused by Nanoparticles, Ethics, Challenges and Future.

Text Books

1. Vo-Dinh T, editor. Nanotechnology in biology and medicine: methods, devices, and applications. CRC Press; 2017.

2. Binns C. Introduction to nanoscience and nanotechnology. John Wiley & Sons; 2010.
3. Rosenthal SJ, Wright DW, editors. Nanobiotechnology protocols. Totowa: Humana Press; 2005.
4. Wilson M, Kannangara K, Smith G, Simmons M, Raguse B. Nanotechnology: basic science and emerging technologies. CRC press; 2002.

Reference Books

1. Nanotechnology in Biology and Medicine: Methods, Devices, and Applications. R.S. Greco, F.B.Prinz and R.L.Smith, Nanoscale Technology in Biological Systems, CRC press, 2005.
2. B. Bhushan , Springer Handbook of Nanotechnology: Volume 1&2, Springer-Verlag. Second ed., 2007.
3. Sandra J Rosethal, David W Wright, Nanobiotechnology Protocols, Series Methods in Molecular Biology, 2005.
4. Christof M. Neimeyer, Chad.A.Mirkin (eds.,) Nanobiotechnology II: More Concepts, and Applications, Wiley VCH Weinheim (2007).

20BT3028	ADVANCED PLANT BIOTECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

1. To know plant genetic materials and molecular biology techniques
2. To know plant metabolic engineering and its importance
3. To know the plant transformation techniques and GM crops

Course Outcome:

1. Understand the plant genome and its molecular mechanisms
2. Interpret additional genomic materials in plant cells
3. Comprehend on metabolic engineering of plant cell metabolites
4. Summarize plant transformation techniques
5. Interpret on mechanisms of plant virus vectors
6. Comprehend on GM crops and its ethical issues

Module 1: Introduction to Plant Molecular Biology (6 hrs)

Genetic material of plant cells, nucleosome structure and its biological significance; transposons, alternative and trans splicing, constitutive and differentially expressed genes in plants

Module 2: Chloroplast and Mitochondria (7 hrs)

Structure, function: Light and dark reaction and genetic material; rubisco synthesis and assembly, coordination, regulation and transport of proteins. Mitochondria: Genome, cytoplasmic male sterility and import of proteins, comparison and differences between mitochondrial and chloroplast genome, chloroplast transformation

Module 3: Plant Metabolism and Metabolic Engineering (7 hrs)

Nitrogen fixation, Nitrogenase activity, nod genes, nif genes, bacteroids, plant nodulins, production of secondary metabolites, flavanoid synthesis and metabolic engineering

Module 4: DNA delivery methods (7 hrs)

Agrobacterium mediated method - Agrobacterium biology; Ti plasmid-based transformation; super virulence and monocot transformation, binary vector; Floral dip transformation; Direct DNA delivery methods - protoplasts using PEG; electroporation; particle bombardment; Chloroplast transformation and transient expression by viral vectors

Module 5: Design of gene construct and advanced technologies (9 hrs)

Factors influencing transgene expression – designing gene constructs - Promoters and polyA signals; Protein targeting signals; Plant selectable markers; Reporter genes; Positive selection; Selectable marker elimination; Transgene silencing; Strategies to avoid transgene silencing; Analysis of transgenic plants - Advanced technologies – cis genesis and intragenesis; RNAi technology, genome editing technology, CRISPR/Cas etc.

Module 6: Application of transgenic technology (9 hrs)

Applications of transgenic crop technology - Herbicide resistance; Pest resistance, Bt toxin, synthetic Bt toxin; Crop Engineering for disease resistance; genetic improvement of abiotic stress tolerance, Engineering for nutritional quality - Improved seed storage proteins; Improving and altering the composition of starch and plant oils; enhancement of micro-nutrients – beta carotene, vitamin E, iron; Molecular pharming - production of antibodies and pharmaceuticals in plants

Total Hours: 45

Text Book:

1. Slater A et al. Plant Biotechnology : The Genetic Manipulation of Plants, Oxford University Press, (1st and 2nd edition), 2008
2. Paul Christou and Harry Klee. Handbook of Plant Biotechnology, 2nd volume set, Wiley publisher, (2004).

Reference Book:

1. Athar Ali, Usha Kiran, Malik ZainulAbdin.PlantBiotechnology: Principles and Applications Springer Publications, 2017

20BT3029	CANCER MANAGEMENT TECHNIQUES	L	T	P	C
		3	0	0	3

Course Objectives:

1. To understand the pathology, grades and molecular biology of cancer
2. To analyze cancer type specific symptoms and early diagnostic markers
3. To develop skills in the cancer management techniques like detection, treatment, prevention and palliative care

Course Outcomes:

1. Understand the pathology and metabolism of cancers and their reporting systems.
2. Recall the molecular pathways and relate them in cancer development, progression, detection and therapy.
3. Identify the potential molecular and cellular targets for diagnosis and therapy
4. Evaluate the technologies available for early diagnosis-prevention, targeted therapy and for effective management of post therapy – palliative care
5. Analyze the challenges in the present cancer management methods
6. Apply the knowledge and discuss new means of cancer management, prevention strategies and modes of palliative care to prolong the life of cancer cases.

Module 1: Pathology and types of cancer (8 hrs)

Benign and cancer tumor; Characteristics and hallmarks of cancer; Histopathology of cancer, Cancer malignancy – spread, invasion and metastasis; Cancer classes and types; Cancer inflammation, Cancer immunology, Cancer stem cells, Cancer death - obstructions.

Module 2: Molecular Cell Biology of Cancer (8 hrs)

Cell growth regulation abnormalities in cancer – Alteration in Growth factors and cell signaling pathways, signal targets; Cell adhesion defects in cancer; Cell migration promoters in cancer-Proteases; Metastatic spread promoters, cancer cells mimicking inflammatory immune cells; Apoptosis regulation defects in cancer; Angiogenesis promoters in cancer.

Module 3: Cancer Symptoms, Metabolism and Markers (7 hrs)

Cancer Symptoms – General and specific; Cancer metabolism – Metabolic alterations and role of mitochondria; Cancer Markers – Proteins – Enzymes, Antigens, Antibodies, Hormones; Testing samples - Urine, Blood, Stool, Tumor tissue, other body fluids; Genetic markers – DNA, mRNA and Protein expressions.

Module 4: Cancer Detection Methods and Techniques (8 hrs)

Cancer Screening: Clinical Examination; Laboratory Tests for cancer markers;- Immunodetection techniques (Shift before imaging); Imaging Techniques – Ultra sound and Endoscopic Examinations; X-ray; CT, and MRI scans; Nuclear and isotopic techniques - PET scans; Confirming cancer by pathologic report - Biopsy and Smear examinations; Cancer staging and grading; Genetic marker Testing Techniques

– PCR, RT-PCR, qPCR, Microchip; Scope for early diagnosis: Early diagnostic methods – Mammography, PAP test

Module 5: Cancer Therapeutics (7 hrs)

Combination Therapy; Adjuvant-Neoadjuvant therapy- Chemotherapy, Radiotherapy; Targeted therapy – Targeted drug delivery, targeted therapy drugs; Molecular therapy, Immunotherapy –Antibody, Interferon, Gene therapy; Hormone therapy; Treatment fatigue; Clinical trials. Review on cancer stem cells.

Module 6: Cancer Prevention and Palliative Care (7 hrs)

Cancer risk factors; Food and lifestyle in cancer prevention; Post treatment recurrence preventive measures; Paliative care; Herbal remedies and plant derived cancer drugs.

Review on recent advancements in cancer management- Role of IoT, Theranostics, Nano-therapy.

Total Hours: 45

Text Books:

1. Stella Pelengaris, Michael Khan, The molecular Biology of Cancer, Blackwell Publishing, 1st edition, 2006.
2. Robert A. Weinberg, The Biology of Cancer, Garland Science, 2nd edition, 2014

Reference Books:

1. Macdonald F and Ford CHJ. "Molecular Biology of Cancer", Bios Scientific Publishers, 2002.
2. Richard Pazdur, Kevin A. Camphausen, Lawrence D. Wagman, William J. Hoskins, Cancer Management: A Multidisciplinary Approach**,** 11th illustrated edition, Oncology Publishers, 2003
3. Thomas N. Sayfried, Cancer as a Metabolic Disease: On the Origin, Management, and Prevention of Cancer 1st Edition, Wiley Publications; 2012

20BT3030	GENOMICS AND PROTEOMICS	L	T	P	C
		3	0	0	3

Course Objectives:

To improve knowledge on

1. Genomics and Proteomics including fundamentals, current techniques and applications.
2. To propose appropriate methods for analysis of given sample type with respect to purpose of analysis
3. Recent trends in Genomics and Proteomics research

Course Outcomes:

The students will be able

1. Relate and comprehend the concepts in genome organization, genomics and proteomics.
2. Explain some of the current genomics technologies and illustrate how these can be used to study gene function.
3. Apply interdisciplinary knowledge (e.g. chemistry, biophysics) to solve problems in proteomics and genomics
4. Analyze and infer genomes and proteomes by employing database search, algorithms and tools.
5. Appraise the applications of genomics and proteomics in medicine
6. Compile, discuss and critically review the recent updates / progress in genomics and proteomics research

Module 1: Introduction to Genomics (8 Hours)

Introduction to Genomics, Genome Organization of prokaryotes and Eukaryotes, Gene Structure of Bacteria, Archaebacteria and Eukaryotes, Human Genome Project

Module 2: DNA sequence and mapping (8 Hours)

Methodology for DNA sequencing, Contig Assembly, Genetic Mapping- Mendel's Laws of Inheritance, Partial Linkage, DNA Markers and its types, Physical Mapping and its types

Module 3: Functional Genomics and its applications (7 Hours)

Introduction to Functional Genomics, Genome Annotation- traditional routes of gene identification, Detecting Open Reading Frames, Software programs for finding genes, identifying the function of new gene, Gene Ontology. Pharmacogenomics, Comparative genomics

Module 4: Introduction to Proteomics (7 Hours)

Proteomics- Introduction, The proteome, Genomics vs Proteomics, Proteomics and the new biology

Module 5: Analytical Proteomics (8 Hours)

2 Dimensional Polyacrylamide Gel Electrophoresis, Mass Spectrometry for Protein and Peptide Analysis (MALDI-TOF and ESI-Tandem MS), Designing Microarray experiments, Types of Microarrays

Module 6: Applications of Proteomics (7 Hours)

Applications of Proteomics- Mining Proteomes, Protein Expression Profiling, Mapping Post-translational Modification, Peptide Mass Fingerprinting. Proteomics and Medicine.

Text Books:

1. Brown T.A., "Genomes", BIOS Scientific Publishers Ltd, Oxford, 4th Edition, 2018.
2. Daniel C. Liebler, "Introduction to Proteomics: Tools for the New Biology", Humana Press, Totowa, New Jersey, 2002

Reference Books:

1. Sandor Suhai, "Genomics and Proteomics- Functional and computational Aspects", Springer, New York, 2000.
2. Malcolm Campbell A. and Laurie J. Heyer, "Discovering genomics, proteomics and Bioinformatics", Pearson/Benjamin Cummings, New Delhi, 2006.
3. Mount, D. "Bioinformatics; Sequence and Genome Analysis", Cold Spring Harbor Laboratory Press, New York, 2004

20BT3031	ADVANCED ENVIRONMENTAL BIOTECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

1. To analyse environmental problems and find solutions through innovations
2. To develop bioreactors and biotreatment methods of industrial wastewater
3. To learn novel technologies for remediation of environmental pollution

Course Outcome:

1. Create an awareness of professional responsibility towards protecting the environment.
2. Learn environmental issues involved engineering and resources projects
3. Study the natural and engineered bio-treatment methods to remediate the pollutants
4. Develop treatment methods and create awareness about opportunities in environmental management
5. Future challenges for bioremediation and biodegradation process
6. Investigate the opportunities for incorporating environmental quality into products, processes and projects

Module 1: Environment and Ecosystem(8 hrs)

Current status of biotechnology in environmental protection and its future prospects. Characteristics of wastewater, Classification of pollutants, Impact of pollutants on biotreatment.

Environment pollution and its control; pollution indicators; waste management: domestic, industrial, solid and hazardous wastes; strain improvement; Biodiversity and its conservation; Role of microorganisms in geochemical cycles; microbial energy metabolism, microbial growth kinetics and elementary chemostat theory, microbial ecology.

Module 2: Environmental Pollution (7 hrs)

Current research on environment of Soil pollution, Water pollution, Air pollution**,** Oil pollution, Heavy metal pollution – case studies and technology development aspects

Module 2: Bioreactors for Wastewater Treatment (7 hrs)

Design and evaluation of suspended growth reactors, Activated sludge, Biological nutrient removal, Bio filtration, Aerobic digestion, anaerobic processes and lagoons , Design and evaluation of attached growth

reactors, Trickling filter, Rotating Biological Contactor, Fluidized bed biological reactors, Up flow anaerobic sludge blanket reactor ,Hybrid reactor, Sequential batch reactor , Techniques for Evaluating Kinetics and Stoichiometric parameters.

Module 3: Biotreatment of Industrial Wastewater (8 hrs)

Wastewater treatment of effluents from dye, tannery, dairy and food industries, Wastewater treatment of effluents from pharmaceutical, distilleries, polymer, electrochemical industries, Wastewater treatment of effluents from explosive, pesticide and petrochemical industries, Treatment of industrial gaseous pollutants and Vocs. Medical waste and solid waste management.

Module 4: Bioremediation and Biodegradation (8 hrs)

Biostimulation of naturally occurring microbial activities, Bioaugmentation, *In situ, ex situ* and engineered bioremediation, Microbial system for heavy metal accumulation , Biosorption, Bioleaching, Detoxification of chlorinated hydrocarbons, aromatics and DIOXINS, Biodesulphurisation of crude petroleum , Future challenges, fate and effects of xenobiotic organic chemicals

Methods and strategies of application (biostimulation, bioaugmentation) – examples, bioremediation of metals (Cr, As, Se, Hg), radionuclides (U, Te), organic pollutants (PAHs, PCBs, Pesticides, TNT etc.), technological aspects of bioremediation (in situ, ex situ) Application of bacteria and fungi in bioremediation: White rot fungi vs specialized degrading bacteria; Phytoremediation

Module 5: Biomass and Biofuels (7 hrs):

Production of Biofuels: Biogas; bioethanol; biodiesel; biohydrogen; Industrial processes involved, microorganisms and biotechnological interventions for optimization of production; Microbiologically enhanced oil recovery (MEOR); Bioleaching of metals; Production of bioplastics; Production of biosurfactants: bioemulsifiers; Paper production: use of xylanases and white rot fungi.

Module 6: Novel Biotechnology Methods for Pollution Control(7 hrs)

Application of nanobiotechnology in environment, Vermitechnology, Genomic tools in bioremediation, Aerobiotechnology, Development of biodegradable and ecofriendly products, Biosensor, Quorum sensing, Global environmental problems: Ozone depletion, UV-radiation, Greenhouse gases, acid rain and biotechnological approaches of their management.

Total Hours: 45

Text Books:

1. Metcalf and Eddy, "Waste water Engineering Treatment, Disposal and Reuse". McGraw Hill, 2013.
2. Prescott, Harley and Klein, "Microbiology", 5th edition, McGraw Hill, 2014.
3. Graty. C.P.L., Daigger, G and Lim, H.C, "Biological Wastewater Treatment". 4th Edition, Marcel Dekker, 2011

Reference Books:

1. Jogdand, S.N. "Environmental Biotechnology". Himalaya Publishing House, New Delhi, 2012.
2. Karnely D. Chakrabarty K. Ovnen G.S. "Biotechnology and Biodegradation, Advances in Applied Biotechnology series", Gulf Publications Co. London 2011
3. R. C. Dubey A Textbook of Biotechnology, S.Chand publications, 4th edition, 2014
4. InduShekhar Thakur, "Environment Biotechnology basic concepts and applications", IK International, 5th edition, 2016

20BT3032	ENTREPRENEURSHIP AND MANAGEMENT	L	T	P	C
		3	0	0	3

Course Objectives:

1. To impart various aspects of product design and development
2. To inculcate concept generation and selection
3. To understand technology behind the product of the service

Course Outcome:

1. Understand the principles of product design, basic management techniques, entrepreneurial skills and funding agencies.

2. Apply knowledge to the fundamentals of business plan, practical management concepts like leadership and motivation.
3. Induce entrepreneurial intent as well as innovation, scalability and marketing of the product.
4. Demonstrate the ability to provide a self-analysis in the context of an entrepreneurial career.
5. Assess the commercial viability of a new technology based idea to prototype.
6. Transfer technology and process of the product for commercialization

Module 1: Introduction and product design (8 hrs)

Entrepreneurship and economic development. evolution of entrepreneurship, stages in entrepreneurial process, entrepreneurship in India, Role of SSI in economic development, Government support for SSI. Role of society and family in the growth of an entrepreneur. Challenges faced by women entrepreneurship. Product design and development Process, sources of ideas for designing new products, stages in product design. Guidelines of DBT for formulating project and financing.

Module 2: Product Design (7 hrs)

Product design, importance, objectives, factors influencing product design, Product Development Process, sources of ideas for designing new products, stages in product design. Guidelines of DBT for formulating project and financing.

Module 2: Innovation And Prototype (7 hrs)

Creativity and innovation, generation of ideas, technical and market feasibility study, opportunity assessment, business plan preparation, execution of business plan, conversion of ideas to prototype, risk taking-concept; types of business risks.

Module 4: IPR and copyright (8 hrs)

IPR and copy right, financial opportunity identification; banking sources; non-banking institutions and agencies; venture capital and angel investors, meaning and role in entrepreneurship, government schemes for promoting entrepreneurship. GMO and IPR; WTO, GATT and TRIPS agreement; Indian Patent Act; Patenting procedures

Module 5: Biosafety (8 hrs)

Plant Breeder's Rights; Biosafety – levels; Biosafety guidelines; Role of Biosafety committee; Definition of GMOs & LMOs; Risk factors; Overview of National Regulations and relevant International Agreements including Cartagena Protocol, Biological material transfer procedure.

Module 3: Start Up Process (7 hrs)

Procedure for getting license and registration, challenges and difficulties in starting an enterprise, host institution support, Funding agencies – BIRAC, NEN, STEP, DST-NIMAT, TSDB; The role of technology/social media in creating new forms of firms, organizations, networks and cooperative clusters. Market- traditional and E-commerce, expanding markets: local to global.

Module 4: Innovation and entrepreneurship in bio-business (8 hrs)

Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (e.g. pharmaceuticals vs. Industrial biotech), Strategy and operations of bio-sector firms: Factors shaping opportunities for innovation and entrepreneurship in bio-sectors, and the business implications of those opportunities, strategic dimensions of patenting & commercialization strategies.

Module 5: Bio markets - business strategy and marketing (7 hrs)

Negotiating the road from lab to the market, Pricing strategy, Challenges in marketing in bio business (market conditions and segments; developing distribution channels, the nature, analysis and management of customer needs), Basic contract principles, different types of agreement and contract terms typically found in joint venture and development agreements, Dispute resolution skills. Angel investors and venture capitalist.

Module 6: Technology management (8 hrs)

Technology – assessment, development and upgradation, Managing technology transfer, Quality control & transfer of foreign technologies, Knowledge centers and Technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP).

Total Hours: 45

Text Books:

1. Kankanala C., Genetic Patent Law & Strategy, 1st Edition, Manupatra, Information Solution Pvt. Ltd., 2007.
2. "Entrepreneurship: Theory", Process and Practice, Donald F. Kuratko, 9th Edition, Cengage Learning, 2011.
3. 4. S.S.Kanka Entrepreneurship Development, S.Chand and Co, New Delhi 2007.

Reference Books:

1. BAREACT, Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., 2007.
2. Anupam Singh and Ashwani Singh. Intellectual property rights and Bio-Technology (Biosafety and Bioethics), NPH, New Delhi (2010)
3. "Entrepreneurial Development", Jayshree Suresh, 5th Edition, Margham Publications, 2008.
4. "Entrepreneurship", Robert D. Hisrich, 6th Edition, Tata McGraw Hill Publications.2009.

Electives-for other department students

20BT3033	INDUSTRIAL WASTE MANAGEMENT	L	T	P	C
		3	0	0	3

Course Objectives:

1. To know problems of different kind of hazardous waste from industrial process.
2. To Engineer and technical options for site specific waste management
3. To know cleaner Industrial process and zero waste sustainable initiatives

Course Outcomes:

1. List out different industrially relevant waste and their challenges in management
2. Infer suitability of available treatment options depending on nature of waste
3. Make use of bio-chemical reactions to develop optimal treatment system
4. Examine energy and eco-efficiency of solid waste and waste-water treatment
5. Recommend advanced treatment technologies with different Industrial Scenarios
6. Formulate cleaner production and waste management technologies

Module 1: Introduction to Industrial Waste Management System (9 hrs)

Uses of water by industry-Sources and types of industrial wastewater; regulatory requirements for treatment of industrial wastewater-Industrial waste survey Industrial Wastewater generation; Treatment Evaluation for Air Emission and Solid waste; Waste Characterization and classification;

Module 2:Solid Waste Treatment and Disposal (7 hrs)

Categories and Characterization, Solid waste land fill, Land-fill cover and Cap, Waste stabilization, Management of Organic industrial waste, Incineration strategies and Energy recovery, Composting Industrial waste.

Module 3:Industrial Waste Water Treatment (10 hrs)

Equalization- Neutralization- Oil separation Flotation-Precipitation-Heavy metal Removal - Refractory organics separation by adsorption. Aerobic and anaerobic biological treatment sequencing batch reactors; Oxidation –Ozonation. Photo catalysis, Wet Air Oxidation-Evaporation Ion Exchange-Membrane Technologies – Nutrient removal.

Module 4:Case Studies with Different Industrial Scenarios (7 hrs)

Tanneries-pulp and paper-metal finishing; Petroleum Refining-Pharmaceuticals-Sugar and Distilleries; Food Processing-Thermal Power Plants.

Module 5: Environmental aAudits and Clean up Technology (5 hrs)

Environmental audits, waste audit, life cycle assessment, industrial symbiosis, clean technology and Clean up technology, materials reuse, waste reduction.

Module 6:Cleaner Production and Newer Management Strategies (7 hrs)

Waste management Approach – Volume and strength reduction – Material and process modifications – Recycle, reuse and byproduct recovery – Applications, Zero discharge attainment strategies, Naturally Evolving Industrial complexes.

Total Hours: 45

Text Book:

1. Woodard Frank (2001) *Industrial Waste treatment Handbook*, Butterworth Heinemann

Reference Books:

1. Nelson Leonard Nemerow, Industrial Waste Treatment: Contemporary Practice and Vision for the Future, Elsevier, (2010).
2. Wang Lawrence K., Hung Yung-Tse, Lo Howard H., Constantine Yapijakis, Hazardous Industrial Waste Treatment, CRC Press, (2006)
3. John Pichtel, Waste Management Practices: Municipal, Hazardous, and Industrial, Second Edition, CRC Press, 2014.
4. Wang Lawrence K., Hung Yung-Tse, Shammas Nazih, K. Handbook of Advanced Industrial and Hazardous Wastes Treatment, CRC Press, (2009).

20BT3034	INDUSTRIAL SAFETY	L	T	P	C
		3	0	0	3

Course Objectives:

1. To provide a general concept in the dimensions of disasters caused by nature beyond the human control
2. To know the disasters and environmental hazards induced by human activities with emphasis on disaster preparedness, response and recovery.
3. To improve knowledge about rescue methods

Course Outcomes:

1. Learn the different safety aspects in industries and daily life
2. Learn safety procedure followed in industries
3. Learn the different types of rescues
4. Know the procedure for risk analysis
5. Know different type of disaster
6. Know procedure for damage assessment

Module 1: Safety Management (8 hrs)

High pressure-high temperature operation- dangerous and toxic chemicals, highly radioactive materials safe handling and operation of materials and machineries. Work environment-noise-effect of noise-unit of sound-noise levels in industries-control of noise

Module 2: Disaster Management (8 hrs)

Introduction on Disaster Different Types of Disaster: Natural Disaster Man-made Disaster Biological Disasters, Accidents (Air, Sea, Rail & Road), Structural failures (Building and Bridge), War & Terrorism etc. Causes, effects and practical examples for all disasters. Major industrial accidents in India and in other countries,

Module 3: Accident Prevention and Risk Analysis (8 hrs)

Identification and analysis of causes of injury to men and machineries-accident prevention-accident proneness-vocational guidance, fire prevention and fire protection-personal protective equipments. Occupational, industrial health hazards –health standards and rules-safe working environments.

Module 4: Responsibility of Engineers (8 hrs)

Role of Engineers on Disaster Management. Response- Disaster Response : Introduction, Disaster Response Plan, Communication, Participation, and Activation of Emergency Preparedness Plan, Search, Rescue, Evacuation and Logistic Management, Role of Government, International and NGO Bodies, Psychological Response and Management (Trauma, Stress, Rumor and Panic) , Medical Health Response to Different Disasters

Module 5: Reconstruction and Recovery (7 hrs)

Rehabilitation, Reconstruction and Rehabilitation as a Means of Development, Damage Assessment, Post Disaster effects and Remedial Measures, Creation of Long-term Job Opportunities and Livelihood Options, Disaster Resistant House Construction , Sanitation and Hygiene,

Module 6: Safety Awareness (6 hrs)

Education and Awareness, Dealing with Victims' Psychology, Long-term Counter Disaster Planning,

Role of Educational Institute, Role of Government, safety organization, management and trade unions in promoting industrial safety- on site and off site safety provisions.

Total Hours: 45

Text Book:

1. Crowl D A, Louvar J F, "Chemical Process Safety Fundamentals with applications", 2nd Prentice Hall, NJ (2002).

Reference Books:

1. Effective Environmental, Health, and Safety Management Using the Team Approach by Bill Taylor, Culinary and Hospitality Industry Publications Services2005
2. Environmental and Health and Safety Management by Nicholas P. Cheremisinoff and Madelyn L. Graffia, William Andrew Inc. NY, 1995
3. The Facility Manager's Guide to Environmental Health and Safety by Brian Gallant, Government Inst Publ., 2007.
4. Cheremisinoff, N. P., Practical Guide to Industrial Safety: Methods for Process Safety Professionals, CRC Press, 2001.

20BT3051	BIOCHEMISTRY	L	T	P	C
		3	0	0	3

Course Objectives:

1. To ensure students will have strong foundation in structure, properties and function of various biomolecules.
2. To provide knowledge regarding the basic structure of biomolecules which are involved in metabolic pathways
3. To articulate the significance of biomolecules

Course Outcome:

The students will be able to

1. Acquire knowledge on structure, properties and biological functions of carbohydrates, lipids and proteins
2. Assess the significance of nucleic acid structure, properties and functions
3. To impart knowledge on the significance of Vitamins and mineral functions
4. Integrate the metabolic pathways of synthesis and degradation of biomolecules
5. Justify the clinical and biological significance of biomolecules
6. Classify the biomolecules and understand their specific roles in biological system.

Module I: Carbohydrates (9 Lecture Hours)

Classification, structure, properties and functions of carbohydrates: Monosaccharides, Disaccharides, Oligosaccharides-examples; Polysaccharide – classes- homo and hetero polysaccharides, glycolysis,TCA cycle, Pentose Phosphate Pathway, bioenergetics and oxidative phosphorylation

Module II: Fatty Acids and Lipids (9 Lecture Hours)

Fatty acids- basic structure, types, properties, functions and essential fatty acids; ketone bodies, Classes, structure, properties and functions of lipids: Simple lipid-fat and wax, Compound lipid-Phospholipid, sphingolipid, ether lipid and glycolipid, Derived lipid –, fatty acid biosynthesis and degradation, biosynthesis of triacylglycerol, Inborn errors of lipid metabolism.

Module III: Amino Acids, Peptides and Proteins (9 Lecture Hours)

Amino acids- classification, properties; Essential amino acids; Peptide bond, significant natural and artificial peptides –examples; Proteins- structure / conformation levels-primary, secondary, tertiary and quaternary, Biosynthesis of aromatic amino acids-tyr,trp,phe, biodegradation of leucine, isoleucine and threonine, urea cycle,.

Module IV: Nucleotides and Nucleic Acids (9 Lecture Hours)

Nucleotides- composition, structure, properties and functions; Nucleic acids- types (RNA, DNA), DNA structure-Chargaff's rule on DNA base composition, unusual forms of DNA, RNA types, structure and

functions, biosynthesis of purines and pyrimidines and its degradation, Inborn errors of nucleic acid metabolism - Review.

Module V: Vitamins (4 Lecture Hours)

Vitamins: classification (A, D, E, K, and B-complex members), basic structure, source, daily requirement, functions and deficiency symptoms,

Module VI: Minerals – Functions and Disorders (5 Lecture Hours)

Minerals: classification- macro elements and microelements, sources, biochemical functions, dietary requirements and deficiency disorders, review on vitamins and mineral supplementations.

Total Hours: 45

Text books

1. Biochemistry by LubertStryer , Jeremy M. Berg , John L. Tymoczko , Gregory J. Gatto Jr. 9th Edition, Kindle Edition,2019.
2. Voet and Voet, "Biochemistry", John Wiley & Sons Inc., 2nd Edition, 2013.

References

1. Lehninger, A. L, Nelson D. L and Cox, M. M, "Principles of Biochemistry", Freeman Publishers, New York, seventh edition, 2017
2. Murray R.K, Granner B.K, Mayes P.A, Rodwell V.W. "Harper's Biochemistry", Prentice Hall International, 31st Edition,2018.
3. Jain and Jain "Biochemistry", Chand publication, 2016.Revised Edition

20BT3052	PLANT SECONDARY METABOLITES AND PHARMACEUTICS	L	T	P	C
		3	0	0	3

(Version 1.1)

Course Objectives

1. To recall the myriad of different secondary metabolites produced by plant
2. To analyze the biosynthesis and metabolic engineering of plant secondary metabolites
3. To formulate various products and their dosage forms

Course Outcomes

The students will be able to

1. Enumerate major plant secondary metabolites and its uses.
2. Illustrate the biosynthesis and regulation of plant secondary metabolites
3. Infer the different methods of production of secondary metabolites.
4. Interpret the biochemical pathways for improved secondary metabolite production.
5. Enumerate the pharmaceutical procedures for preformulation studies
6. Examine the development of formulation and dosage forms

Module I: Plant Secondary Metabolites (6 Hours)

Definition and systematics of secondary metabolites. Structures, functions and commercial significance of secondary metabolites: alkaloids, terpenoids/isoprenoids, flavonoids and phenolics. Secondary metabolites in chemical defense of plants, ecological functions, and biological activities

Module II:Biosynthesis and Regulation of Secondary Metabolite (8 Hours)

Integration of primary and secondary metabolism. Shikimate and PHA pathways of alkaloid biosynthesis. MEP pathway of terpenoid biosynthesis. Biosynthesis of flavonoids and polyphenol (lignin). Regulation: metabolic channeling, compartmentalization, cross-talk/exchange of intermediates between biochemical pathways. Precursor feeding, genetic regulation of key enzymes, developmental, seasonal and environmental factors

Module III: Production Technologies (9 Hours)

Production of secondary plant metabolites from higher plants: Tissue cultures, organ cultures, hairy root cultures. Roles of Endophytes in production of secondary metabolites; Bioreactors: scaling up of production of secondary metabolites. Effects of precursors and elicitors. Production of pharmaceutically important secondary metabolites such as Taxol, Berberine and rubber

Module IV: Metabolic Engineering of secondary metabolic pathways (8 Hours)

Cloning and characterization of enzymes of the Shikimate and MEP pathway; functional genomics approaches for improvement of secondary metabolite production. Metabolic engineering of yeast for the production of plant secondary metabolites.

Module V: Pharmaceutics – Preformulation Studies (7 Hours)

Goals of preformulation, preformulation parameters, methodology, Solubility and Partition coefficient, drug excipient compatability. Excipients used in pharmaceutical dosage forms:Properties and selection criteria for various excipients like surfactant, viscosity promoters, diluents, coating materials, plasticizers, preservatives, flavours and colours

Module VI:Powder and Liquid dosage forms (7 Hours)

Formulation development and manufacture of powder dosage forms for internal and external use including inhalations dosage forms, Formulations, production and evaluation of hard and soft gelatin capsules. Manufacturing of monophasic dosage forms. Recent advances in formulation aspects and manufacturing of suspensions and dry syrups

Total: 45 Hours

Text Books:

1. Plant Secondary Metabolites. Y. M. Shukla, New India Publishing Agency, ISBN-10: 8190851225, ISBN-13: 9788190851220, (2009).
2. Metabolic Engineering of Plant Secondary Metabolism. R. Verpoorte, A. Wilhelm Alfermann, Springer Science and Business Media. ISBN 0792363604, 9780792363606, (2000).

References

1. Plant Secondary Metabolism, David S. Seigler, Springer Science and Business Media, ISBN: 0412019817, 9780412019814, (1998).
2. Liberman, HA &lachman L Pharmaceutical dosage forms: Disperse systems vol I , II & III
3. Carstensen JT, Theory of Pharmaceutical systems academic press New York and London.

20BT3053	MOLECULAR BIOLOGY AND CELL SIGNALING	L	T	P	C
		3	0	0	3

Course Objectives:

To improve knowledge on

1. Core principles and applications of molecular biology
2. Gene expression and Cell signaling mechanisms and their regulation
3. Recent trends in biomedical research

Course Outcome:

The students will be able to

1. Exhibit a knowledge base in DNA replication, transcription, translation and Cell signaling
2. Summarize the process of gene expression and its regulation in prokaryotes and eukaryotes
3. Experiment with model organisms in gene expression studies and cancer research
4. Compare and contrast the different molecular processes in gene expression, signalling processes and cancer mechanism
5. Engage in review of scientific literature in the areas of biomedical sciences
6. Critique and professionally present primary literature articles in the general biomedical sciences field

Module I : DNA replication, repair and recombination (7 Lecture Hours)

Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extrachromosomal replicons, DNA damage and repair mechanisms, homologous and site-specific recombination.

Module II: Gene expression (10 Lecture Hours)

RNA synthesis and processing - transcription factors and machinery, RNA polymerases, formation of initiation complex, capping, elongation, and termination, RNA processing, RNA editing, splicing, and polyadenylation, Protein synthesis and processing - Genetic code, aminoacylation of tRNA, Ribosome, Initiation, elongation and termination, translational inhibitors, Post- translational modification of proteins.

Module III: Regulation of Gene expression (6 Lecture Hours)

Role of Promoters, Enhancers, Silencers in gene regulation. Regulation in Phages - Lytic and Lysogeny. Regulation in Bacteria – operons. Regulation in Eukaryotes - role of chromatin in gene expression and gene silencing (RNA interference). Epigenetic modifications

Module IV: Cell signaling and cellular communication (10 Lecture Hours)

Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways. General principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix.

Module V: Molecular basis of Cancer (6 Lecture Hours)

Genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, apoptosis, therapeutic interventions of uncontrolled cell growth.

Module VI: Review on recent advances in research (6 Lecture Hours)

Noble prize research work on Physiology and Medicine – Cells sense and adapt to oxygen availability (2019), Cancer therapy by inhibition of negative immune regulation (2018), Molecular mechanisms controlling the circadian rhythm (2017), Mechanisms for autophagy (2016), Novel therapy against infections caused by roundworm parasites(2015).

Total: 45 Hours

Text book

1. Harvey Lodish, Arnold Berk, Paul Matsudaira, "Molecular cell biology", WH Freeman & Company, New York, 6th edition, 2017.
2. Geoffrey M. Cooper and Robert E. Hausman, The Cell: A Molecular Approach, Fifth Edition, ASM Press and Sinauer Associates, Inc., USA, 2015.

References

1. David R Hyde, "Genetic and Molecular Biology", Tata McGraw Hill Publications, New Delhi, 2010.
2. Bruce Alberts, Alexander Johnson, Julian Lewis and Martin Raff, Molecular Biology of the cell, fifth edition, Taylor and Francis group, 2012.
3. Lehninger, A. L, Nelson D. L and Cox, M. M, "Principles of Biochemistry", Freeman Publishers, New York, Seventh edition, 2017

20BT3054	MICROBIOLOGY AND MOLECULAR GENETICS	L	T	P	C
		3	0	0	3

(Version 1.1)

Course Objectives:

1. To familiarize students with conventional and molecular characterization of microorganisms
2. To illustrate the role of microbes in health care, agriculture and environment
3. To exemplify the importance of genetic composition in microbial inheritance and mutations

Course Outcomes:

The students will be able to:

1. Analyze the classification, diversity, and ubiquity of major categories of microorganisms
2. Demonstrate the structural, physiological differences of microorganisms and their growth control
3. Evaluate the interactions between microbes, hosts and environment.
4. Acquire knowledge on prokaryotic, eukaryotic genome organization and the process of replication
5. Interpret the epigenetic effects on transposons in genes of interest
6. Describe the causes and consequences of mutations on microbial evolution and the generation of diversity

Module I: Microbial diversity and Molecular Taxonomy (9 hours)

Concepts of species and hierarchical taxa – Bergey‟s system of classification– Classification of Bacteria, Fungi, and Viruses; Modern methods to study microbial diversity: NGS – MiSeq; Molecular Taxonomy-

16S rRNA gene sequencing, Phylogenetic grouping. Fatty Acid Methyl Ester (FAME) analysis, ITS; Methods to study microbial community: DGGE, SSCP, T-RFLP.

Module II: Microbial Physiology and Metabolism (8 Hours)

Morphology, structure and functions of prokaryotic and eukaryotic cells, Control of Microbial growth – Physical and Chemical, Metabolic Pathways: Anaerobic Carbon metabolism: Anaerobic respiration, Sulphate respiration, Methane oxidizing and Methanogenic bacteria, Aerobic Carbon metabolism: TCA cycle alternative metabolic pathways; Quorum sensing: Vibrio fischeri, virulence- Pseudomonas aeruginosa, Staphylococcus aureus, Preservation and maintenance of microbes

Module III: Clinical, Agricultural and Environmental Microbiology (9 Hours)

Clinical Microbiology- Survey of disease causing microbes; Bacterial Diseases: Mycobacterium tuberculosis, Salmonella, Viral Diseases: HINI, Fungal Diseases: Candida, Protozoan Diseases: Malaria, Antibiotics and their targets, Human Microbiome- gut microbiota, Microbes and Agriculture: Symbiotic Nitrogen fixation Rhizobium, Cyanobacteria (Anabaena, Azolla etc.), Mycorrihizae; Environmental Microbiology: Xenobiotic degrading consortia, Bioremediation; Biofilm and its ecological implication

Module IV: Genetics of bacteriophages and Yeast (6 Hours)

Genetics of bacteria and bacteriophages: Mapping of genes in bacterial and phage chromosomes by classical genetic crosses; fine structure analysis of a gene; genetic complementation and other genetic crosses using phenotypic markers. Yeast genetics: Meiotic crosses, tetrad analyses, non-Mendelian and Mendelian ratios.

Module V: Transposons and epigenetics (7 Hours)

DNA-based Transposons in bacteria, Eukaryotic Transposons (DNA-based), Retrotransposons and Retroviruses (eukaryotes); Epigenetics: RNA-based silencing, X-chromosome inactivation.

Module VI: Microbial Mutation (6 Hours)

Molecular basis of mutation, mutagen and origin of spontaneous mutations- Fluctuation test – inference of function of genes based on isolation of mutations – various types of mutations – missense – nonsense – frameshift, Conditional Lethal - mutagens – physical and chemical agents – Mode of action of important mutagens (5BU, 2AP, NTG, Hydroxylamine, Nitrous acid) – use of mutagenic chemicals in isolation of mutants and their advantages.

Textbooks:

1. Prescott LM, Harley JP, Klein DA, Microbiology, 3rd Edition, Wm. C. Brown Publishers, 2001
2. Brock Biology of Microorganisms by M. Madigan, K. Bender, D. Buckley, W. Sattley, D. Stahl. 15th Edition. Pearson Education. 2018.
3. Modern Microbial Genetics by U.N. Streips and R.E. Yasbin, 2nd edition; Wiley Publishers; 2002

References

1. Lim D, "Microbiology", Second Edition, WCB-Mc Graw Hill, 2001.
2. Weaver, Robert Franklin, Molecular biology. 5thedition. McGraw Hill, New York. 2012
3. Bergey"s Manual of Systematic Bacteriology. Volumes 1-5. Williams & Wilkins
4. ErkoStackebrandt. Molecular identification, systematics, and population structure of prokaryotes. Springer-Verlag Berlin Heidelberg. 2006
5. Lewin's GENES X, Volume 10 Benjamin Lewin, Jocelyn Krebs, Stephen T. Kilpatrick, Elliott S. Goldstein Jones & Bartlett Learning, 2011

20BT3055	ANIMAL BIOTECHNOLOGY AND IMMUNOLOGY	L	T	P	C
		3	0	0	3

(Version 1.1)

Course Objectives:

1. To provide insights into animal biotechnology
2. To impart knowledge in animal breeding
3. To equip students with advancement in immunology and immunotechnology

Course outcomes:

The students will be able to

1. Explain the role of cryopreservation of embryos and embryo sexing.
2. Describe the basic concepts in animal biotechnology and its importance in livestock improvement.
3. Relate and identify the genetic defects in animal embryos through molecular techniques.
4. Identify the cellular and molecular basis of immune responsiveness through antigen and antibody interactions.
5. Describe the roles of the immune system in both maintaining health and contributing to disease.
6. Demonstrate a capacity for problem-solving about immune responsiveness.

Module I: Embryo Cryopreservation (8 Hours)

Introduction to Animal Biotechnology, Cryopreservation of Sperms, Ova of livestock, Artificial Insemination, Super Ovulation, In Vitro fertilization, Culture of embryos, Cryopreservation of Embryos, Embryo transfer, Embryo splitting, Embryo sexing.

Module II: Germplasm Preservation and Livestock Improvement (7 Hours)

In situ and ex situ preservation of germplasm, In utero testing of foetus for genetic defects, pregnancy diagnostic kits, anti-fertility animal vaccines, Genetic characterization of livestock breeds, Marker assisted breeding of livestock,

Module III: Transgenic Animals (7 Hours)

Transgenic animal production and application in expression of therapeutic proteins, Animal model for diseases, Detection of meat adulteration using DNA based methods.

Module IV: Organs and Cells of the Immune System (7 Hours)

Organs of the immune system, Primary Lymphoid organs, Secondary Lymphoid organs, Formation of Lymph, The Lymphatic vessels and circulation, Cells of the immune system, Granulocytes and Agranulocytes, Lymphocytes & its sub-types, Extravasation. Signaling in the Immune system.

Module V: Antibodies and Antibody Engineering (6 Hours)

Immunoglobulins - Structure and Classes, Immunization and Antibody generation, Monoclonal Antibody production, Antibody Engineering and its outcomes.

Module VI: The Immune Response (10 Hours)

Antigen Presentation, MHC Class-I, MHC Class-II, Antigen Procession-Endogenous pathway, Antigen Procession-Exogenous pathway, T-Cell Activation, Vaccination & Vaccine Types, The social Impact of Immunology.

Total: 45 Hours

Text Books

1. Ian Freshney B. Culture of Animal cells & Manual of basic technique, 6th ed., Wiley – liss publication, 2011.
2. Kuby J, "Immunology", 7th ed., WH Freeman & Co., 2013.

Reference Books

1. Levine MM, Kaper JB, Rappuoli R, Liu MA, Good MF,. *New Generation Vaccines*. 3rd Ed. Informa Healthcare, 2004.
2. Animal Cell Culture by John R.W. Masters 3rd ed., Oxford University Press, 2009.
3. David Male Jonathan BrostoffDavid Roth Ivan Roitt, Immunology. 8th ed., Elsevier, 2012
4. F.C. Hay, O.M.R. Westwood, Practical Immunology, 4th ed., Blackwell Publishing, 2002
5. Goldsby , R.A., Kindt, T.J., Osbome, B.A. and Kerby J. Kuby Immunology, 6th ed., W.H. Freeman, 2005

20BT3056	RESEARCH METHODOLOGY AND APPLIED STATISTICS	L	T	P	C
		2	0	0	2

Course Objectives:

1. Empower students to formulate research questions and develop a sufficiently coherent research design

2. Apprehend the need and review the guidelines for good research and publication ethics
3. Enable the students to understandthe need of statistical data analytic techniques in biological research

Course Outcome:

The students will be able to

1. Design their experiment keeping in mind the appropriate statistical test to be adopted in support of research hypothesis
2. Understand key steps to transform a wobbly idea into a convincing research proposal report - connecting the small objectives to big-picture
3. Perform hypothesis testing based on parametric and non-parametric approach in statistical package, office tools
4. Analyze the need of literature, experimental data, and supporting information in realm of research publication
5. Practice good-research and publication ethics
6. Understand the need of statistical analysis pertinent to their experimental data

Module I: Research Methodologies: strategies, planning (4 Lecture Hours)

Resources or search engines available for gathering information and literature in related area,
Critical review of available literature, Problem Identification Formulation (finding research gaps),

Module II: Research Concepts and Data Collection (5 Lecture Hours)

Definition of Research, Qualities of Researcher, Components of Research Problem, Various Steps in Scientific Research, **Types of Research**; Hypotheses Research Purposes - Research Design – Survey Research. **Sources of Data**: Primary Data, Secondary Data; Procedure. Questionnaire - **Sampling** Merits and Demerits - Experiments - Kinds - Procedure; **Control Observation** - Merits - Demerits - Kinds – Procedure. Research conditions: repeatability and reproducibility, bias, measurement and source of error: Type-I Error - Type-II Error, experimental controls, Association versus causality

Module III: Crafting Scientific publication (6 Lecture Hours)

Types of publications - their purpose and readers, Choosing Appropriate Journal/Publisher - available tools, Steps in drafting reports, editing and evaluation of final draft, evaluating the final draft; Good Research Report, observation and research report., *Component of an articles*: Introduction, M&M, Results, Discussion, and Conclusion. Brevity in scientific writing, *Authors guidelines* in scientific publications, Language polishing, Citation style and editor, uniformity.

Module IV: Research, publication, and ethics (3 Lecture Hours)

Scientific conduct and misconduct, fabrication, falsification, duplicate-publication, Plagiarism and self-plagiarism, Erratum, Retraction, *Authorship and issues*, statement of authors contribution, Corresponding authors role and responsibility, Need for Acknowledgement, Conflict of interest, Plagiarism, COPE guidelines, *Publication models* - subscription *vs.* open access, Authors right, Editorial process and publication life-cycle.

Module V: Advanced and Applied statistics (9 Lecture Hours)

Hypothesis Testing: One-Sample Test for the Mean of a Normal Distribution, Hypothesis Testing and Confidence Intervals, Interval Estimation for the Comparison of Means, Two-Sample *t* Test, Paired *t* test, One-way and two-way ANOVA,**Non-parametric** *Wilcoxon Signed-Rank Test*,

Module VI: Correlation and regression analysis (3 Lecture Hours)

The Method of Least Squares, Regression coefficient, Correlation Coefficient, Multiple Regression

Total: 30 Hours

Text Book

1. Kothari C.R., 2004. Research Methodology Methods and Techniques, New Age international (P) Limited, New Delhi
2. Rosner, B. (Ed.), Fundamentals of Biostatistics, 8th ed. Cengage Learning, Boston, 2016.

Reference Book

1. Laake, P., Benestad, H.B., Olsen, B.R., 2007. Research methodology in the medical and biological sciences, 1st ed. Academic Press.

2. Blackwell, J, Martin J 2011. A Scientific Approach to Scientific Writing, Springer

20BT3057	BIOPROCESS AND DOWNSTREAM PROCESSING	L	T	P	C
		3	0	0	3

Course Objectives:

1. To understand the principles of upstream and downstream processing in Bioprocess Technology
2. To illustrate knowledge on the requirement of media formulations, sterilization and inoculum development
3. To acquire knowledge on microbial growth and product formation

Course Outcomes:

The students will be able to;

1. Understand the process of fermentation and its requirements
2. Recall the media formulation, medium optimization and sterilization process
3. Illustrate the importance of microbial screening and preservation in bioprocessing
4. Discuss the cell growth and product formation
5. Apply knowledge on various unit operations in downstream processing
6. Analyze industrial product development in fermentation process

Module I: Overview of Fermentation Process (6 Lecture hours)

Overview of fermentation industry, general requirements of fermentation processes, basic configuration of fermenter, main parameters to be monitored and controlled in Fermentation processes- Temperature, pH, pressure, flow measurement, rate of stirring, biomass weight, Dissolved Oxygen

Module II: Medium Formulation, Optimization and sterilization (10 Lecture hours)

Criteria for good medium, medium requirements for fermentation processes, examples of simple and complex media, design of various commercial media for industrial fermentations, medium optimization methods, liquid heat and filter sterlization of media

Module III: Isolation of Industrially Important Microbes and Inoculum development (6 Lecture hours)

Isolation of industrially important microbes- primary screening, preservation and storage of industrially important microbes, Inoculum development for Industrial fermentation process

Module IV: Cell Growth and Product formation (7 Lecture hours)

Cell number and Cell mass calculations, growth model- Monod model, Effect of Substrate and product inhibition on growth, Product formation model- Leude king piret model, Factors affecting microbial growth

Module V: Cell separation and Extraction (8 Lecture hours)

Cell disruption for product release, separation of cells from fermented broth- sedimentation, Filtration, Centrifugation , Extraction of product, leaching, adsorption and precipitation of proteins.

Module VI: Purification and Finishing (8 Lecture hours)

Chromatography adsorption, reverse phase, ion exchange, size exclusion, bio affinity and pseudo affinity, crystallization, drying and lyophilization, packaging, case studies of downstream Processing - Baker's yeast, Ethanol, Citric acid, Penicillin.

Total: 45 Hours

Text Books:

1. Shuler M.L. and Kargi F., Bioprocess Engineering: Basic Concepts, Prentice-Hall (2001).
2. Stanbury, P.F., Principles of Fermentation Technology, Book News, Inc. (1992).
3. Vogel H. C.and Haber C. C., Fermentation and Biochemical Engineering Handbook, Noyes Publications (2001).

Reference Books:

1. Bailey, J.E. and Ollis, D.F., Biochemical Engineering Fundamentals, McGraw-Hill (1986).
2. Wang D.C. and Humphrey, L, Fermentation and Enzyme Technology, John Wiley (1989).
3. Doran P M, Bioprocess Engineering Principles, Academic Press (1995).

20BT3058	MOLECULAR MEDICINE AND DIAGNOSTICS	L	T	P	C
		3	0	0	3

Course Objectives:

The students will

1. Learn to self-reliantly analyze and understand research results and technologies.
2. Learn techniques for emerging novel molecular diagnostics and therapies.
3. Be able to study applications in healthcare, research and industry.

Course Outcome:

The students will be able to

1. Recognize molecular mechanisms in development of disease
2. Predict the use of molecular genetic methods in the detection, identification and quantification of different microorganisms.
3. Apply the principles of molecular diagnostics and advantages/limitations of its applications
4. Develop technological integration of chemistry, physics and molecular biology for use in bioanalysis relevant for biomedical research and diagnostics.
5. Design advanced study in the theoretical and practical aspects of the genetic basis and diagnosis of disease from both human and pathogen perspectives.
6. Appraise the knowledge of molecular testing to the most commonly performed applications in the clinical laboratory such as: nucleic acid extraction, resolution and detection, analysis and characterization of nucleic acids and proteins, nucleic acid amplification and DNA sequencing.

Module I: Introduction to Molecular medicine, Nanomedicine (7 Lecture Hours)

Extracellular and intracellular signaling systems. Methods of DNA analysis and gene technology. Nanomedicine - Overview. Identification of genes and variants in the genome and gene mapping.

Module II: Molecular and Medical Microbiology (7 Lecture Hours)

Molecular methods for detection and characterization of microorganisms, Primer and probe design. Databases - Molecular genetic assays, genotypic assays for molecular epidemiology.

Module III: Cell Imaging and Biobanking (8 Lecture Hours)

Cell Imaging: Preparation and microscopy of biological specimens, tissue and cell morphology. Biobanks: classifications, common and distinctive features of the different types of biobanks. National regulations, international conventions, use of human biological materials and personal data, Research biobanks, Ethical aspects, role of Research Ethics Committees, consent for biobanking, alternatives to consent, Logistics and quality management, quality assurance and quality control of collection, storage, retrieval and use of samples, Role of biobanks in health surveys like HUNT, Mother-Child etc.,

Module IV: Introduction to Molecular diagnostics (7 Lecture Hours)

Introduction and History of diagnostics, Diseases- infectious, physiological and metabolic errors, genetic basis of diseases, inherited diseases. Infection – mode of transmission in infections, factors predisposing to microbial pathogenicity, types of infectious diseases- bacterial, viral, fungal, protozoans and other parasites. · Philosophy and general approach to clinical specimens, Sample collection- method of collection, transport and processing of samples, Interpretation of results, Normal microbial flora of the human body, Host - Parasite relationships.

Module V: Diagnostic tests and diseases (8 Lecture Hours)

Duchenne muscular Dystrophy (Creatine phosphokinase-CPK), Amino acid deficiency - PKU (phenylketonuria) –- Inborn error, G6PD deficiency syndrome (G6PD), Sickle cell anemia, PCR diagnosis of Tuberculosis, Prenatal screening of Cystic Fibrosis. Endocrine disorders related to thyroid and reproduction (TSH, T3, T4, Estradiol, Testosterone, LH, FSH). Pyrosequencing. Lab on a Chip. Personalized Medicine - Pharmacogenomics.

Module VI: Genetic Disorders and Immunodiagnostics (8 Lecture Hours)

Major Metabolic disorder, Genetic disorders, Bone and blood disorders. Overview of immune system, Major Histocompatibility Complex (MHC), HLA typing, monoclonal and polyclonal antibodies, Immunoassays – types [Chemiluminescent IA, FIA] and specific applications; Immunohistochemistry –

principle and techniques. Good Laboratory Practices. Different Levels of Biosafety, Containment. Future trends.

Total: 45 Hours

Text Books

1. Textbook of Molecular medicine, Jones and Bartlett Publishers.
2. Jawetz, Melnick, &Adelberg's Medical Microbiology (2004), Geo F. Brooks, Stephen A. Morse, Janet S. Butel.

References

1. Principles of Biochemistry (Lehinger) (5th edition), MM Cox and DL Nelson, CBS Publishers.
2. Molecular Cell Biology: Darnell J, Lodish H and Baltimore D.
3. Principles of Immunology and Immunodiagnostics: Ralph Michael Aloisi. Lippincott Williams and Wilkins.
4. Genomes (3rd edition) TA Brown, Garland Science Publishing.

20BT3059	MICROBIAL TECHNOLOGY LAB	L	T	P	C
		0	0	4	2

Course Objective:

1. To introduce students to experiments of microbial analysis – Growth curve
2. To deliver hands-on experience on various enzymatic assays
3. Provide idea about quantification of DNA, RNA and protein from microbial samples

Course Outcome:

1. Perform suitable technique to analyse growth curve of bacteria
2. Hands on skills of quantification of DNA, RNA and protein from bacterial cells and its visualization by performing agar electrophoresis.
3. Gain hands-on experience in screening microbial enzymes and assays
4. Apply appropriate technique for the isolation and identification of mutant strains
5. Demonstrate the sensitivity of microbial pathogens to various available drugs.
6. Construct phylogenetic trees using distance-based methods.

Experiments:

1. Establishment of bacterial growth curve
2. Screening of microbes for the production of enzymes - chitinase, protease, lipase, cellulase
3. Antimicrobial Sensitivity Test- Minimum Inhibitory Concentration
4. Quantification of Biofilm using microtitre plate (TCP) method
5. Phylogenetic analysis of microbes using UPGMA method
6. Isolation and quantification of total DNA from bacteria and fungi
7. Isolation and quantification of RNA.
8. Isolation and quantification of microbial protein
9. Replica plating technique- Ames Technique
10. Photoreactivation of UV irradiated E. coli.
11. Development of auxotrophic mutants employing Ethyl Methane Sulfonate
12. Blue and white colony selection employing X-gal-IPTG

Reference Books:

1. Microbiology: A Laboratory Manual, 11th edition James G. Cappuccino Chad T. Welsh Published by Pearson, 2017
2. Practical Microbiology, Dubey and Maheshwari, S Chand Publishing, 2010
3. Essentials of Practical Microbiology**,** ApurbaSankarSastry, Sandhya Bhat, 2018

20BT3060	BIOPROCESS AND DOWNSTREAM PROCESSING LAB	L	T	P	C
		0	0	4	2

Course Objectives:

1. To acquire knowledge about principles of growth of microbes, importance of maintaining the cultures, techniques used for enhancing the yield

2. To design criteria for fermenter and operation of bioreactor, solid state fermentation
3. To produce different metabolites from microbial culture

Course Outcomes:

The student will be able to:

1. Understand the growth kinetics of microorganism.
2. Understand various factors affecting the growth
3. Illustration of fermentation in production of primary and secondary metabolites
4. Application of Immobilization technique in production of metabolites
5. Analyze the various operations in product recovery and isolation
6. Evaluate the purification and polishing of the bioproducts

List of Experiments

1. Laboratory fermenter, sterilization and operations.
2. Revival of culture from frozen vial to shake flask culture
3. Standardization of conditions for scale up of the culture in fermenter
4. Optimization of growth of bacteria in batch cultivation by statistical method
5. Immobilization of bacteria using alginate and agar
6. Study on growth kinetics and toxic compound inhibition kinetics
7. Solid state fermentation for the production of bioproducts
8. Cell disruption study
9. Isolation of product from the broth by extraction
10. Partial purification of enzymes by ammonium sulphate precipitation
11. Chromatographic techniques (column) for the product purification.
12. Product drying by lyophilization

Text Books

1. Kargi, Michael Shuler L. Fikret, and Matthew DeLisa. *Bioprocess engineering: basic concepts*. Prentice Hall, 2017.
2. Stanbury, Peter F., Allan Whitaker, and Stephen J. Hall. *Principles of fermentation technology*. Elsevier, 2013.
3. Doble, Mukesh, and Sathyanarayana N. Gummadi. *Biochemical engineering*. PHI Learning Pvt. Ltd., 2007

References

1. Todaro, Celeste M., and Henry C. Vogel, eds. *Fermentation and biochemical engineering handbook*. William Andrew, 2014.
2. Bailey, J.E. and Ollis, D.F., Biochemical Engineering Fundamentals, Tata McGraw-Hill (2010)

20BT3061	IMMUNOLOGICAL TECHNIQUES LAB	L	T	P	C
		0	0	4	2

Course Objectives:

1. To deliver hands-on experience on various immunological techniques
2. To impart technical skills in the preparation of antigen
3. To provide knowledge in the production of antibodies and antibody titre assays

Course Outcomes:

1. Understand the procedure for antigen preparation
2. Categorize the methods of immunization
3. Identify the steps involved for the production of antibodies
4. Perform purification of the antibodies
5. Evaluate the methods involved for antigen and antibody reactions
6. Analyze and interpret the results obtained by the immunological experiments

List of Experiments:

1. Acclimatization of Fish & Chicken
2. Preparation of Antigen
3. Administration of Antigen in Fish & Chicken
4. Isolation of Lymphocytes from lymphoid organs.

5. Drawing Blood and separation of Serum from fish
6. Visualization of immune cells in blood smears.
7. Isolation of IgY antibodies from Chicken egg
8. Molecular weight identification of antibodies using SDS Page analysis
9. Estimation of specific Antibodies using Haemagglutination.
10. Estimation of specific Antibodies using immunodiffusion
11. Graft Rejection
12. Delayed type hypersensitivity in Fish

Reference Books:

1. Frank C Hay, Olwyn M.R. West Wood. Practical Immunology, 4th ed., Wiley- Blackwell,2008
2. David Male, JonathanBrost, David Roth, Ivan Roitt. Immunology. 8th ed., Elsevier, 2012.

20BT3062	INDUSTRIAL BIOTECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

1. To inculcate knowledge on history of biotechnology, origin and analysis of different kinds of microorganisms for industrial biotechnology.
2. To elaborates on the process of industrial biotechnology
3. To facilitate various production strategies of bio products employed for sustainable bioprocess development

Course Outcome:

1. The students will be able to
2. Acquire knowledge on industrial bioprocess and process flow diagrams.
3. Remember various types of bioproducts and steps in fermentation technology.
4. Understand the problems related to handling microorganisms and selection of microbial culture for specific kind of bioproducts
5. Analyze industrial-market value of the bio products and relate them with the scope of biotechnology
6. Justify the clinical and biological significance of these bio products for sustainable bioprocess engineering,
7. Illustrate the difference in manufacturing commercial bioproducts and the ethical issues related to entrepreneurial aptitude.

MODULE 1: Introduction to Industrial Bioprocess (10 Lecture Hours)

Fermentation- Bacterial, Fungal and Yeast, Biochemistry of fermentation. Traditional and Modern Biotechnology- A brief survey of organisms, processes, products. Basic concepts of Upstream and Downstream processing in Bioprocess, Process flow sheeting – block diagrams, pictorial representation.

MODULE II : Production of Primary Metabolites (8 Lecture Hours)

Primary Metabolites- Production of commercially important primary metabolites like organic acids, amino acids and alcohols.

MODULE III : Production of Secondary Metabolites (8 Lecture Hours)

Secondary Metabolites- Production processes for various classes of secondary metabolites: Antibiotics, Vitamins and Steroids.

MODULE IV : Production of Enzymes and other Bioproducts (11 Lecture Hours)

Production of Industrial Enzymes (Amylase, Laccase), Biofertilizers, Biopreservatives, Biopolymers Biodiesel. Cheese, Beer, Mushroom culture, Bioremediation.

MODULE V : Production of Modern Biotechnology Products (4 Lecture Hours)

Production of recombinant proteins having therapeutic and diagnostic applications, vaccines. Bioprocess strategies in Plant Cell and Animal Cell culture.

MODULE VI : Production of Target Specific Fine Bioproducts (4 Lecture Hours)

Single Cell Proteins and fine bio products for pharmaceutical applications like monoclonal antibodies.

Total Hours: 45

Text Books

1. Prescott and Dunn, Industrial Microbiology, Fourth Edition, 2004.
2. P.F. Stanbury and Whitaker, Fermentation Technology, Third Edition, 2016.

References Books

1. ElmarHeinzle,Sustainable Bioprocess Development, John Wiley & Sons,2008.
2. Robert H. Perry, Handbook of ChemicalEngineering, McGraw-Hill Education 2019.

20BT3063	PHARMACEUTICAL TECHNOLOGY AND CLINICAL TRIAL	L	T	P	C
		2	0	2	3

Course Objectives:

1. To understand the impact of pharmaceutical technology and manufacturing process of drug formulation.
2. To learn and work on pharmaceutical laboratory process on multidisciplinary tasks.
3. To explore an ability to design an experiment, component or process as per needs and specifications.

Course Outcome:

The students will be able to

1. Distinguish to excel in research and to succeed in Biopharmaceutical technology profession through global, rigorous post graduate education.
2. Contrast students with a solid foundation in pharmacology, scientific and engineering fundamentals required to solve biopharmaceutical related problems.
3. Understand students with good scientific and technical knowledge so as to comprehend novel products and solutions for the health care issues.
4. Articulate in scientific & professional ethics on biological product manufacturing process.
5. Discover scientific methods and SOPs in clinical trials and fundamentals in new drug discovery process.
6. Develop academic environment aware of excellence in new drug discovery and patenting professional career.

Module I: Introduction of drug action (7 Lecture Hours)

History & Definition of Drugs- Sources of Drugs - Plant, Animals, Microbes and Minerals- Different dosage forms- Routes of drug administration- Pharmacodynamics- Physico-Chemical Principles. Mechanism of drug action- drug receptors- and Physiological receptors- structural and functional families -Pharmacokinetics- Drug absorption- factors that affect the absorption of drugs-Distribution of drugs-Biotransformation of drugs- Bioavailability of drugs.

Module II: Important Unit Processes and their Applications (6 Lecture Hours)

Chemical conversion processes – Alkylation – Carboxylation – Condensation and Cyclization – Dehydration, Esterification (Alcoholysis) – Halogenation – Oxidation, Sulfonation – Complex Chemical Conversions – Fermentation

Module III: Manufacturing Principles (7 Lecture Hours)

Compressed tablets – wet granulation – Dry granulation or slugging – Direct compression – Tablet presses formulation – Coating – Pills – Capsules sustained action dosage forms – Parental solutions and injections – Oral liquids –ointments – standard of hygiene and good manufacturing practice.

Module IV: Biopharmaceutical products (7 Lecture Hours)

Antibiotics – Biological hormones – Vitamins – preservation- Analytical methods and tests for various drugs and pharmaceuticals- Packing – Packing Techniques – Quality Control - Recent advances in the manufacture of drugs using r-DNA technology.

Module V: Drug delivery systems (6 Lecture Hours)

Biomaterials and their applications-Controlled and sustained delivery of drugs- Biomaterial for the sustained drug delivery- Liposome mediated drug delivery- Drug delivery methods for therapeutic proteins.

Module VI:Drug discovery and Clinical trials (6 Lecture Hours)

Glossary of terms in clinical trials, history, requirements, new drug development process, need for new drug, selection of a chemical compound as a potential drug, screening of chemical compounds, translation medicine, assessment of preclinical data. Phases of clinical trials.

Total Hours: 45

Text Books

1. R.S.Sathoskar, S.D.Bhandrkar, S.S.Ainapure "*Pharmacology and pharmacotherapeutics* "17th edition, Popular Prakashan pub. (2001)
2. Remington, The Science and Practice of Pharmacy, Lippincot Williams & Wilkins pub.(2014)
3. Leon Lachman, Herbert A. Lieberman and Joseph L. Kanig, *Theory & Practice of Industrial Pharmacy*, (3rd ed.) Varghese Pub. 2013

References Books

1. Googman and Gilman's The pharmacological Basis of Therapeutics,13th Edition 2017
2. Methodology of Clinical Drug Trials, 2nd Edition. Spriet A., Dupin-Spriet T., Simon P. Publisher: Karger. 2010.

Lab

Course Objective:

1. To prepare students to excel in research and to succeed in Biopharmaceutical technology profession through global, rigorous post graduate education.
2. To train students with good scientific and technical knowledge so as to comprehend, analyze, design, and create novel products and solutions for the health related problems.
3. To provide students with a solid foundation in statistical, scientific and engineering fundamentals required to solve biopharmaceutical related problems

Course Outcome:

The students will be able to,

1. Demonstrate to design and conduct experiments, analyze and interpret data.
2. Develop an experiment, component or process as per needs and specifications
3. Construct to visualize and work on laboratory and multidisciplinary tasks.
4. Organize to employ modern technology, software and equipment to analyze problems.
5. Classify to identify, formulate and solve health related issues.
6. Create impact of pharmaceutical technology on the society and also will be aware of contemporary issues

List of experiments:

1. Introduction to CDS (cleaning, decontamination and sanitization) protocols as per GLP norms.
2. Sterility testing of finished biopharmaceutical products (Injectable / freeze dried formulations).
3. Isolation, screening and quantification of bioactive compounds from natural source. Comet assay: single cell gel electrophoresis.
4. Separation and purification of isolated bioactive components.
5. Determination of pharmacokinetic (PK) release profile of biopharmaceuticals.
6. Preparation and evaluation of controlled release formulation.
7. Clinical data integration (eCRF, images, laboratories, and other instrumentation)

Reference:

1. Gary Walsh, Biopharmaceuticals: Biochemistry and Biotechnology, 2nd Edition. John Wiley & Sons, Inc, (2003).
2. Rodney J. Y. Ho, Biotechnology and Biopharmaceuticals: Transforming Proteins and Genes into Drugs, 2nd Edition. John Wiley & Sons, Inc.(2013)
3. Gary Walsh, Pharmaceutical Biotechnology: Concepts and Applications. John Wiley & Sons, Inc.(2007)
4. Oliver Kayser, HeribertWarzecha, Pharmaceutical Biotechnology: Drug Discovery and Clinical Applications, 2nd Edition. John Wiley & Sons, InC, (2012).

		L	T	P	C
20BT3064	**BIOINFORMATICS AND BASICS OF R PROGRAMMING**	2	0	2	3

Course Objectives:

1. To explore various tools and database to understand the Biomolecules at structural and functional level
2. To perform big data analytics for Biological data set.
3. To familiarize with Predictive Analytics and Data Visualization.

Course Outcome:

The students will be able to

1. Familiarized with various biological database and software tools
2. Predict the structure and functions of biomolecules
3. Apprehend the knowledge on ligand and structure based drug design
4. Enable to write, compile, and run R programs.
5. Analyze data from different interfaces
6. Develop R script for various biological problems.

Module I: Biological Databases (6 Lecture Hours)

Nucleotide databanks – Genbank, NCBI, EMBL, DDBJ – protein databanks –sequence databanks – PIR, SWISSPROT, TrEMBL- structural databases – PDB, SCOP, CATH.

Module II: Sequencing Alignment and Dynamic Programming (6 Lecture Hours)

Local, Global alignment, pairwise and multiple sequence alignments. Alignment algorithms. Dynamic programming in sequence alignment: Needleman-Wunsch Algorithm and Smith Waterman Algorithm, Aminoacid Substitution matrices (PAM, BLOSUM).

Module III: Molecular Modeling and Drug Discovery (3 Lecture Hours)

Basic concepts of Molecular modeling, Structure Identifications and Validations, Computer Aided Drug Design, HTVS, QSAR

Module IV: Introduction & R Objects (6 Lecture Hours)

R console, CRAN, Installation, configuration, R studio environment setup, Basic syntax, Data types, Variables, Operators, Vectors , Lists, Matrices, Arrays, Factors , Data frames

Module V: R Packages & Data interfaces (6 Lecture Hours)

Installing a package from CRAN, Manual installation and configuration of a package, loading package to library, Exploring R packages for Bioinformatics applications

Module VI: Big data analytics for Health care (3 Lecture Hours)

Big data analytics in bioinformatics, Health care, Data mining using sequence data, Chemical mining, Biological sequence motifs and patterns.

Total Hours: 30

Textbooks

1. A.M. Lesk. Introduction to Bioinformatics. Oxford University Press India, 2017.
2. S.C. Rastogi and N. Mendiratla and P.Rastogi. Bioinformatics methods and applications-Genomics, Proteomics and Drug Discovery. Prentice Hall India, 2013
3. D.W. Mount. Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbour Laboratory Press, New York, 2012.

References

1. VenkatAnkam, "Big Data analytics", Packt publishing 2016
2. Parag Kulkarni, Sarang Joshi, " Big Data analytics " , PHI learning 2016
3. Wang, Baoying, Big Data Analytics in Bioinformatics and Healthcare, IGI global edition

Lab

Course Objectives:

1. To explore various tools and databases to understand the Biomolecules at sequential, structural and functional level
2. To performing big data analytics for Biological data set.
3. To familiar with practical knowledge in recent techniques like Predictive Analytics and Data Visualization to plot

Course Outcome:

The students will be able to

1. Analyze Biomolecules using biological databases, software/tools and online
2. Understand and exhibit the knowledge vital role for new drug design by various methodologies to save the human health
3. Recognize the need for independent and lifelong learning experience in bimolecular analysis and application
4. Enable to write, compile, and run R programs.
5. Analyze data from different data interfaces
6. Ability to develop R script for various biological problems.

List of experiments:

1. Biological Databases with Reference to Expasy and NCBI
2. Sequence similarity searching using BLAST
3. Overview of Protein and their interaction with ligand
4. Protein structure modeling, verification and validation.
5. Creation Data frames
6. Creating a pie chart using the R
7. Regression analysis using R
8. Protein data analysis by using R Programming from external sources like Protein Databank (PDB)
9. *ChemmineR*: Cheminformatics Toolkit for R
10. Read and analyse a genome sequence file using seqinr package.

Text Book:

1. A.M. Lesk. Introduction to Bioinformatics. Oxford University Press India, 2017.
2. S.C. Rastogi and N. Mendiratla and P.Rastogi. Bioinformatics methods and applications-Genomics, Proteomics and Drug Discovery. Prentice Hall India, 2013
3. Wang, Baoying, Big Data Analytics in Bioinformatics and Healthcare, IGI global edition

Reference Book:

1. VenkatAnkam, "Big Data analytics", Packt publishing 2016
2. Parag Kulkarni, Sarang Joshi, "Big Data analytics", PHI learning 2016
3. D.W. Mount. Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbour Laboratory Press, New York, 2012.

20BT3065	NEXT GENERATION SEQUENCING DATA ANALYSIS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To improve the knowledge of the NGS data analysis
2. To learn NGS data and analyze these in an UNIX/Linux working environment.
3. To solve computational genomics problems using advanced statistical methods.

Course Outcome:

The students will be able to

1. Summarize the applications of the different NGS technologies, including the weakness and strengths of the approaches.
2. Demonstrate the steps involved in a general NGS data analysis.
3. Record key theoretical concepts of alignment and de novo assembly.
4. Synthesize and formulate a project and relevant question within the field.
5. Illustrate the basics of NGS data analysis.
6. Infer analytical and reflective skills in analyzing results from individual steps and the final project.

Module I: UNIX Operating System (7 Lecture hours)

General purpose utilities; Navigating the File system; Handling ordinary files; The Shell; The Vi Editor; The Environment-Basic File Attributes

Module II: File Attributes **(8 Lecture hours)**

System Administration-The Routine Duties; The Regular Expressions and The grep family-The Process; Communication and Electronic mail; Shell Programming

Module III: NGS Data Analysis **(7 Lecture hours)**

Next Generation Sequencing: Early Stage NGS data analysis, Computing needs for NGS data management and analysis

Module IV: Application specific NGS data analysis **(9 Lecture hours)**

Transcriptomics, Genotyping and Genomic Variation discovery by whole genome resequencing

Module V: Metagenomics **(7 Lecture hours)**

Metagenome analysis by NGS, changing landscape of NGS, Epigenomics data analysis:*De novo* genome assembly from NGS reads

Module VI:RNA and ChIP Sequencing Analysis **(7 Lecture hours)**

Mapping Protein-DNA interactions with ChIP-seq, RNA Sequencing Analysis

Total Hours: 45

Textbooks

1. Xinkun Wang, "Next-Generation Sequencing Data Analysis" CRC Press 2016
2. Sumitabha Das, Unix – Concepts and Applications, Tata McGraw Hill, 2ndEdition.

References

1. Next-Generation DNA Sequencing Informatics [Kindle Edition] by Stuart Brown, Cold Spring Harbor Laboratory Press Newyork, 2013.
2. Tag-based Next Generation Sequencing by Matthias Harbers and GuenterKahl (Wiley Blackwell Germany 2012
3. Wong, Lee-Jun C., Next Generation Sequencing- Translation to Clinical Diagnostics, Springer, 2013

20BT3066	ALGAE BIOTECHNOLOGY	L	T	P	C
		2	0	2	3

Course Objective:

1. Impart the knowledge of different techniques employed in alage technology
2. Improve the understanding of applications and products derived from microalgae
3. Illustrate the characterization of algae using biochemical and molecular tools

Course Outcome:

The students will be able to

1. Understand the importance of algae and their culture techniques
2. Summarize the value added products of algae
3. Outline the application of algae in Industry and environment.
4. Elaborate the cell characteristics of microalgae
5. Investigate different products from algal sources through technological interventions
6. Infer algal characterization using molecular tools

Module 1: Algae cells **(4 hours)**

Algae and its culture - Isolation Techniques (Downstream Techniques) - Growth curve – Microscopy – Streaking - Culture Collection and Maintenance.

Module 2: Culture medium/nutrients and Condition **(6 hours)**

Culturing Media – Types of Media (BB, CFTRI, Fog's Medium, Shibin, Guillard's F/2 medium, Walne Medium) – Media Modification – Maintaining Conditions (Temperature, pH, Light, Salts etc).

Module 3: Phycoremediation **(5 hours)**

Adsorbing – Application in Environmental Clean up – Heavy Metal uptake, Wastewater treatment – Dye remediation –Agricultural application

Module 4: Value Added compounds **(6 hours)**

Oils and fatty acids – PUFA – Single Cell Protein – Biofilms – Secondary metabolites – Pigments – Proteins – Feed and Food - Biofuels

Module 5: Characterization **(3 hours)**

GC of Fatty acid – MS in Result analysis – FTIR – SEM

Module 6: Genomic studies **(6 hours)**

Molecular Techniques – DNA isolation – PCR – Molecular Identification – Phylogentic analysis – Pathway Analysis – Biomarkers.

List of Experiments:

1. Isolation of algae cells by serial dilution and microscopic observation
2. Culture Media preparation, sterilization and plating techniques
3. Maintenance of the isolated microalgal cells using synthetic medium
4. Growth curve measurement of alga cells using spectrophotometer
5. Effect of temperature on biomass generation
6. Dye decolourization studies using microalgae
7. Phycoremediation of waste water using microalgae
8. Solvent extraction of bio-oil from algal biomass
9. Algae bioinformatics – data base search and phylogenetics
10. GC-MS/FID profiling of the Fatty acid obtained from algal biomass

Text Books

1. M. Arumugam, S. Kathiresan., N. Subramani, Applied Algal Technology. Nova Science Publishers, New York, (2020).
2. AVSS Sambamurthy A Textbook of Algae, I.K. International Pvt. Ltd. New Delhi, (2017)
3. C. Vanden Hoek, D.G. Mann and H.M. Jahns . Algae – An introduction to Phycology, Cambridge University Press, (1995).
4. Kristian N. Hagen, Algae - Nutrition, Pollution Control and Energy Sources, Nova Science Publishers, 2009

References:

1. FaizalBux, Yusuf Chisti. Algae Biotechnology: Products and Processes, Springer International Publishing, Switzerland, 2016.
2. Gokare A. Ravishankar, Ambati Ranga Rao. Handbook of Algal Technologies and Phytochemicals, CRC Press, Taylor and Francis Group, 2019.

20BT3067	TISSUE ENGINEERING AND STEM CELL TECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objective:

1. To inculcate knowledge in cell culture techniques
2. To develop technical skills in tissue implants and transplants and understand its regulation in tissue engineering
3. To impart the clinical potential, significance and ethics of stem cells

Course Outcome:

The Students will be able to:

1. Explain the concepts in cell culture techniques
2. Understand the importance of 3D cell culture and its applications
3. Analyze tissue engineering process and applications in the field of medicine
4. Categorize different types of stem cells and its functions
5. Examine the methods involved in the isolation of stem cells.
6. Justify the clinical potential, significance and ethics of stem cells

Module I: Cell Culture **(7 Lecture Hours)**

Commercial scale production of animal cells, Application of animal cell culture for in vitro testing of drugs, Cytotoxicity and viability assays, Cell line preservation and authentication.

Module II: 3D Culturing **(8 Lecture Hours)**

3D cell culturing and protocols involved for the 3D cell culture of different types of cells cell transplantation for liver, Multicellular tumor Spheroids, Experimental tissue modeling. Current research in tissue modeling

Module III: Tissue Engineering (7 Lecture Hours)

Tissue Engineering, Design stages for tissue engineering, Cell substrate and support materials, Cell sources, Orientation, Different methods and steps involved in cell seeding of implantable materials

Module IV: Stem cell-Types (7 Lecture Hours)

Types of stems cells, Embryonic stem cells, Pleuripotent stem cells, Adult stem cells, Induced pleuripotent stem cells, Transit amplifying cells, Symmetry during cell division in Stem cells.

Module V: Isolation and culturing of stem cells (8 Lecture Hours)

Isolation of Embryonic stem cells, Mesenchymal stem cells, Pleuripotent stem cells, Cord cells, Cord blood banking advantages and dis advantages, Differentiation of stem cells into osteoblast cells with protocols.

Module VI: Applications of Stem cell Technology (8 Lecture Hours)

Application of stem cells: Stem cells in Cancer treatment, Stem cells in wound healing, Stem cells in tissue engineering & organ regeneration, Stem cells in autoimmune disorders. Ethical and social concern of stem cell technology.

Total Hours: 45

Text Book Text Book

1. Ian Freshney B. Culture of Animal cells & Manual of basic technique, 6th ed., Wiley – liss publication, 2011.
2. Bernhard Palsson, Jeffery A. Hubbell, Robert Plonsey, Joseph D. Bronzino, Tissue Engineering, 7th ed., CRC Press, 2019.

Reference Books

1. Robert Lanza and Anthony Atala, Essentials of Stem Cell Biology, 3rd ed., Elsevier 2014
2. Satish Totey and Kaushik D. Deb, Stem Cell Technologies: Basics and Applications, McGraw-Hill, 2010
3. Warburton David, Stem Cells, Tissue Engineering and Regenerative Medicine, 2015

20BT3068	METABOLIC ENGINEERING FOR INDUSTRIAL PRODUCTION	L	T	P	C
		3	0	0	3

Course Objectives:

1. To understand the basic concepts of metabolism playing role in industrial productions
2. To evaluate the possible mechanisms of metabolic alterations for improved production
3. To analyze the significance and ways of effective bioconversion by metabolic engineering

Course Outcome:

The students will be able to

1 Understand the concepts of metabolism in the industrial productions of bio-products
2 Outline the current status of industrial production and the challenges to improve it
3 Analyze the possible engineering ways of metabolic pathways and their effects in products
4 Evaluate the basic normal and the altered metabolic pathways in industrial bioprocesses
5 Apply the knowledge on the ways of alteration in metabolic pathways in case studies
6 Propose a model of metabolic alteration for improved industrial production process

Module I: Metabolism overview (6 Lecture Hours)

Basic concept of metabolic engineering, Overview of cellular metabolism: Transport of molecules across plasma membrane, Fueling Reactions, Biosynthesis, Polymerization.

Module II: Regulation of Metabolic Pathways (9 Lecture Hours)

Metabolism regulation at enzyme level, Metabolism regulation at whole cell level. Jacob Monod model for gene expression regulation-Lac operon, catabolite regulation/repression- glucose effect- cAMP deficiency. Feed back regulation/repression, regulation in branched pathways- differential regulation by isoenzymes, concerted feed back regulation, cumulative feed back regulation, permeability control: passive diffusion, active transport, group transportation.

Module III Metabolic Engineering for Primary Metabolites production (9 Lecture Hours)

Role of metabolic engineering in Strain improvement and selection, improving fermentation. Auxotrophic mutants for high yield, Alteration of feedback regulation, limiting accumulation of end products, feedback

resistant mutants, alteration of permeability for metabolites. Induction, feed- back repression, mutants resistant to repression for enzyme production.

Module IV Metabolic Engineering for Secondary Metabolites production (9 Lecture Hours)

Producers of secondary metabolites, trophophase - idiophase relationship, Auxotrophic Mutants for high yield, Inducer and enhancer for secondary metabolites- an example, resistant to precursor effects, resistant to toxic compounds and toxic effects of secondary metabolites, Revertant mutant for secondary metabolite production. Metabolic engineering for production of plant secondary metabolites

Module V Bioconversions (6 Lecture Hours)

Advantages of bioconversions, specificity, yields, factors affecting bioconversion, Xenobiotic degradation, mutation, permeability, co-metabolism, avoidance of product inhibition, mixed or sequential bioconversions, conversion of insoluble substances.

Module VI Applications and Advancements of Metabolic Engineering (6Lecture Hours)

Self - Learning: Applications in different fields, Case studies of metabolic engineering, Review on advancements - designing models.

Total hours : 45 hours

Text Book:

1. Del Carmen Cortassa, S., Aon, MA(2011) *An Introduction to Metabolic and Cellular Engineering* (2nd Edition). World Scientific.
2. Peter F. Stanbury, Stephen J. Hall & A. Whitaker, Principles of Fermentation Technology, Second Edition, Butterworth – Heinemann An Imprint of Elsevier India Pvt. Ltd., 2005

References

1. Nielsen J and Villadsen J, "Bioreaction Engineering Principles", Springer, 2007.
2. Christiana D Smolke, "The Metabolic Pathway Engineering Handbook Fundamentals", CRC Press Taylor & Francis Group, 2010.
3. Boris N Kholodenko and Hans V Westerhoff, "Metabolic Engineering in the Post Genomic Era", Horizon Bioscience, 2004.
4. Stephanopoulos, G.N., Aristidou, A.A., Nielsen, J.(2000). *Metabolic Engineering: Principles and Methodologies*. Academic Press.

20BT3069	HUMAN ANATOMY, PHYSIOLOGY AND HEALTH EDUCATION	L	T	P	C
		3	0	0	3

Course Objectives:

1. To explain the gross morphology, structure and functions of various organs of the human body.
2. To describe the various homeostatic mechanisms and their imbalance
3. To identify the various communicable pandemic disease and healthcare precautions on different systems of human body

Course Outcome:

The students will be able to

1. Recall the anatomical terminology to identify and describe locations of major organs of each system covered.
2. Explain interrelationships among molecular, cellular, tissue and organ functions in each system.
3. Summaries the interdependency and interactions of the systems
4. Enumerate contributions of organs and systems to the maintenance of homeostasis.
5. Describe the physiological role of CVS system on human body.
6. Infer to aware of excellence in health education and first aid and to describe modern technology and tools used to study for excellent education carrier and well beings.

Module I: Introduction to human body (7 Lecture Hours)

Introduction to human body & organization of human body. b. Functional & structural characteristics of cell. c. Detailed structure of cell membrane & physiology of transport process. Structural & functional characteristics of tissues- epithelial, connective, muscle and nerve.

Module II: Human Skeletal system (6 Lecture Hours)

Divisions of skeletal system, types of bone, salient features and functions of bones of axial and appendicular skeletal system Organization of skeletal muscle, physiology of muscle contraction, neuromuscular junction.

Module III: Body fluids and blood (7 Lecture Hours)

Body fluids, composition and functions of blood, hemopoeisis, formation of hemoglobin, anemia, mechanisms of coagulation, blood grouping, Rh factors, transfusion, its significance and disorders of blood, Reticuloendothelial system.

Module IV:Lymphatic system (8 Lecture Hours)

Lymphatic organs and tissues, lymphatic vessels, lymph circulation and functions of lymphatic system Peripheral nervous system: Classification of peripheral nervous system: Structure and functions of sympathetic and parasympathetic nervous system. Origin and functions of spinal and cranial nerves.

Module V:Cardiovascular system (8 Lecture Hours)

Heart – anatomy of heart, blood circulation, blood vessels, structure and functions of artery, vein and capillaries, elements of conduction system of heart and heart beat, its regulation by Autonomic nervous system, cardiac output, cardiac cycle. Regulation of blood pressure, pulse, electrocardiogram and disorders of heart

Module VI:Health education (9 Lecture Hours)

Concepts of health and disease. Disease causing agents and prevention of disease.Nutrition: Balanced diet, deficiency disorders of various nutrients, their prevention and treatment. Communicable diseases: The causative agents, modes of transmission and prevention of chicken pox, measles, diphtheria, tuberculosis, malaria, poliomyelitis, filariasis, rabies, tetanus, STD and AIDS. Vaccination schedule. First Aid: Emergency treatment of shock, snakebite, burns, poisoning, fractures and resuscitation methods. Family planning: Different measures of family planning in male and female

Total Hours: 45

Text Books

1. Gray's Anatomy: The Anatomical Basis of Clinical Practice, 41th Ed (2015)
2. Guyton A.C. Hall J.E. Text book of Medical Physiology. (2016)
3. Best and Tailor's "Physiological basis of Medical Practice". (1979)

Reference Books

1. Human Physiology by C.C. Chatterjee. (2019)
2. Samson Wright's Applied Physiology by Cyril A. Keek, Eric Neil and Norman Joels. (2008)
3. Textbook of Preventive and Social Medicine by J.E. Park and K. Park.(2015)

20BT3070	VACCINE TECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

1. To impart knowledge on the role vaccination in improving the immune system.
2. To gain an understanding of recent developments in vaccine technology.
3. To make aware about the commercialization and regulatory guidelines in vaccine production

Course Outcome:

The students will be able to

1. Describe the role of immune cells and their mechanism and concept of vaccination.
2. Categorize the different types of vaccines available for diseases.
3. Understand the modern strategies and routes of immunization.
4. Apply the concept of vaccine technology for development of vaccines.
5. Evaluate various delivery methods suitable for vaccines.
6. Relate the quality control and regulatory guidelines involved in vaccine production.

Module-I Basics of Immune system (6 Lecture Hours)

Overview of the immune system and basic aspects of immune response(s) to vaccines. Active and passive immunity. Humoral and cell mediated immunity. Antibody production mechanism and factors affecting it. Cytokines, Primary and secondary immune response. Monoclonal and polyclonal antibodies. Super-antigens, Induction of cell mediated immunity.

Module-II Introduction to vaccination (6 Lecture Hours)

Vaccination: Introduction, history and principles of vaccine development. Conventional and modern strategies for vaccine improvement. Immunization strategies: Active and Passive. Epidemiology and pathophysiology of vaccine preventable diseases with special emphasis on Diphtheria, Tetanus, Hepatitis, Human papillomavirus.

Module-III Classification of Vaccines and its production (9 Lecture Hours)

Types of vaccines: Live, attenuated, subunit, killed vaccines, Recombinant peptide vaccines, recombinant live vector vaccines, conjugate vaccines, toxoid vaccines, Naked DNA vaccines, cell-based vaccines, edible vaccines. Reverse vaccinology. Adjuvants: history, classification, mechanisms. Factors affecting adjuvants selection and production.

Module-IV Delivery of vaccines (7 Lecture Hours)

Controlled delivery system for vaccines: emulsions, microparticles, immune-stimulating complexes (ISCOMs, liposomes), Virosomes. Application of Nanoparticles in vaccine delivery, Induction of immune responses by nanoparticle-based vaccine. Role of polymeric nanoparticles in vaccine delivery. Transdermal vaccine delivery system.

Module-V Vaccine Design and Development (9 Lecture Hours)

Fundamental research to rational vaccine design. Antigen identification and delivery, T-Cell expression cloning for identification of vaccine targets for intracellular pathogens, Fundamentals of Immune recognition, implications for manipulating the T-Cell repertoire, Targeting Dendritic cells; a rational approach for Vaccine development, Cellular basis of T- Cell memory, Rational design of new vectors, CpG adjuvant activity, Transcutaneous immunization.

Module-VI Commercial production and regulatory guidelines (8 Lecture Hours)

Quality control and regulations in vaccine research, In-vitro experimental validations for predictions of vaccines by software, Animal testing, Rational design to clinical trials, Large scale production, Commercialization, ethics. Overview of national and international regulatory requirements/ guidance for production of vaccines, quality control and implementation of good clinical practices. Overview of currently approved methods and alternative methods under development. Storage and handling, assessment of vaccine safety. **Total Hours: 45**

Reference books

1. New Generation Vaccines. Fourth Edition, Myrone M. Levine , Myron M. Levine, Gordon Dougan , Michael F. Good , Margaret A. Liu , Gary J. Nabel , James P. Nataro, RinoRappuoli., 2016
2. Vaccines, 6th Edition, Stanley Plotkin Walter Orenstein Paul Offit, 2012

Text books

1. Vaccine Development and Manufacturing. Emily P. Wen Ronald Ellis Narahari S. Pujar, Wiley online, 2014
2. Vaccines & Vaccine Technologies. Jose Ronnie Vasconcelos, OMICS International, 2015
3. Kuby, RA Goldsby, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition, Freeman, 2002.