B. Tech (Biotechnology) - 2022 Batch

PROGRAMME STRUCTURE

S. No.	Category	Credits
1	Humanities and Social Sciences including Management courses	9
2	Entrepreneurship	10
3	Basic Science Courses	16
4	Engineering Science courses including workshop, drawing, basics of electrical/mechanical/computer etc.	15
5	Professional Core Courses	68
6	Project work, seminar and internship in industry or appropriate work place/ academic and research institutions in India/abroad	#15/9
7	Professional Elective courses relevant to chosen specialization/branch	18/24
8	Open subjects – Electives from other technical and /or emerging Courses	9
9	Online Courses	5*
10	Mandatory Courses [Environmental Studies, Induction Program, Indian Constitution, Value Education, etc.]	(non-credit)
	Total	**160+5***

#Project- Full Semester-12 credits or Half Semester-6 credits + Internship - 3

**The students shall earn 5 credits through online courses between 2nd and 7th semester (both inclusive)*

CURRICULUM COMPONENTS

Category 1: Humanities, Social Sciences and Management Courses

No.	Course Code	Course Title	Credit
1	20MS2005	Soft Skills	1
2		Technical Communication / Other Languages • A Stream - Foreign Languages • B Stream - Online Course • C Stream - Classroom teaching including lab	2
3	20BT2057	Bioethics, IPR and Biosafety	3:0:0:3
4	22BT2070	Total Quality Management and Process Economics	3:0:0:3
		Total	**9**

Category 2: Entrepreneurship

No.	Course Code	Course Title	Credit
1	20MS2003	Concepts of Entrepreneurship	1
2	20MS2004	Entrepreneurship and Product Development	3
3	20MS2007	Business Plan	3
4	19CS2012	Artificial Intelligence for Biotechnology	3:0:0:3
		Total	**10**

Category 3: Basic Sciences

No.	Course Code	Course Title	Credit
1.	22MA1001	Basic Mathematics and Numerical Computing using Python	2:0:2:3
2.	20MA2009	Probability, Statistics using R Programming	2:0:2:3
3.	20PH1017	Applied Physics for Biotechnology Engineering	2:0:2:3
4.	20BT2001	Chemistry of Biomolecules	3:0:0:3
5.	20BT2002	Chemistry of Biomolecules Laboratory	0:0:2:1
6.	22BT2071	Good Manufacturing and Laboratory Practices	3:0:0:3
			16

Category 4: Engineering Sciences

No.	Course Code	Course Title	Credit
1	20BT1001	Engineering Design and Drawing Lab	0:0:2:1
2	20BT2004	Workshop Practices in Biotechnology	0:0:2:1
3	20EE1003	Sensors and Measurement Techniques in Biotechnology	2:0:2:3
4	20CS1003	Fundamentals of Programming for Problem Solving	3:0:2:4
5	20BT2005	Basics of Industrial Biotechnology	3:0:0:3
6	20BT2015	Bioprocess Principles	3:0:0:3
		Total credits	**15**

Category 5: Professional Core

No.	Course Code	Course Title	Credit
1.	20BT1002	Basics of Python Programming	2:0:2:3
2.	20BT2003	Cell Biology	3:0:0:3
3.	20BT2007	Bio-analytical Techniques	3:0:0:3
4.	20BT2008	Bio-analytical Techniques Lab	0:0:3:1.5
5.	20BT2009	Biochemistry	3:0:0:3
6.	20BT2010	Biochemistry Lab	0:0:3:1.5
7.	20BT2011	Microbiology	3:0:0:3

8.	20BT2012	Microbiology Lab	0:0:3:1.5
9.	22BT2075	Bioprocess Lab	0:0:3:1.5
10.	20BT2017	Molecular Biology	3:0:0:3
11.	20BT2018	Genetic Engineering	3:0:0:3
12.	20BT2019	Molecular Biology and Genetic Engineering Lab	0:0:3:1.5
13.	22BT2074	Bioprocess Engineering	3:0:0:3
14.	20BT2023	Downstream Processing	3:0:0:3
15.	20BT2024	Downstream Processing Lab	0:0:3:1.5
16.	20BT2025	Immunology	3:0:0:3
17.	20BT2026	Cell Biology and Immunology Lab	0:0:3:1.5
18.	20BT2030	Concepts of Bioinformatics	2:0:2:3
19.	20BT2052	Plant and Animal Tissue Culture Lab	0:0:4:2
20.	20BT2054	Environmental Biotechnology	3:0:0:3
21.	20BT2059	IoT in Biotechnology	2:1:0:3
22.	20BT2068	Principles of Plant Biotechnology and Applications	3:0:0:3
23.	20BT2069	Advances in Animal Biotechnology	3:0:0:3
24.	22BT2072	Metabolic Engineering	3:0:0:3
25.	22BT2073	Cheminformatics and Medicinal Chemistry	3:0:0:3
26.	22BT2076	Data analysis and simulations	2:1:0:3
27.	22BT2097	Comprehensive practices	0:0:3:1.5
		Total Credits	**68**

Category 6: Professional Electives

No.	Courses	Credit
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**

Category 7: Open Electives

No.	Courses	Credit
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: Online Courses

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

Category 9: Internships, Projects, Patent and Products

No.	Courses	Credit
1	Industry Internships/ Mini project	3
2	Projects, Patent and Products	12
	Total	**15**

Category 10: Mandatory Courses

No.	Courses	Credit
1	Constitution of India	0
2	Environmental Studies	0
3	Induction Program	0

Industry Internships/Mini project

1	Sem II – VI	**3**

Professional Electives

1.	22BT2077	Big Data Analytics	2.1.0:3
2.	22BT2078	Biosimilars Technology	3.0.0:3
3.	22BT2079	Waste Management and Upcycling	3.0.0:3
4.	22BT2080	Gene Expression and Transgenics	3.0.0:3
5.	22BT2081	Rational Drug Discovery	2.1.0:3
6.	22BT2082	Precision Medicine and Wellness	3.0.0:3
7.	22BT2083	Nano Biotechnology	3.0.0:3
8.	22BT2084	Structural Biology	3:0:0:3
9.	22BT2085	Synthetic and Systems Biology	2:1:0:3

10.	22EC2028	Fundamentals of bio imaging	3:0:0:3
11.	20BT2043	Stem Cell Technology	3:0:0:3
12.	20BT2058	Tissue Engineering	3:0:0:3
Open Electives			
1.	22BT1095	Biomaterials	3. 0.0:3
2.	22BT1096	Bioterrorism and National Security	3.0.0:3

SEMESTERWISE CURRICULUM

Semester-1

S.No	Course Code	Course Title	Hours/Week			Credits [L:T:P:C]
			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	20EE1003	Sensors and Measurement Techniques in Biotechnology	2	0	2	3
4	20BT2001	Chemistry of Biomolecules	3	0	0	3
5	20BT2002	Chemistry of Biomolecules Laboratory	0	0	2	1
6		Mandatory Course- I				0
7		Technical Communication English/French/German/Spanish	2	0	0	2
Total						**15**

Semester-2

S.No	Course Code	Course Title	Hours/Week			Credits [L:T:P:C]
			L	T	P	
1	20MS2003	Concepts of Entrepneurship	1	0	0	1
3	20MA2009	Probability, Statistics using R programming	2	1	0	3
4	20CS1003	Fundamentals of Programming for Problem Solving	3	0	2	4
5	20BT2005	Basics of Industrial Biotechnology	3	0	0	3
6	20BT1001	Engineering Design and Drawing Lab	0	0	2	1
7	20BT2004	Workshop Practices in Biotechnology	0	0	2	1
8	20BT1002	Basics of Python Programming	2	0	2	3
9		Mandatory Course - II				0
Total						**16**

Semester-3

S.No	Course Code	Course Title	Hours/Week			Credits [L:T:P:C]
			L	T	P	
1.	20BT2015	Bioprocess Principles	3	0	0	3
2.	20BT2009	Biochemistry	3	0	0	3
3.	20BT2011	Microbiology	3	0	0	3
4.	22BT2071	Good Manufacturing and Laboratory Practices	3	0	0	3
5.	20BT2012	Microbiology Lab	0	0	3	1.5
6.	20BT2010	Biochemistry Lab	0	0	3	1.5

7.	20MS2004	Entrepreneurship and Product Development	3	0	0	3
8.		Open Elective I				3
Total						**21**

Semester-4

S.No	**Course Code**	**Course Title**	**Hours/Week**			**Credits**
			L	**T**	**P**	**[L:T:P:C]**
1	20MS2005	Soft Skills	3	0	0	1
2	20BT2003	Cell biology	3	0	0	3
3	20BT2007	Bio-analytical Techniques	3	0	0	3
4	22BT2072	Metabolic Engineering	3	0	0	3
5	22BT2074	Bioprocess Engineering	3	0	0	3
6	19CS2012	Artificial Intelligence for Biotechnology	3	0	0	3
7	20BT2008	Bio-analytical Techniques Lab	0	0	3	1.5
8	22BT2075	Bioprocess Lab	0	0	3	1.5
		Professional Elective – 1	3	0	0	3
Total						**22**

Semester-5

S.No	**Course Code**	**Course Title**	**Hours/Week**			**Credits**
			L	**T**	**P**	**[L:T:P:C]**
1	20BT2017	Molecular Biology	3	0	0	3
2	22BT2073	Cheminformatics and Medicinal Chemistry	2	1	0	3
3	20BT2068	Principles of Plant Biotechnology and Applications	3	0	0	3

4	20BT2025	Immunology	3	0	0	3
5		Professional Elective-2	3	0	0	3
6		Professional Elective-3	3	0	0	3
7	22BT2097	Comprehensive practices	0	0	3	1.5
8	20BT2026	Cell Biology and Immunology Lab	0	0	3	1.5
9	20BT2059	IoT in Biotechnology	2	1	0	3
Total						**23**

Semester-6

S.No	**Course Code**	**Course Title**	**Hours/Week**			**Credits [L:T:P:C]**
			L	**T**	**P**	
1	20BT2018	Genetic Engineering	3	0	0	3
2	20BT2057	Bioethics, IPR and Biosafety	3	0	0	3
3	22BT2076	Data analysis and simulations	2	1	0	3
4	20BT2069	Advances in Animal Biotechnology	3	0	0	3
5		Professional Elective-4	3	0	0	3
6		Open Elective-2	3	0	0	3
7		Open Elective-3	3	0	0	3
8	20BT2019	Molecular biology and Genetic Engineering Lab	0	0	3	1.5
9	20BT2052	Plant and Animal Tissue Culture Lab	0	0	4	2
Total						**24.5**

Semester-7

S.No	**Course Code**	**Course Title**	**Hours/Week**			**Credits [L:T:P:C]**
			L	**T**	**P**	
1	20BT2023	Downstream processing	3	0	0	3

2	22BT2070	Total Quality Management and Process Economics	3	0	0	3
3		Professional Elective-5	3	0	0	3
4		Professional Elective-6	3	0	0	3
5	20BT2054	Environmental Biotechnology	3	0	0	3
6	20BT2030	Concepts of Bioinformatics	2	0	2	3
7	20BT2024	Downstream processing Lab	0	0	3	1.5
9	20MS2007	Business Plan	3	0	0	3
Total						**22.5**

Semester-8

S.No	**Course Code**	**Course Title**	**Hours/Week**			**Credits [L:T:P:C]**
			L	**T**	**P**	
1	20BT2999	Full Semester Project	0	0	12	12
Total			**0**	**0**	**12**	**12**

List of Courses for Specialization (Hons)

S.N	Code	**1**. Courses for **Drug Engineering (Hons)**	L	T	P	C
1	22BT2086	Molecular Pharmaceutics	3	0	0	3
2	22BT2087	Computer Aided Drug Design	3	0	0	3
3	22BT2088	Drug Formulation Development Lab	0	0	3	2
		2. Courses for **Precision Health Technology** (Hons)				
1	22BT2092	Pharmacogenomics	3	0	0	3
2	22BT2093	Precision Medicine	3	0	0	3
3	22BT2094	Precision Medicine Lab	0	0	3	2
		3. Courses for **Genetic Engineering and**				

		Technology (Hons)				
1	22BT2089	Genome engineering in Livestock and Agriculture	3	0	0	3
2	22BT2090	Genome Editing for Therapy	3	0	0	3
3	22BT2091	Genetic Manipulation Lab	0	0	3	2

M.Tech. Biotechnology

PROGRAMME STRUCTURE

S. No.	Category	Credits
1	Professional Core courses	22
2	Professional Elective courses	15
3	Open Courses – Electives from other Technical and /or Emerging Courses	3
4	Industrial Training / Mini Project	2
5	Project – Phase I & II	26
6	Audit Courses 1 & 2	(non-credit)
7	Online Courses	2*
	Total Credits	**68+2***

**The students shall earn 2 credits through online courses between 1st and 3rd semester (both inclusive)*

COURSE COMPONENTS

Table 1

PROFESSIONAL CORE COURSES

S. No.	Course Code	Course Title	Hours per Week			Credits
			L	T	P	
1	18MA3005	Foundations of Mathematics and Statistics	3	0	0	3
2	20BT3001	Advances in Biopolymer and Applications	3	0	0	3
3	20BT3002	Genetic Engineering and Recombinant Products	3	0	0	3
4	20BT3003	Bioprocess Modelling and Simulation	3	0	0	3
5	20BT3004	Lab – I Biochemical Analysis Lab	0	0	4	2
6	20BT3005	Lab – II Animal and Plant Tissue Culture Lab	0	0	4	2

7	20BT3006	Lab – III Advanced Process Equipment Design and Drawing Lab	0	0	4	2
8	20BT3007	Lab – IV Genetic Engineering Lab	0	0	4	2
9	18MS3104	Research Methodology and IPR	2	0	0	2
		Total				**22**
10	ITP3901/ MP3951	Industrial Training/ Mini Project	0	0	4	2
11	20BT3998	Project – Phase I	0	0	20	10
12	20BT3999	Project – Phase II	0	0	32	16
		Grand Total				**50**

Table 2

PROFESSIONAL ELECTIVE COURSES

S. No.	**Course Code**	**Course Title**	**Hours per Week**			**Credits**
			L	**T**	**P**	
Elective – I						
1	20BT3008	Enzyme Technology and Industrial Applications	3	0	0	3
2	20BT3009	Microbial Biotechnology	3	0	0	3
3	20BT3010	Agriculture and Food Biotechnology	3	0	0	3
4	20BT3011	Big Data Analytics	3	0	0	3
5	20BT3012	Bioethics and Biosafety	3	0	0	3
Elective – II						
1	20BT3013	Chemical Process Technology	3	0	0	3
2	20BT3014	Immunotechnology	3	0	0	3

3	20BT3015	Computational Biology	3	0	0	3
4	20BT3016	Metabolic Regulation and Engineering	3	0	0	3
5	20BT3017	Clinical trials and Bioethics	3	0	0	3
Elective – III						
1	20BT3018	Sustainable Bioprocess Development	3	0	0	3
2	20BT3019	Advanced Animal Biotechnology and Tissue Culture	3	0	0	3
3	20BT3020	Molecular Diagnostics	3	0	0	3
4	20BT3021	Drug Design and Discovery	3	0	0	3
5	20BT3022	Introductory AI in Biotechnology	3	0	0	3
Elective – IV						
1	20BT3023	Transport Phenomena	3	0	0	3
2	20BT3024	Pharmaceutical Biotechnology	3	0	0	3
3	20BT3025	Bioreactor Engineering	3	0	0	3
4	20BT3026	Stem Cell Therapeutics	3	0	0	3
5	20BT3027	Nanobiotechnology	3	0	0	3
Elective – V						
1	20BT3028	Advanced Plant Biotechnology	3	0	0	3
2	20BT3029	Cancer Management Techniques	3	0	0	3
3	20BT3030	Genomics and Proteomics	3	0	0	3
4	20BT3031	Advanced Environmental Biotechnology	3	0	0	3
5	20BT3032	Entrepreneurship and Management	3	0	0	3

Table 3

OPEN ELECTIVE COURSES

S. No.	Course Code	Course Title	Hours per Week			Credits
			L	T	P	
1	20BT3033	Industrial Waste Management	3	0	0	3
2	20BT3034	Industrial Safety	3	0	0	3

Table 4

AUDIT COURSE (MANDATORY COURSES) – 2 COURSE

S. No.	Course Code	Course Title	Hours per Week			Credits
			L	T	P	
1	18VE3001	Value Education	0	0	2	0
2	18EN3001	English for Research Paper Writing	2	0	0	0
3	18MS3105	Constitution of India	2	0	0	0
4	18CE3083	Disaster Management	2	0	0	0

Table 5 **Online Course (2 credits)**
The students shall earn 2 credits through online courses between 1st and 3rd semester (both inclusive)

SEMESTER WISE CURRICULUM

SEMESTER I

S. No.	Course Code	Course Title	Hours/Week			Credits
			L	T	P	
1	18MA3005	Foundations of Mathematics and Statistics	3	0	0	3

2	20BT3001	Advances in Biopolymer and Applications	3	0	0	3
3		Elective I	3	0	0	3
4		Elective II	3	0	0	3
5	20BT3004	Lab - I Biochemical Analysis Lab	0	0	4	2
6	20BT3005	Lab – II Animal and Plant Tissue Culture Lab	0	0	4	2
7	18MS3104	Research Methodology and IPR	2	0	0	2
8		Audit course 1	2	0	0	0
		Total	**16**	**0**	**8**	**18**

SEMESTER II

S. No.	**Course Code**	**Course Title**	**Hours/Week**			**Credits**
			L	T	P	
1	20BT3002	Genetic Engineering and Recombinant Products	3	0	0	3
2	20BT3003	Bioprocess Modelling and Simulation	3	0	0	3
3		Elective III	3	0	0	3
4		Elective IV	3	0	0	3
5	20BT3006	Lab - III Advanced Process Equipment Design and Drawing Lab	0	0	4	2
6	20BT3007	Lab – IV Genetic Engineering Lab	0	0	4	2
7	ITP3901/ MP3951	Industrial Training/ Mini Project	0	0	4	2
8		Audit course 2	2	0	0	0
		Total	**14**	**0**	**12**	**18**

SEMESTER III

S. No.	Course Code	Course Title	Hours/Week			Credits
			L	T	P	
1		Elective V	3	0	0	3
2		Open Elective	3	0	0	3
3	20BT3998	Project – Phase I	-	-	20	10
		Total	**06**	**0**	**20**	**16**

SEMESTER IV

S. No.	Course Code	Course Title	Hours/Week			Credits
			L	T	P	
1	20BT3999	Project – Phase II	-	-	32	16
		Total	**-**	**-**	**32**	**16**

M.Sc. Biotechnology

PROGRAMME STRUCTURE

S. No.	Category	Credits
1	Professional Core courses	35
2	Professional Elective courses	33
3	Online courses	2*
4	Industrial Training / Mini Project	4
5	Project	16
6	Audit courses	(non-credit)
	Total Credits	**90**

**The students will earn 2 credits through online courses between 1st and 3rd Semester (both inclusive)*

COURSE COMPONENTS

Table 1

PROFESSIONAL CORE COURSES

S. No.	Course Code	Course Title	Hours per Week			Credits
			L	T	P	
1	20BT3051	Biochemistry	3	0	0	3
2	20BT3052	Plant secondary metabolites and pharmaceutics	3	0	0	3
3	20BT3053	Molecular Biology and Cell Signaling	3	0	0	3
4	20BT3054	Microbiology and Molecular genetics	3	0	0	3
5	20BT3055	Animal Biotechnology and immunology	3	0	0	3

6	20BT3056	Research Methodology and Applied Statistics	2	0	0	2
7	20BT3057	Bioprocess and Downstream processing	3	0	0	3
8	20BT3058	Molecular Medicine and Diagnostics	3	0	0	3
9	20BT3004	Lab - I Biochemical Analysis Lab	0	0	4	2
10	20BT3005	Lab – II Animal and Plant Tissue Culture Lab	0	0	4	2
11	20BT3059	Lab- III Microbial Technology Lab	0	0	4	2
12	20BT3007	Lab-IV Genetic Engineering Lab	0	0	4	2
13	20BT3060	Lab- V Bioprocess and Downstream processing Lab	0	0	4	2
14	20BT3061	Lab-VI Immunological Techniques Lab	0	0	4	2
		Total				**35**
15	ITP3902	Industrial Training	0	0	4	2
16	MP3951	Mini Project	0	0	4	2
17	20BT3999	Project	0	0	32	16
		Grand Total				**55**

Table 2

PROFESSIONAL ELECTIVE COURSES

S. No.	Course Code	Course Title	Hours per Week			Credits
			L	T	P	
1	20BT3062	Industrial Biotechnology	3	0	0	3
2	20BT3063	Pharmaceutical Technology and clinical trial	2	0	2	3
3	20BT3064	Bioinformatics and Basics of R programming	2	0	2	3
4	20BT3065	NGS Data Analysis	3	0	0	3
5	20BT3022	Introductory AI in Biotechnology	3	0	0	3

6	20BT3030	Genomics and proteomics	3	0	0	3
7	20BT3032	Entrepreneurship and Management	3	0	0	3
8	20BT3066	Algae Biotechnology	2	0	2	3
9	20BT3067	Tissue Engineering and Stem Cell Technology	3	0	0	3
10	20BT3010	Agricultural and Food Biotechnology	3	0	0	3
11	20BT3027	Nanobiotechnology	3	0	0	3
12	20BT3031	Advanced Environmental Biotechnology	3	0	0	3
13	20BT3012	Bioethics and Biosafety	3	0	0	3
14	20BT3068	Metabolic Engineering for Industrial Production	3	0	0	3
15	20BT3069	Human anatomy, physiology and health education	3	0	0	3
16	20BT3070	Vaccine Technology	3	0	0	3

Table 3

AUDIT COURSE (MANDATORY COURSES)

S. No.	Course Code	Course Title	Hours per Week			Credits
			L	T	P	
1	18VE3001	Value Education	0	0	2	0

Table 4

Online Course (2 credits)
**The students will earn 2 credits through online courses between 1st and 3rd Semester (both inclusive)*

SEMESTER WISE CURRICULUM

SEMESTER I

S. No.	Course Type/ Code	Course Title	Hours/Week			Credits
			L	T	P	
1	20BT3051	Biochemistry	3	0	0	3
2	20BT3052	Plant secondary metabolites and pharmaceutics	3	0	0	3
3	20BT3053	Molecular Biology and Cell Signaling	3	0	0	3
4	20BT3054	Microbiology and Molecular genetics	3	0	0	3
5	20BT3055	Animal Biotechnology and immunology	3	0	0	3
6	20BT3056	Research Methodology and Applied Statistics	2	0	0	2
7	20BT3004	Lab - I Biochemical Analysis Lab	0	0	4	2
8	20BT3005	Lab – II Animal and Plant Tissue Culture Lab	0	0	4	2
9	20BT3059	Lab- III Microbial Technology Lab	0	0	4	2
		Total	**19**	**0**	**12**	**23**

SEMESTER II

S. No.	Course Type/ Code	Course Title	Hours/Week			Credits
			L	T	P	
1	20BT3057	Bioprocess and Downstream processing	3	0	0	3
2		Elective –I	3	0	0	3
3		Elective –II	2	0	2	3
4		Elective –III	2	0	2	3
5		Elective –IV	3	0	0	3
6		Elective –V	3	0	0	3

7	20BT3007	Lab – IV Genetic Engineering Lab	0	0	4	2
8		Audit course	2	0	0	0
9	ITP3902	Industrial Training	0	0	4	2
		Total	**18**	**0**	**8**	**22**

SEMESTER III

S. No.	**Course type/code**	**Course Title**	**Hours/Week**			**Credits**
			L	T	P	
1	20BT3058	Molecular Medicine and Diagnostics	3	0	0	3
2		Elective –VI	3	0	0	3
3		Elective –VII	3	0	0	3
4		Elective –VIII	3	0	0	3
5		Elective –IX	3	0	0	3
6		Elective –X	3	0	0	3
7		Elective –XI	3	0	0	3
8	20BT3060	Lab V-Bioprocess and Downstream processing Lab	0	0	4	2
9	20BT3061	Lab VI-Immunological Techniques Lab	0	0	4	2
10	MP3951	Mini Project	0	0	4	2
		Total	**18**	**0**	**18**	**27**

SEMESTER IV

S. No.	**Course code**	**Course Title**	**Hours/Week**			**Credits**
			L	T	P	
1	20BT3999	Project	-	-	32	16
		Total	**-**	**-**	**32**	**16**

List of new Courses

S No	Subject Code	Courses	Credit
1	22BT2070	Total Quality Management and Process Economics	3.0.0:3
2	22BT2071	Good Manufacturing and Laboratory Practice	3.0.0:3
3	22BT2072	Metabolic Engineering	3:0:0:3
4	22BT2073	Cheminformatics and Medicinal Chemistry	2:1:0:3
5	22BT2074	Bioprocess Engineering	3:0:0:3
6	22BT2075	Bioprocess Lab	0.0.3.:1.5
7	22BT2076	Data analysis and Simulations	3:0:0:3
8	22BT2077	Big Data Analytics	2.1.0:3
9	22BT2078	Biosimilars Technology	3.0.0:3
10	22BT2079	Waste Management and Upcycling	3.0.0:3
11	22BT2080	Gene Expression and Transgenics	3.0.0:3
12	22BT2081	Rational Drug Discovery	2.1.0:3
13	22BT2082	Precision Medicine and Wellness	3.0.0:3
14	22BT2083	Nano Biotechnology	3.0.0:3
15	22BT2084	Structural Biology	3:0:0:3
16	22BT2085	Synthetic and Systems Biology	2:1:0:3
17	22BT2086	Molecular Pharmaceutics	3:0:0:3
18	22BT2087	Computer Aided Drug Design	3:0:0:3
19	22BT2088	Drug Formulation Development Lab	0:0:3:2
20	22BT2089	Genome engineering in Livestock and Agriculture	3:0:0:3
21	22BT2090	Genome Editing for Therapy	3:0:0:3

22	22BT2091	Genetic Manipulation Lab	0:0:3:2
23	22BT2092	Pharmacogenomics	3:0:0:3
24	22BT2093	Precision Medicine	3:0:0:3
25	22BT2094	Precision Medicine Lab	0:0:3:2
26	22BT1095	Biomaterials in Biotechnology	3.0.0:3
27	22BT1096	Bioterrorism and National Security	3.0.0:3

22BT2070	TOTAL QUALITY MANAGEMENT AND PROCESS ECONOMICS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To make students understand the importance of Quality management and the role of Human resources management in ensuring Quality.
2. To familiarize the students with the statistical tools used in Quality management, Market structure and Failure.
3. To gain insights into Quality Management systems and Process Equipment Economics.

Course Outcome:

At the end of the course the students will be able to

1. Understand the quality management in manufacturing and servicing organization
2. Understand the Framework of TQM
3. Appraise the implementation process for TQM
4. Evaluate Process control tools for better Quality management and Control Charts
5. Analyze Process equipment economics and Market structure.
6. Enumerate cost entities in estimation and costing of Bioreactors.

Module I: Introduction (7 hrs)

Differences between manufacturing and service organizations – cost of quality – evolution of TQM – concepts of TQM Philosophy – Seven tools of quality control

Module II: TQM Concepts (7 hrs)

Gurus of TQM, TQM framework, Defining Quality, Benefits of TQM- Leadership: Definitions, Characteristics of Quality Leaders, The Deming Philosophy, Quality council- Customer satisfaction: Customer perception of Quality, Translating needs into requirements

Module III: Continuous Process Improvement (7 hrs)

Juran Trilogy, PDSA Cycle, Kaizen – Supplier Partnership: Principles of Supplier relationship, Supplier selection, Supplier certification, Supplier rating- Performance measures, Quality costs- Benchmarking: Definition and process

Module IV: Quality Management Systems and Statistical Process Control (8 hrs)

ISO, Benefits of ISO - Implementation, Documentation, Internal Audits, Registration – Environmental Management System: Concept of Quality Function Deployment – The QFD. Pareto diagram, Process flow diagram, Cause and Effect diagram, Check Sheets, Histograms, Control charts for Attributes, Control charts for Variables, Process capability- Taguchi's Loss Function, Malcom Balridge Award, Deming Prize

Module V: Market Structure and Failure (8 hrs)

Market Structure: Perfect Competition – Characteristics – Price and output determination in short run and long run – Monopoly – Price Discrimination –Monopolistic Competition – Product Differentiation – Oligopoly and Duopoly. Market Failure: Causes – Type of Goods – Rivalrous and Non-rivalrous goods – Excludable and Non-excludable goods – Solutions – Government Intervention.

Module VI: Process Economics (8 hrs)

Types of Bioreactors - Introduction to cost diagrams, application of cost diagrams, Introduction to Project Economics, Process Selection and Site Survey, Project Cost estimation, Time Value of Money, Interest and Depreciation, Project Finance & Profitability Analysis.

Text Books

1. Besterfield,D.H(2004), Total Quality Management (3 rd edn.), Pearson education: New Delhi
2. Subburaj Ramasamy (2011), Total Quality Management, Tata McGraw Hill, New Delhi.
3. Joshi, M.V, "Process Equipment Design", MacMillan, 3rd edition, 2004.
4. Premvir Kapoor, "Sociology & Economics for Engineers", Khanna Publishing House, 2018.

Reference Books

1. Charantimath, 2010. Total Quality Management. Pearson,
2. Paul A Samuelson & William, "Economics", 2012. Tata McGraw Hill, New Delhi, 2012.
3. Principles, Practice and Economics of Plant and Process Design. 2007. Gavin Towler and Ray Sinnott. Elsevier.

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

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:

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).

		L	T	P	C
22BT2073	CHEMINFORMATICS AND MEDICINAL CHEMISTRY	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:

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

		L	T	P	C
22BT2074	BIOPROCESS ENGINEERING	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.

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.

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:

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.
1.

		L	T	P	C
22BT2077	BIG DATA ANALYTICS	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 know how or 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 & 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. Categories 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.

		L	T	P	C
22BT2080	GENE EXPRESSION AND TRANSGENICS	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 2	T 1	P 0	C 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:

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 3	T 0	P 0	C 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:

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:

2. The Art of Molecular Dynamics Simulation by D. C. Rapaport Cambridge University Press; 2nd edition 2004.
3. 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.

		L	T	P	C
22BT2085	SYNTHETIC AND SYSTEMS BIOLOGY	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)

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.

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:

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:

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)

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. (8)

Moldule II An overview of modern drug discovery process:

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. (7)

Moldule III Quantitative Structure Activity Relationships:

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. (8)

Moldule VI Molecular Modeling and Docking

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)
(8)

Moldule V Molecular Properties and Drug Design

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.
(7)

Moldule VI Pharmacophore Mapping and Virtual Screening

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. (7)

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:

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.

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

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)

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)

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)

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)

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 (7)

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.

		L	T	P	C
22BT2090	GENOME EDITING FOR THERAPY	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)
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)
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)
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)
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)
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)
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

22BT2092	PHARMACOGENOMICS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To providing basic understanding of discipline of pharmacogenomics.

2. Understanding of the genetic basis of variability in drug response can contribute to drug efficacy and toxicity, adverse drug reactions and drug-drug interaction. As such, pharmacists need a thorough understanding of the genetic component of patient variability to deliver effective individualized pharmaceutical care.
3. To get better knowledge and manage the new genomics based diagnostic tools as they become available as well as make best treatment choices.

Course Outcomes:

The students will be able to

1. Explain the basic principles of human genetics and heredity as they apply to inter-individual variation in treatment response
2. Apply the principles of molecular and cellular biology to explain the genetic basis of variability in drug response.
3. Outline how genetic variability in genes encoding drug metabolizing enzymes, drug transporting proteins, and drug receptors (targets) can contribute to variability in drug disposition and action, leading to changes in pharmacokinetics, pharmacodynamics, and clinical outcome
4. Understand the impact of Pharmacogenomics in different therapeutic areas. Discuss case studies reporting the clinical consequences of pharmacogenomics on therapeutic efficacy or toxicity.
5. Recognize the societal and ethical implications of clinical trials and the resultant individualization of drug therapy.
6. Summarize the current methods and technology on clinical trials and drug discovery.

Module 1: Pharmacogenomics (8 Hours)

Introduction, Concepts of genetic diseases. Personalized medicine- introduction and importance. The genetics of therapeutic targets and gene-based targets. Pharmacogenomics necessity in drug designing.

Module 2: Polymorphisms (8 Hours)

Introduction, types and importance in Drug targets. Prediction of structural changes among sequences by the influence of polymorphisms.

Module 3: Pharmacogenomics dose response **(8 Hours)**

Drug response to patients, Structural influence in the Drug response. Efficacy and metabolism of drugs. Pharmacogenomics vs. Structural Pharmacogenomics. Drug metabolism pathways and adverse drug reactions.

Module 4: Pharmacogenomics tools (7 Hours)

Tools for pharmacogenomic analysis. Pharmacokinetics (PK), Pharmacodynamics (PD). Process in Structural Pharmacogenomics - Target Structure optimization, Validation, lead identification, ADME prediction, synthesis, assays and Clinical trials.

Module 5: Clinical Applications of Pharmacogenomics in precision medicine

(7 Hours)

Contributions of pharmacogenomics to variability in drug metabolism, use of pharmacogenomics to identify patients at risk for adverse drug reactions, and clinical use of pharmacogenomic data in drug therapy for multiple therapeutic areas, including cardiovascular, oncology, pain management, neurologic, psychiatric, transplantation, and infectious diseases

Module 6: Regulatory Process (7 Hours)

Implementation of clinical trial protocol, source documents, data entry, Developing Standard Operating Procedures (SOP), Person to Person differences in drug metabolism-importance for drug therapy, Overview of Investigational drug services and role of research pharmacist. Role of FDA and IND application process

Total Hours: 45

Text Books

1. Mount, D. W. (2004). Bioinformatics: Sequence and Genome Analysis. Thailand: Cold Spring Harbor Laboratory Press.
2. Baxevanis, A.D., Francis Ouellellette, B.F. (1998). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. (1998). Germany: Wiley.

Reference Books

1. Rapley, R., Harbron, S (2004), "Molecular analysis and Genome discovery"; John Willey & Sons, Ltd.
2. Machin, D., Fayers, P. M. (2010). Randomized Clinical Trials: Design, Practice and Reporting. Germany: Wiley.
3. Friedman, L. M., Granger, C. B., Furberg, C. D., Reboussin, D. M., DeMets, D. L. (2015) Fundamentals of Clinical Trials. Germany: Springer International Publishing.
4. Piantadosi, S. (2005). Clinical trials : a methodologic perspective. Germany: Wiley.

22BT2093	PRECISION MEDICINE	L 3	T 0	P 0	C 3

Course Objectives

1. To explore the possibilities, promises, and pitfalls of precision medicine, using real-world examples.
2. To bridge the gap between basic and translational research and its practical clinical applications, which will help prepare any student interested in research or health professions careers.
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

Upon successful completion of this course, 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 of genetic change leading to health implications.
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: Introduction to precision medicine (7 Lecture Hours)
Overview on Precision Medicine, the Human Genome, and Human Genomic Variation. Pharmacogenome: Whole Genome Sequencing (WGS). Epigenome: DNA Methylation, Histone Modifications and Chromatin Remodeling Factors. Transcriptome. Proteome. Metabolome. Microbiome.

Module 2: Medical Molecular genetics (7 Lecture Hours)
Human genetics/genomics, including pedigree analysis, non-Mendelian genetics, cytogenetics, polymorphism analysis, physical mapping and the human genome, mutation analysis and pathogenesis, genomic imprinting, viral and non-viral gene therapy.

Module 3: Applications of precision medicine (7 Lecture Hours)
Applications of precision medicine in diagnosis and treatment considerations of concepts in monogenic diseases and complex diseases. Important concepts include susceptibility genomics, diagnostic approaches, laboratory testing, and treatment considerations for genomic medicine. Diseases include cystic fibrosis, monogenic diabetes, Marfan syndrome, Huntington's disease, as well as cardiovascular, metabolic, neurologic, mental health disorders and addiction, and others.

Module 4: Clinical applications of precision medicine: Precision oncology (7 Lecture Hours)
Cancer marker analysis; Approaches and technologies in diagnosing or treating cancer, including the genetics of cancer, targeted cancer treatments, somatic testing, current and future research and clinical trends, and other information on precision oncology

Module 5: Clinical Trials (7 Lecture Hours)
Basics of Clinical Trials: Need for clinical trials, History of Clinical Trials, Glossary in clinical Trials- Clinical Research, Healthy Volunteer, Inclusion/Exclusion Criteria, Informed Consent, Patient Volunteer, Phases of Clinical Trials, Placebo, Protocol, Principal Investigator, Randomization, Single- or Double-Blind, Studies, Types. Clinical Trials: Developing Evidence for PM & Designing PM Clinical Trials; Implementation Science & Costs of PM; Educating the Public and Providers

Module 6: AI for precision medicine (7 Lecture Hours)
Practicing precision medicine with intelligently integrative clinical and multi-omics data analysis, Human gene and disease associations for clinical-genomics and precision medicine, Robotic surgery, Use robot to monitor effectiveness of treatment.

Text Books

1. Genomic and Precision Medicine, 3rd Edition, Geoffrey Ginsburg and Huntington Willard, 2016

Reference Books

2. The Language of Life: DNA and the Revolution in Personalized Medicine, Francis S. Collins, 2010

22BT2094	PRECISION MEDICINE LAB	L	T	P	C

		0	0	3	2

Course objective

1. To identify genomic regulatory features of tobacco and menthol metabolizing genes and to assess their mutations, copy number variations, and gene expression in lung cancer patients
2. To identify and validate population-specific SNPs in tobacco and menthol metabolizing genes
3. To adapt the methods used in molecular detection of diseases and therapeutic index.

Course outcomes

Students will be able to

1. Utilize modern human genomic and transcriptomic methods to analyze health and disease data in dry and wet lab settings.
2. Understand the role of genetic and genomic variation throughout the genome in health and disease.
3. Demonstrate the disease risk prediction
4. Analyze the methods of molecular diagnosis
5. Understand the methods of evaluation of disease progression and therapy
6. Evaluate primary and secondary precision medicine research

List Experiments

1. DRY LAB: World Tour of the Human Genome I: Exploring the Human Genome and ENCODE with the UCSC Genome Browser
2. DRY LAB: World Tour of the Human Genome II: Exploring Human Genomic Variation and 1000 Genomes Project (1KG) WGS Data with the Ensembl Genome Browser
3. DRY LAB: World Tour of the Human Genome III: Exploring WES Data with the Exome Aggregation Consortium (ExAC) Browser and NHLBI Exome Sequencing Project Exome Variant Server (EVS)
4. DRY LAB: Mining the The Cancer Genome Atlas (TCGA) with cBioPortal, Broad GDAC Firehose, and Firebrowse
5. DRY LAB: CURE Clinic I - Data Summary and Hypothesis Refinement (5)
6. DRY LAB: qRT-PCR primer design (5)
7. WET LAB (control reaction): RNA isolation, DNase-treatment, and RNA quantification
8. WET LAB (control reaction): cDNA synthesis
9. WET LAB (control reaction): Semi-quantitative Reverse Transcription PCR (RT-PCR)
10. WET LAB (control reaction): RT-PCR product analysis
11. WET LAB (control reaction): quantitative Reverse Transcription PCR (qRT-PCR)
12. WET LAB (experimental + control reaction): qRT-PCR analysis / Polymorphism analysis of DNA using PCR

Reference Books

1. Genomic and Precision Medicine, 3rd Edition, Geoffrey Ginsburg and Huntington Willard, 2016

20BT2095	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,

20BT2096	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

20BT2097	**Comprehensive practices**	**L**	**T**	**P**	**C**
		0	**0**	**3**	**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.

List of Revised Courses for 2022 Batch (2020 Version 1.1)

Program: B.Tech. Biotechnology

S.No	Code	Names of Courses	L	T	P	C
1	20BT2048	Molecular Forensics	3	0	0	3

Program: M.Sc. Biotechnology

S.No	Code	Names of Courses	L	T	P	C
1	20BT3052	Plant Secondary Metabolites And Pharmaceutics	3	0	0	3
2	20BT3054	Microbiology And Molecular Genetics	3	0	0	3
3	20BT3055	Animal Biotechnology And Immunology	3	0	0	3

Syllabi (Version 1.1)

20BT2048	MOLECULAR FORENSICS	L 3	T 0	P 0	C 3

Course Objectives:

1. Provide knowledge in the field of forensic science and crime scene investigations.
2. To ensure students gain knowledge about the recovery of human remains.
3. Impart technical skills to know the procedures involved in the identification of the criminals usingmolecular tools

Course Outcomes:

1. Explain the steps involved in forensic investigation
2. Identify the methods involved in the collection of biological samples for molecular analysis
3. Interpret the results of molecular techniques for the identification of the criminals and the victims
4. Appraise the knowledge in paleo biology and anthropology and its importance in Forensics
5. Design experiments in molecular techniques and implementation in forensic science
6. Analyze forensic case studies

Module 1: Introduction to Forensic Science (9)

Introduction to crime laboratories, Responsibilities of the forensic scientist, Securing and Searching the Crime Scene, Recording and collection of crime scene evidence, Document examination, Ethics and Integrity

Module 2: Discovery and Recovery Of Human Remains (9)

History of Forensic Genetics, Biological sample collections, The Autopsy and handling of a Dead Body, The Stages and factors of decomposition, Determining the Age and Provenance of Remains, Asphyxia, Gunshot Wounds, Bite Marks

Module 3: Pattern Analysis (8)

Biological Evidence Overview, Body Fluids - Peripheral blood, Saliva, Semen, Urine, and Sweat, Blood, Markers for Evidence, Study of Hair, Study of Fibre. Detecting the Presence of Blood, Bloodstain Pattern Analysis.

Module 4: Methods of Identification (9)

Forensic anthropology, Paleontology, Drug Identification and Toxicology, Methods used in forensic for human identification: Autosomal STR Profiling, Analysis of Y chromosome, Analysis of Mitochondrial DNA.

Module 5: Sequencing Methods in Forensics (5)

Rules and Principles of Identification under Criminal Justice System, Autosomal single-nucleotide polymorphisms (SNP) typing, Biomarkers in forensic identification, Polymorphic Enzymes, DNA Finger Printing- RFLP. PCR directed Y chromosome sequences, PCR Amelogenein Gene, Next generation Sequencing

Module 6: Forensic Case Studies (5)

Case studies of Royal Romanov Family, Ice Man, King Tut (Tuttenkhamun), The Hitler Diaries, Criminal investigations revolutionized by DNA. Study of Kinship by DNA Profiling, Paternity disputes, Illegal hunting case identification using Molecular markers; detection of narcotics in body fluids.

Text Books:

1. Lincoln PJ & Thomson J, "Forensic DNA Profiling Protocols", Humana Press. 2011.
2. Sandy B. Primrose, Richard Twyman "Principles of Gene Manipulation and Genomics" BackwellScientific Publications 2010

References Books:

1. Rudin N & Inman K. "An Introduction to Forensic DNA Analysis", 2nd Ed. CRC Press. 2002.
2. Brown T.A, Gene Cloning and DNA Analysis, 6th Edition, Blackwell Publishing Ltd

2010

20BT3052	PLANT SECONDARY METABOLITES AND PHARMACEUTICS	L	T	P	C
		3	0	0	3

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 Lecture 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 Lecture 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 Lecture 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 Lecture 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 Lecture 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 Lecture 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

		L	T	P	C
20BT3054	**MICROBIOLOGY AND MOLECULAR GENETICS**	3	0	0	3

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 Lecture 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 Lecture 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 (9Lecture 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 Lecture 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 Lecture 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 Lecture 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
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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