DEPARTMENT OF BIOTECHNOLOGY

DELHI TECHNOLOGICAL UNIVERSITY: DELHI
Established under Govt. of Delhi Act 6 of 2009
Shahbad Daulatpur, Bawana Road, Delhi-110042

INTEGRATED M.SC (BIOTECHNOLOGY) SYLLABUS

FIRST YEAR (Semester 1)

					Contact hours/Week			**Exam Duration**		**Relative Weightage**				
S.No	**Subject Code**	**Course title**	**Course Type**	**Credit**	**L**	**T**	**P**	**Th**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1.	IMSBT101	Introduction to Biotechnology	DCC1	4	3	1	0	3	0	25	-	25	50	-
2.	IMSBT103	Microbiology	DCC2	4	3	0	2	3	2	15	25	20	40	-
3.	IMSBT105	Biochemistry	DCC3	4	3	0	2	3	2	15	25	20	40	-
4.			GEC1	4	4/3/3	0/1/0	0/0/2							
5.	IAEC 1yy		AEC1	2	2	0	0	**2**	**0**	**50**	**-**	**-**	**50**	**-**
6.	ISEC 1 yy		SEC 1	2	2/1/0	0/1/0	0/0/4							
7.	IVAC 1yy		VAC 1	2	2/1/0	0	0/2/4	**2/2/0**	**0/0/3**	**25/15/0**	**0/25/50**	**25/20/0**	**50/40/0**	**0/0/50**
		Total		22										

Discipline Specific core course (DCC), Generic electives (GEC), Ability Enhancement (AEC), Skill enhancement (SEC) and Value Addition course (VAC) ,Discipline Specific laboratory may be included in DCC (4 Cr) with LTP :0/0/8 **MINOR PROGRAM: TRANSLATIONAL HEALTH SCIENCES.**

FIRST YEAR (Semester 2)

	Teaching Scheme hours/Week			Contact				Exam Duration		Relative Weightage				
S.No	**Subject Code**	**Course title**	**Course Type**	**Credit**	**L**	**T**	**P**	**Th**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1.	IMSBT102	Molecular Biology	DCC 4	4	3	0	2			15	25	20	40	-
2.	IMSBT104	Genetics/Molecular Genetics	DCC 5	4	3	0	2			15	25	20	40	-
3.	IMSBT106	Cell Biology	DCC 6	4	3	1	0			25	-	25	50	-
4.			GEC2	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
5.	IAEC 1yy		AEC2	2	2	0	0	**2**	**0**	**50**	**-**	**-**	**50**	**-**
6.	ISEC 1 yy		SEC 2	2	2/1/0	0/1/0	0/0/4							
7.	IVAC 1yy		VAC 2	2	2/1/0	0	0/2/4	**2/2/0**	**0/0/3**	**25/15/0**	**0/25/50**	**25/20/0**	**50/40/0**	**0/0/50**
8.		Total		22										

Exit: after securing 44 credits awarded undergraduate certificate (NHEQF level-4.5) in the relevant discipline/subject. This certification is contingent upon achieving a minimum of 4 credits through work based vocational courses offered during the summer term or through internship/apprenticeship experiences, in addition to acquiring 4 credits from skill-based courses undertaken throughout the first and second semesters.

Second year (Semester 3)

Teaching scheme					Contact hours/Week			Exam Duration		Relative Weightage				
S.No	**Subject Code**	**Course title**	**Course Type**	**Credit**	**L**	**T**	**P**	**Th**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1.	IMSBT201	Basic Techniques in biological Sciences	DCC 7	4	3	0	2	**3**	**2**	15	25	20	40	-
2.	IMSBT 203	Introduction to computational Biology	DCC 8	4	3	0	2	**3**	**2**	15	25	20	40	-
3.	IMSBT205	Human analogy and physiology	DCC 9	4	3	1	0	**3**	**0**	25	-	25	50	-
4.			GEC3	2	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
5.	IMSXX2yy/code of GEC		DEC1/GEC4	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
6.	IAEC 2yy		AEC 3	2	0	0	**2**	**0**	**50**	**-**	**-**	**50**	**-**	2
7.	ISEC 2yy		SEC 3	2	2/1/0	0/1/0	0/0/4							
8.		Total		22										

Discipline Specific core course (DCC), Generic electives (GEC),Ability Enhancement (AEC), Skill enhancement (SEC) and Value Addition course (VAC) ,Discipline Specific laboratory may be included in DCC (4 Cr)with LTP :0/0/8

Second year (Semester 4)

Teaching scheme					Contact hours/Week			Exam Duration		Relative Weightage				
S.No	**Subject Code**	**Course title**	**Course Type**	**Credit**	**L**	**T**	**P**	**Th**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1.	IMSBT202	Enzymology	DCC 10	4	3	1	0			25	-	25	50	-
2.	IMSBT204	Environmental Biotechnology	DCC 11	4	3	1	0							
3.	IMSBT 206	Introduction to Nanosciences	DCC 12	4	3	1	0			25	-	25	50	-
4.	IMSXX 2yy/Code of GEC		DEC2/GEC 5	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
5.	IAEC 2yy		AEC 4	2	2	0	0	**2**	**0**	**50**	**-**	**-**	**50**	**-**
6.	ISEC 2yy		SEC 4	2	2/1/0	0/1/0	0/0/4							
7.	IVAC 2yy		VAC 3	2	2/1/0	0	0/2/4	**2/2/0**	**0/0/3**	**25/15/0**	**0/25/50**	**25/20/0**	**50/40/0**	**0/0/50**
8.		Total		22										

Exit : after securing 88 credits awarded undergraduate certificate (NHEQF level-5.0) in the relevant discipline/subject. This certification is contingent upon achieving a minimum of 4 credits through work based vocational courses offered during the first year or second year summer.

Third Year (Semester 5)

		Teaching Scheme			Contact hours/Week			Exam Duration		Relative Weightage				
S.No	**Subject Code**	**Course title**	**Course Type**	**Credit**	**L**	**T**	**P**	**Th**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1.	IMSBT301	Bioprocess Engineering	DCC 13	4	3	0	2			15	25	20	40	-
2.	IMSBT303	Plant Biotechnology	DCC 14	4	3	0	2			15	25	20	40	-
3.	IMSBT 305	Animal Biotechnology	DCC 15	4	3	0	2			15	25	20	40	-
4.	IMSXX 3XX/code of GEC		DEC3/GEC6	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
5.	IMSXX 3XX/code of GEC		DEC4/GEC7	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
6.	IMSXX 307	Summer internship	DCC	2										
7.		Total		22										

Third year (semester 6)

Teaching Scheme			Contact hours/Week					Exam Duration		Relative Weightage				
S.No	**Subject Code**	**Course title**	**Course Type**	**Credit**	**L**	**T**	**P**	**Th**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1.	IMSBT302	Genomics and proteomics	DCC 16	4	3	1	0			25	-	25	50	-
2.	IMSBT304	Advanced Immunlogy	DCC 17	4	3	0	2			**15**	**25**	**20**	**40**	**-**
3.	IMSBT 306	Developmental Biotechnology	DCC 18	4	3	1	0			25	-	25	50	-
4.	IMSXX 3XX/code of GEC		DEC6/GEC8	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
5.	IMSXX 3XX/code of GEC		DEC7/GEC9	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
6.	**ISEC 3yy**		SEC 5	2	2/1/0	0/1/0	0/0/4							
7.		Total		22										

Exit : After completing three years-Bachelor of (_____)-132 (NHEQF level 5.5) students who want undertake 3 year UG programme will be awarded UG degree in the relevant Discipline/subject upon securing 132 credits.

Fourth Year (Semester 7)

	Teachnig Scheme				Contact hours/Week			Exam Duration		Relative Weightage				
S.No	**Subject Code**	**Course title**	**Course Type**	**Credit**	**L**	**T**	**P**	**Th**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1.	IMSBT401	Advances in Biotechnology	DCC 19	4	3	1	0			25	-	25	50	-
2.	IMSBT403	Bioresource and bioprospective Technology	DCC 20	4	3	1	0			25	-	25	50	-
3.	IMSBT 405	Intellectual property Rights	DCC 21	4	3	1	0			25	-	25	50	-
4.	IMSXX 4XX/code of GEC		DEC8/GEC 10	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
5.	IMSXX 407		DCC	6										
6.		Total		22										

S.No. 5: Dissertation1/Acedemic project 1/Entrepreneurship 1 like startups,business etc.The dissertation/Academic project/Entrepreneurship will start in VII semester and continued to VIII semester, however,their evaluation will be done in both semesters.

*Research methodology shall be offered in VI or VII semester under DEC category.

Fourth Year (Semester 8)

	Teachnig Scheme				Contact hours/Week			Exam Duration		Relative Weightage				
S.No	**Subject Code**	**Course title**	**Course Type**	**Credit**	**L**	**T**	**P**	**Th**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1.	**IMSBT 402**	Fermentation and Industrial Biotechnology	DCC 22	4	3	1	0			25	-	25	50	-
2.	**IMSBT 404**	Bioethics and biosafety	DCC 23	4	3	1	0			25	-	25	50	-
3.	**IMSXX 4XX**		DEC9/GEC11	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
4.	**IMSXX 4XX**		DEC10/GEC12	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
5.	**IMSXX 406**	Project	DCC	6										
6.		Total		22										

S.No.5: Dissertation1/Academic project 1/Entrepreneurship 1 like startups, business etc. The dissertation/Academic project/Entrepreneurship will start in VII semester and continued to VIII semester; however, their evaluation will be done in both semesters.

Exit: After completing four years Bachelor of (----------)(Honors) with research /Academic projects/Entrepreneurship-176 Cr (NHEQF level 6.0)will be awarded UG degree (Honors) with research in the relevant discipline/subject upon -176 Credits.

Fifth Year (Semester 9)

		Teaching Scheme			Contact hours/Week			Exam Duration		Relative Weightage				
S.No	**Subject Code**	**Course title**	**Course Type**	**Credit**	**L**	**T**	**P**	**Th**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1.	**IMSBT 501**	Plant metabolic Engineering	DCC 24	4	3	1	0			**25**	**-**	**25**	**50**	**-**
2.	**IMSBT 503**	Genetic Engineering	DCC 25	4	3	0	2			**15**	**15**	**30**	**40**	**-**
3.	**IMSXX 5XX**		DEC11/GEC13	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
4.	**IMSXX 505**	Lab	DCC26	2	0	0	4							
5.	**IMSXX 507**	Project	DCC	6										
6.		Total		20										

The dissertation /Academic project will start in IX semester and continued to X semester , however their evaluation will be done in both semesters**.**

Fifth Year (Semester 10)

	Teachnig Scheme				Contact hours/Week			Exam Duration		Relative Weightage				
S.No	**Subject Code**	**Course title**	**Course Type**	**Credit**	**L**	**T**	**P**	**Th**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1.	**IMSBT 502**	Drug Design and delivery	DCC 27	4	3	1	0	**3**	**0**	25	-	25	50	-
2.	**IMSBT 504**	Concepts in public health	DCC 28	4	3	1	0	**3**	**0**	25	-	25	50	-
3.	**IMSXX 5XX/code of GEC**		DEC12/GEC14	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
4.	**IMSXX 506**	Biotechnology Entrepreneurship	DCC 29	2										
5.	**IMSXX 508**	Project	DCC	6										
6.		Total		20										

The dissertation /Academic project will start in IX semester and continued to X semester , however their evaluation will be done in both

Ability Enhancement courses (AEC)														
		Teachnig Scheme			Contact hours/Week			Exam Duration			Relative Weightage			
S.No	Subject Code	Course title	Course Type	Credit	L	T	P	Th	P	CWS	PRS	MTE	ETE	PRE
1.	IAEC ---yy	Applied biostatistics	AEC	2	2	0	0	2	0	50	-	-	50	-
2.	IAEC --yy	Research methodology	AEC	2	2	0	0	2	0	50	-	-	50	-
3.		Nutraceuticals	AEC	2	2	0	0	2	0	50	-	-	50	-

Skill enhancement course (SEC)														
		Teaching Scheme			Contact hours/Week			Exam Duration		Relative Weightage				
S.No	Subject Code	Course title	Course Type	Credit	L	T	P	Th	P	CWS	PRS	MTE	ETE	PRE
1.	ISEC --yy	Aquaculture	SEC	2	2	0	0	2	0	50	-	-	50	-
2.	ISEC --yy	Diagnostic Techniques	SEC	2	0	0	4	0	4	-	50	-	-	50
3.	ISEC ---yy	Cell culture Techniques	SEC	2	0	0	4	0	4	-	50	-	-	50
4.	ISEC ---yy	Machine learning in bioinformatics	SEC	2	0	0	4	0	4	-	50	-	-	50
5.	ISEC ---yy	Bioinstrumentation	SEC	2	0	0	4	0	4	-	50	-	-	50

Value Addition course (VAC)														
		Teachnig Scheme			Contact hours/Week			Exam Duration		Relative Weightage				
S.No	Subject Code	Course title	Course Type	Credit	L	T	P	Th	P	CWS	PRS	MTE	ETE	PRE
	IVAC --yy	Ethics in science	VAC	2	2/1/0	0	0/2/4	2/2/0	0/0/3	25/15/0	0/25/50	25/20/0	50/40/0	0/0/50
	IVAC --yy	Biotechnology for society	VAC	2	2/1/0	0	0/2/4	2/2/0	0/0/3	25/15/0	0/25/50	25/20/0	50/40/0	0/0/50
	IVAC --yy	Science of well being	VAC	2	2/1/0	0	0/2/4	2/2/0	0/0/3	25/15/0	0/25/50	25/20/0	50/40/0	0/0/50
	IVAC --yy	Human Nutrition	VAC	2	2/1/0	0	0/2/4	2/2/0	0/0/3	25/15/0	0/25/50	25/20/0	50/40/0	0/0/50

	IVAC --- yy	Introduction to biological sciences	**VAC**	2	2/1/0	0	0/2/4	**2/2/0**	**0/0/3**	**25/15/0**	**0/25/50**	**25/20/0**	**50/40/0**	**0/0/50**

DEPARTMENT ELECTIVE COURSE (DEC)														
		Teachnig Scheme			**Contact hours/Week**			**Exam Duration**			**Relative Weightage**			
S.No	**Subject Code**	**Course title**	**Course Type**	**Credit**	**L**	**T**	**P**	**Th**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
	IMSBT-	Transgenic Technology	DEC	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
	IMSBT-	Population Genetics	DEC	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
	IMSBT-	Stem Cells and Regenerative Medicine	DEC	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
	IMSBT-	Metabolic Engineering	DEC	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
	IMSBT-	Ecology and Evolution	DEC	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
	IMSBT-	Bioenergy and Biofuels	DEC	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
	IMSBT-	Genomics in Medicine	DEC	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
	IMSBT-	Protein Engineering	DEC	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
	IMSBT-	Medical Microbiology	DEC	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
	IMSBT-	Bioinformatics approaches in Complex disorders	DEC	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
	IMSBT-	Concepts in Neurobiology	DEC	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
	IMSBT-	Plant Bioinformatics	DEC	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
	IMSBT-	Pharmacogenomics and Personalized Medicine	DEC	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
	IMSBT-	Agriculture Microbiology	DEC	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
	IMSBT-	System Biology	DEC	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
	IMSBT-	Crop protection and Pest management	DEC	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
	IMSBT-	Molecular Therapeutics	DEC	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
	IMSBT-	Structual Biology and Biophysics	DEC	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
	IMSBT-	Gene Therapy	DEC	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
	IMSBT-	Database management in	DEC	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**

		Biotechnology												

Generic electives course (GEC)														
	Teachnig Scheme			Contact hours/Week				Exam Duration		Relative Weightage				
S.No	Subject Code	Course title	Course Type	Credit	L	T	P	Th	P	CWS	PRS	MTE	ETE	PRE
1.		Current topics in Biotechnology	GEC	4	3	1	0	3	0	25	-	25	50	-
2.		Biopolymers	GEC	4	3	1	0	3	0	25	-	25	50	-
3.		Cancer Biology	GEC	4	3	1	0	3	0	25	-	25	50	-
4.		Biomaterials	GEC	4	3	1	0	3	0	25	-	25	50	-
5.		Pharmaceutical Sciences	GEC	4	3	1	0	3	0	25	-	25	50	-
6.		Basic Epidemiology	GEC	4	3	1	0	3	0	25	-	25	50	-
7.		Principle of imaging processing in medicine	GEC	4	3	1	0	3	0	25	-	25	50	-
8.		Rehabilitation Engineering	GEC	4	3	1	0	3	0	25	-	25	50	-
9.		Green Energy Technology	GEC	4	3	1	0	3	0	25	-	25	50	-
10.		Basics of computer applications	GEC	4	3	1	0	3	0	25	-	25	50	-
11.		Food nutrition and hygiene	GEC	4	3	1	0	3	0	25	-	25	50	-
12.		Principles of Toxicology	GEC	4	3	1	0	3	0	25	-	25	50	-
13.		Computer aided drug design (from M.Tech BI)	GEC	4	3	1	0	3	0	25	-	25	50	-
14.		Food Biotechnology	GEC	4	3	1	0	3	0	25	-	25	50	-
15.		Introduction to Biomedical Engineering	GEC	4	3	1	0	3	0	25	-	25	50	-
16.	IMSBT-	Biosensor	GEC	4	3	1	0	3	0	25	-	25	50	-
17.	IMSBT-	Healthcare and Diagnostics	GEC	4	3	1	0	3	0	25	-	25	50	-

18.	IMSBT-	Waste water treatment	DEC	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**
19.	IMSBT-	Algal Biotechology	DEC	4	3	1	0	**3**	**0**	**25**	**-**	**25**	**50**	**-**

DEPARTMENT OF BIOTECHNOLOGY

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Shahbad Daulatpur, Bawana Road, Delhi-110042

Integrated M.Sc syllabus

(DEPARTMENT CORE COURSES)

FIRST YEAR (Semester 1)

Introduction to Biotechnology (IMSBT101)

Details of course:-

Course Title	**Course Structure**			**Pre-Requisite**
	L	T	P	
Introduction to Biotechnology (IMSBT101)	3	1	0	Nil

Course Objective: Biotechnology encompasses several disciplines. This course provides foundational concepts in a broad spectrum of disciplines, such as Cell Biology, Biochemistry, Microbiology, Fermentation, Molecular Biology, Genetic Engineering, and Instrumentation

Course Outcomes:	
1.	To gain insight into the potential applications of Biotechnology for human welfare
2.	To understand cellular architecture and comprehend the functioning of various biomolecules and enzymes
3.	To compare and contrast various microorganisms and their role in fermentation processes
4.	To explain the underlying mechanism of gene expression and to appraise the genetic engineering of organisms for human welfare
5.	To explain and translate separation, purification, and identification techniques for biomolecules in research

S. No.	**Content**	**Contact Hours**

Unit 1	**Biotechnology in Human Welfare:** Introduction; Applications of Biotechnology	**8**
Unit 2	**Basics of Cell Biology and Biochemistry:** Types and structure of cells; Cell organelles; Prokaryotes and Eukaryotes; Structure and function of biomolecules, Enzymes	**9**
Unit 3	**Basics of Microbiology and Fermentation:** Types and characteristics of microbes; Basics of fermentation and downstream processing	**9**
Unit 4	**Basics of Molecular Biology and Genetic Engineering:** Structure of DNA and RNA; Genes; DNA as hereditary material; Basics of gene expression; Genetic code; Concept of recombinant DNA technology	**10**
Unit 5	**Basic Instrumentation in Biotechnology:** Chromatography; Electrophoresis; Centrifugation; Microscopy	**9**
	Total	**45**

Books :

S.No.	Name of Book/Author/Publisher
1.	Concepts in Biotechnology by CFA Bryce, D Balasubramanian. Publisher: Universities Press
2.	Cell and Molecular Biology by M Jacob. Publisher: CBS
3.	Lehninger's Principle of Biochemistry by DL Nelson, MM Cox. Publisher: WH Freeman
4.	Microbiology by MJ Pelczar, ECS Chan, NR Krieg Publisher: Tata McGraw Hill
5.	Molecular Biology of the Gene by JD Watson et al. Publisher: Pearson
6.	Genetic Engineering by S Rastogi, N Pathak. Publisher: OUP
7.	Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology by A Hoffman, S Clokie. Publisher: CUP

Microbiology (IMSBT-103)

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Microbiology (IMSBT-103)	3	0	2	Nil

Course Objective: To impart basic knowledge of all classes of micro-organisms namely, bacteria, viruses, algae, fungi and protozoa and also methods of sterilization and culturing of microbes. The course also aims to give a broad overview of the applications of microbiology in our present world.

Course Outcomes:

1	Elucidating the discovery of the microbial world and illustrating the methods of culture and sterilization
2	Demonstrate the Prokaryotic Structure and Function
3	Summarize Microbial Nutrition and Growth.
4	Understand the Microbial Taxonomy and nomenclature
5	Compare and contrast Host–Pathogen interactions.

S. No.	**Content**	**Contact Hours**
Unit 1	Unit 1: **Introduction and Methods in Microbiology:** Discovery of the microbial world, principles of microbial nutrition, Culture media, Theory and practice of sterilization, Bacterial Inactivation Kinetics, pure culture techniques.	9
Unit 2	Unit 2: **Prokaryotic Structure and Function:** functional anatomy of bacteria: cell envelope, cell wall, cytoplasmic membrane, capsule, surface appendages, cytoplasm and cytoplasmic inclusions.	9
Unit 3	Unit 3: **Microbial Nutrition and Growth:** The definition of growth, mathematical expression of growth, growth yields, continuous culture, growth as affected by environmental factors	9
Unit 4	Unit 4: **Microbial Taxonomy:** New approaches to bacterial taxonomy, classification including ribotyping, ribosomal RNA sequencing, taxonomy, nomenclature and Bergey's manual.	9
Unit 5	Unit 5: **Host-parasite Relationship and Microbial Pathogenesis:** Normal microflora of skin, oral cavity, gastrointestinal tract; entry of pathogens into the host, types of toxins (exo-, endo-, entero-) and their structure, mode of actions, and pathogenesis.	9
	Total	45

Books :

S.No.	**Name of Book/Author/Publisher**
1.	Microbiology by M.J. Pelczar, E.C.S. Chan and N.R. Kreig. Publisher: Tata McGraw Hill (2005)
2.	Microbiology by Bernard D. Davis, Renato Dulbecco, Herman N.Eisen and Harold S. Ginsberg. Publisher: Lippincott Williams & Wilkins (1990)
3.	Brock Biology of Microorganisms by M.T. Madigan, J.M. Martinko and J. Parker. Publisher: Prentice-Hall, Inc (1997)
4.	General microbiology by R.Y. Stanier, J.L. Ingraham, M.L. Wheelis and P.R. Painter. Publisher: Macmillan (1987)

List of Experiments

1. To study different techniques of sterilization.
2. Preparation of LB solid & liquid media for growth of various microorganisms.
3. To perform different streaking & spreading techniques of microbial culture.
4. Isolation & screening of microbes by serial dilution, plating and CFU calculations.
5. To perform gram staining of diff microorganisms.

Biochemistry (IMSBT-105)

Details of course:-

Course Title	**Course Structure**			**Pre-Requisite**
	L	T	P	
Biochemistry (IMSBT-105)	3	0	2	Nil

Course Objective: To impart basic knowledge of biochemistry and biochemical principles for cell metabolism and bioenergetics.

Course Outcomes:	
1	Analyse the chemistry of biomolecules.
2	Compare and contrast different types of biomolecules
3	Understand the concept of Metabolism and Bioenergetics.
4	Analyse the Carbohydrate Metabolism and its regulation.
5	To gain knowledge about the Lipid and Cholesterol metabolism.

S. No.	**Content**	**Contact Hours**
Unit 1	**Chemical Foundations of Biology:** Properties of water; acids, bases and buffers, covalent bonds, Noncovalent interactions in biological systems	9
Unit 2	**Introduction to Biomolecules:** Carbohydrates, Lipids, Proteins, Nucleic acids-classification, structure and function.	9
Unit 3	**Metabolism and Bioenergetics:** First and second law, free energy and chemical equilibrium; Electron transport chain and oxidative photophosphorylation.	9

Unit 4	**Carbohydrate Metabolism:** Glycolysis pathway and reactions, Glycogen breakdown and synthesis, Citric acid cycle – Overview, Gluconeogenesis, Pentose Phosphate Pathway	9
Unit 5	**Lipid Metabolism:** Lipid digestion, absorption and transport, fatty acid oxidation, ketone bodies, fatty acid biosynthesis, regulation of fatty acid metabolism.	9
	Total	45

Books :

S.No	Name of Book/Author/Publisher
1.	Lehninger's Principle of Biochemistry by DL Nelson, MM Cox. Publisher: WH Freeman
2.	Biochemistry by D Voet, JG Voet. Publisher: Wiley
3.	Harper's Illustrated Biochemistry by VW Rodwell, D Bender, KM Botham, PJ Kennelly, PA Weil. Publisher: McGraw Hill
4.	Biochemistry by CK Mathews, KE Van Holde, KG Ahern. Publisher: Benjamin/Cummings

List of Experiments

1. Qualitative analysis of carbohydrates (Glucose, Lactose, Maltose, Sucrose and starch).
2. Identification tests for Proteins.
3. Quantitative analysis of reducing sugars (DNSA method) and Proteins (Biuret method).
4. Preparation of buffer solution and measurement of pH.
5. Study of enzymatic hydrolysis of starch.

FIRST YEAR (Semester 2)

Introduction to Computational Biology (IMSBT-203)

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Introduction to Computational Biology (IMSBT-203)	3	0	2	NIL

Course Objective:
The objective of the course is to introduce students to the current bioinformatics algorithm concepts and their implementation.

Course Outcome:	
S. No.	**Content**
1	To enlist biological databases such as NCBI, PubMed, Entrez, etc., and identify database types, sequence formats, sequence retrieval, and submission.
2	To define genomics and recognize the importance of the Human Genome Project.
3	To perform and apply programming techniques to analyze and manipulate bioinformatics data, including file handling, regular expression-based pattern matching, and utilization of various data structures.
4	To perform Pairwise Sequence Alignment and learn about scoring matrices and the various algorithms involved.
5	To perform Multiple Sequence Alignment and various algorithms involved.

S. No.	Content	Contact Hours
Unit 1	**Introduction to Biological Databases** Overview of Biological Databases and their types: Nucleic acid databases (NCBI: PubMed, Entrez, Blast, OMIM, Books, Taxonomy, Structure, Locuslink), Protein Databases (Primary, Functional,	9

	Composite, Secondary, Structural classification database), Sequence Formats & storage, Sequence submission to sequence Database.	
Unit 2	**Genomics** Structure of DNA, Polymorphisms in DNA Sequence, Human Genome Project, Complete Genome Sequences, Functional Annotation.	9
Unit 3	**Programming for Bioinformatics** Introduction to programming languages and environments relevant to bioinformatics, Functions, Data Types, Data Structures, Arithmetic and Logical operators, Conditionals and Loops, Lists and Arrays, Working with files, File Handling, Regular Expression and Pattern Matching.	9
Unit 4	**Pairwise Sequence Alignment** Techniques and algorithms for Local and Global alignment, Scoring matrices (PAM, BLOSUM), Gaps, Dot Plots, Dynamic programming Approach (Needleman and Wunsch Algorithm, Smith and Waterman Algorithm), Heuristic Approach (BLAST, FASTA).9	9
Unit 5	**Multiple Sequence Alignment** Methods and applications of global and local alignments, scoring matrices and gap penalties, internet resources for multiple sequence alignment, representation, and structural inference.	9
	Total	45

Laboratory Work (Practical):

1. Utilization of Genome Resources (NCBI, EMBL, DDBJ).
2. Exploration of Protein Databases (SwissProt, TrEMBL).
3. Bulk Data Retrieval and inter-conversion of different sequence file formats.
4. Functional Annotation using Gene Ontology.
5. Execution of Pairwise and Multiple sequence alignment using tools like Clustal.

Books :

S.No.	**Name of Book/Author/Publisher**
1.	Hasija, Y., "All About Bioinformatics: From Beginner to Expert", 2023.
2.	Hasija, Y., Chakraborty, R., "Hands on Data Science for Biologists Using Python", 2021.
3.	Tan, T. W., Lee, E. C., "Beginners Guide To Bioinformatics For High Throughput Sequencing", 2018.
4.	Hasija, Y. (Editor), "Translational Biotechnology: A Journey from Laboratory to Clinics", 2021.

5.	Shaik, N., "Essentials of Bioinformatics, Volume II: In silico Life Science: Medicine", 2019.

Genetics (ISMBT104)

Course Title	**Course Structure**			**Pre-Requisite**
Genetics (ISMBT104)	L	T	P	
	3	0	2	Nil

Course Objective: The course aims to provide a solid foundation in genetic principles and their applications in biotechnology, fostering critical thinking and problem-solving skills essential for genetic research and biotechnological innovation. Through theoretical understanding and practical training, students will develop the expertise to analyze genetic data, utilize modern genetic techniques, and contribute ethically to advancements in Biotechnology.

Course Outcome:	
1.	Understanding of the basic principles of genetics in Biotechnology
2.	Imparting knowledge about genetic techniques
3.	Analysis of genetic data obtained from experiments or databases
4.	Knowledge of ethical and social implications of genetics
5.	Learning of application of genetics in other disciplines

S. No.	**Content**	**Contact Hours**

Unit 1	**GENES, CHROMOSOMES & HERIDITY**: Introduction, DNA as genetic material; Cellular Reproduction; Mendelism, Basic Principles	9
Unit 2	**EXTENSION AND VARIATION OF MENDELISM**: Extension of Mendelism, Incomplete Dominance, Codominance, Multiple Alleles, Gene Interactions, Epistasis	9
Unit 3	**Chromosomal Basis of Inheritance:** Variation in chromosome number & structure; Linkage, Crossing Over and Chromosome Mapping; Genetics of Bacteria and viruses; Extra Nuclear Inheritance.	9
Unit 4	**GENE EXPRESSION & GENOMICS**: Molecular structure of DNA –Mutation, DNA repair & Recombination; Transposable elements; Regulation of gene expression	9
Unit 5	**Techniques of molecular genetics**: Cell division; Non disjunction; chromosomal abnormalities; Genetic recombination; Molecular cytogenetics, FISH, RFLP, AFLP, RAPD	9
	Total	45

Books :

S.No.	Name of Book/Author/Publisher
1.	Principles of Genetics by E.J. Gardner, M.J. Simmons and D.P. Snustad. Publisher: John Wiley and Sons Inc.
2.	Concepts of Genetics by W.S. Klug et al. Pearson Education Inc
3.	Strachan T and Read A P, Human molecular genetics, 3rd Edition Wiley Bios, 2006.

Practicals:

1. Study of microscopes.
2. Study of cell structure.
3. Mitosis and Meiosis cell division.
4. Experiments on monohybrid, dihybrid, trihybrid, test cross and back cross
5. To observe permanent slide of Gram positive bacteria
6. To observe permanent slide of Gram negative bacteria

Cell Biology (IMSBT106)

Details of course:-

Course Title	Course Structure			Pre-Requisite
Cell Biology (IMSBT106)	L	T	P	Knowledge of biomolecules
	3	1	0	

Course Objective: Knowledge of basic biology and biomolecules

Course Outcomes:	
1.	To understand the architecture of the basic structural and functional unit of living organism
2.	To learn the structure of locomotory organelles and cytoskeletal elements and their action in cell motility
3.	To explain the concept of cell cycle and cell division and the impact of excessive cell proliferation
4.	To comprehend cell signaling mechanisms
5.	To understand the basics of protein targeting within the cell or to the cell exterior

S. No.	Content	Contact Hours
Unit 1	**Cell structure:** Types of cells; Prokaryotic vs Eukaryotic cell; Animal vs plant cell; Cell organelles and cell surface appendages – basic structure and function; Extracellular matrix; Cell junctions	**10**
Unit 2	**Cell motility:** Locomotory organelles; Cytoskeletal elements	**8**
Unit 3	**Cell Division:** Phases of cell cycle; Mitosis and meiosis; Cancer	**9**
Unit 4	**Cell Signaling:** Basics of cell signaling; Signals; Receptors; Types of signaling	**9**
Unit 5	**Protein Targeting:** Basics of protein targeting; Signal sequence; Transport of secretory proteins; Passive, active, and facilitated diffusion of proteins across membranes	**9**
	Total	**45**

Books:

S.No.	Name of Book/Author/Publisher

1.	Cell and Molecular Biology by P Khanna. Publisher: IK Intl.
2.	Cell and Molecular Biology by M Jacob. Publisher: CBS
3.	Karp's Cell and Molecular Biology by G Karp, J Iwasa, W Marshall. Publisher: John Wiley and Sons, Inc.
4.	The Cell: A Molecular Approach by GM Cooper, RE Hausman. Publisher: Sinauer Associates Inc.
5.	Molecular Biology of the Cell by B Alberts, R Heald, A Johnson, D Morgan, M Raff, K Roberts, P Walter. Publisher: Garland Science
6.	Molecular Cell Biology by H Lodish, A Berk, CA Kaiser, M Krieger, A Bretscher. Publisher: WH Freeman

SECOND YEAR (SEMESTER 3)

Basic Techniques in Biological Sciences (IMSBT-201)

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Basic Techniques in Biological Sciences (IMSBT-201)	3	0	2	Nil

Course Objective: To impart broad knowledge of commonly used instruments and their working principles.

Course Outcomes:	
1.	Discuss viscosity diffusion, sedimentation equilibrium and sedimentation velocity methods
2.	List uses of electrophoretic techniques underlying electrophoresis systems
3.	Discuss chromatographic methods
4.	Explain spectroscopic and diffraction techniques
5.	Define optical techniques like microscopy

S. No.	Content	Contact Hours
Unit 1	**Hydrodynamic Techniques: Centrifugation:** Viscosity and diffusion, Analytical and Preparative centrifuges, application of density gradient and differential centrifugation; Cell disruption techniques	10
Unit 2	**Electrophoretic Techniques:** Paper and gel electrophoresis, Immuno electrophoresis, isoelectric focussing, two - dimensional electrophoresis, capillary electrophoresis.	7
Unit 3	**Chromatographic Methods:** Paper, TLC gas chromatography, gel filtration, ionexchange chromatography, affinity chromatography and HPLC.	8
Unit 4	**Spectroscopic and Diffraction Techniques:** UV and visible, spectrofluorimetry, Atomic absorption spectrophotometry, Mass Spectrometry, Infrared Spectroscopy	10
Unit 5	**Optical Techniques: Microscopy:** Optical and Electron Microscopy, Transmission and Scanning Electron Microscopy, Atomic Force Microscopy, Fluorescence microscopy. **Radioisotope Techniques:** Radio tracers, GM Counter, radioimmunoassay (RIA).	10
	Total	45

Books:

S.No.	Name of Book/Author/Publisher
1.	Principles and Techniques of Practical Biochemistry by Keith Wilson and John Walker, Fifth edition, Cambridge University Press
2.	Biophysical Chemistry: The conformation of Biological Macromolecules by C.R.Cantor and P.R. Schimmel. Publisher: W.H. Freeman
3.	Essentials of Biophysics by P. Narayanan. Publishers: New Age International Publishers
4.	Introduction to Spectroscopy by D.L. Pavia, G.M. Lampman and G. S. Kriz.and Vyvyan Publisher: Brooks Cole
5.	Principles of Physical Biochemistry by Kensal E. Van Holde, Curtis Johnson, K.E. Van Holde., W.Curtis Johnson and Pui Shing Ho. Publisher: Prentice Hall.
6.	Process Biotechnology Fundamentals by S N Mukhopadhyay. Publisher: Viva Books Pvt. Ltd., New Delhi.

Molecular Biology (IMSBT102)

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Molecular Biology (IMSBT102)	3	0	2	Knowledge of DNA and Proteins

Course Objective: To give a detailed perspective of gene expression and basic techniques used in molecular biology.

Course Outcomes:	
1.	To understand the structure of DNA, chromosome, and RNA
2.	To understand the reasons for DNA mutations and know the molecular mechanism of DNA damage repair
3.	To learn the basic mechanisms of biological processed involved in gene expression - replication, transcription and translation
4.	To gain insight into the strategies for gene silencing
5.	To appraise various genetic manipulation, DNA sequencing, DNA amplification, and individual characterization techniques

S. No.	Content	Contact Hours
Unit 1	**DNA and RNA structure:** Chemical composition of DNA; Bonds involved in DNA; Nucleosides vs Nucleotides; Watson Crick double helical structure of DNA; Structure of rRNA and tRNA; Structure of chromosome	**8**
Unit 2	**Genetic Code, Mutation and DNA Damage Repair:** Genetic code dictionary; Codons; Degeneracy of codons; Types of mutations; Mutagens; DNA damage repair processes	**9**
Unit 3	**Concept of Gene Expression:** Process of DNA replication, transcription, and translation; Concept of operon; Reverse transcription	**11**
Unit 4	**Gene Silencing:** Antisense RNA; RNAi, Ribozyme; DNA methylation	**8**
Unit 5	**Molecular Biology Techniques:** Basics of DNA cloning; Traditional methods of DNA sequencing; Basics of PCR; DNA fingerprinting	**9**
	Total	**45**

Books:

S.No.	Name of Book/Author/Publisher
1.	Molecular Biology of the Gene by JD Watson et al. Publisher: Pearson
2.	Biochemistry by D Voet, JG Voet. Publisher: Wiley
3.	Lewin's Gene XII by Kreb's et al. Publisher: Jones & Bartlett Learning

List of Experiments

1. Genomic DNA isolation
2. Agarose gel electrophoresis
3. Estimation of DNA content by diphenylamine method
4. Quantification of DNA by UV spectrophotometric analysis
5. Estimation of RNA content by orcinol method

Human Anatomy and Physiology (IMSBT-205)

Details of course:-

Course Title	Course Structure			Pre-Requisite
Human Anatomy and Physiology (IMSBT-205)	L	T	P	
	3	1	0	NIL

Course Objective: The objective is to provide a comprehensive understanding of the structure and function of the human body at various levels from cells to organ systems.

Course Outcome:	
1.	Understanding of Human Anatomy and Physiology: Grasp cellular structure, physiological systems, and their functions in the human body.
2.	Anatomy and Physiology Proficiency: Master major systems including cardiovascular, nervous, musculo-skeletal, respiratory, gastro-urinal, and integumentary systems.
3.	Physiological Concepts Application: Apply concepts to nervous control, respiratory and temperature regulation, optics of vision, and mechanisms of hearing.
4.	Anatomy-Physiology Integration: Integrate knowledge to understand interactions among systems maintaining homeostasis and overall health.
5.	Critical Analysis of Physiological Mechanisms: Analyze complex processes like vision, hearing, and temperature regulation, considering neurophysiological basis and clinical implications.

S. No.	**Content**	**Contact Hours**
Unit 1	Introduction: Structure and function of cell and cellular components; Membrane Potential; Overview of Immune system	12
Unit 2	Anatomy of physiological systems (I): Cardiovascular system; Nervous System; Nervous control of Heart	08
Unit 3	Anatomy of physiological systems (II): Musculo Skeletal System; Respiratory system; Regulation of Respiration; Artificial respiration	09
Unit 4	Overview of physiological systems: Gastro Urinal system, Urine Reflex; Skin and Sweat Gland – Temperature regulation	08
Unit 5	Physiological functions: Optics of Eye; Photochemistry of Vision; Accommodation Neurophysiology of Vision – EOG; Structure and functions Internal Ear - Mechanism of Hearing – Auditory pathway	08
	Total	45

Books :

S.No.	**Name of Book/Author/Publisher**
1.	Arthur.C.Guyton – Textbook of Medical Physiology – Prism Book (p) Ltd. 1996.
2.	CL.Ghai – A textbook of Practical Physiology – 5th Ed Jaypee Medical Publishers, 2003
3.	Sarada Subramanyam, K.MadhavanKutty and H.D.Singh – Text book of HumanPhysiology – S. Chand & Company, 1996

SECOND YEAR (SEMESTER 4)

Enzymology (IMSBT-202)

Course Title	Course Structure			Pre-Requisite
Enzymology (IMSBT-202)	L 3	T 1	P 0	

Course Objective: To integrate the practical aspects of enzymology with the kinetic theories and provide a mechanistic overview of enzyme activity.

Course Outcomes:	
1	Understand the concept of Enzyme, its application.
2	Illustrate the kinetics and mechanism of Enzyme
3	Compare and contrast the types of Enzyme Immobilization.
4	Identify the Enzyme Reactor for Batch/ continuous enzymatic processing.
5	Analyze the Bioprocess Design and Physical parameters.

S. No.	Content	Contact Hours
Unit 1	Enzyme: Introduction and scope, Nomenclature, Application of enzyme, Enzyme catalysis in organic media.	9
Unit 2	Enzyme Kinetics: Kinetics of enzymatic reaction, Single and multiple substrate systems, Inhibition - substrate, product and inhibitors, Mechanism of enzyme action.	9
Unit 3	Immobilization of Enzyme: Methods of immobilization External and diffusional mass transfer limitation, Effectiveness factor.	9
Unit 4	Enzyme Reactor: Reactors for Batch/ continuous enzymatic processing, choice of reactor type.	9
Unit 5	Bioprocess Design: Physical parameters, immobilized cells.	9
	Total	45

Books :

S.No.	Name of Book/Author/Publisher
1	Introduction to Biochemical Engineering by D.G. Rao, McGraw Hill education (2009)
2	Bioprocess Engineering Principles by P. Doran, Elsevier Science (2013)
3	Biochemistry by D Voet, JG Voet. Publisher: Wiley
4	Fundamentals of Enzymology by Price and Stevens, Enzymes by Robert A. Copeland

ENVIRONMENTAL BIOTECHNOLOGY (IMSBT-202)

Course Title	Course Structure			Pre-Requisite
Environmental Biotechnology (IMSBT-202)	L 3	T 0	P 2	Nil

Course Objective: To impart knowledge about the environment structure and its balance, Pollution and its measurement. The strategies to reduce the pollutant concentrations in the biosphere.

Course Outcomes:	
1	To understand the environmental pollution & its impact on the environment
2	To gain knowledge on different sources, impacts, and measurement parameters for air, and water pollution
3	To impart knowledge on sources of solid waste, vermiculture, composting and bioremediation
4	To understand the impact of acid rain, ozone depletion, and biotechnological approaches for management.

S. No.	Content	Contact Hours
Unit 1	**Environmental Pollution**: Types of pollution, methods for measurement of pollution, Methodology of Environmental Management	9
Unit 2	**Air pollution & its control**: Active trace gases in the air responsible for air pollution, measures and strategies to control air pollution	8

Unit 3	**Water pollution & its control**: Measurement of water pollution, sources of water pollution, Wastewater treatment - physical, chemical and biological treatment processes	10
Unit 4	**Solid Wastes**: Sources of solid waste management (composting, vermiculture, methane production), bioremediation of contaminated soils and waste land	8
Unit 5	**Global Environmental Problems:** Ozone depletion, greenhouse gases, acid rain, and their impact.	10
	Total	45

Laboratory Work (Practical):

1. Environmental Impact Assessment, measurement of Air and Noise Pollution.
2. To calculate the pH, conductivity and TDS of different water samples
3. To calculate the Dissolved oxygen, ammonia and ammonium in water samples.
4. To Measure the dissolved oxygen of different water samples
5. Measurement of BOD and COD.

Books :

S.No.	Name of Book/Author/Publisher
1	Wastewater Engineering - Treatment and Reuse by Metcalf, Eddy and G. Tchobanoglous. Publisher: Tata McGraw Hill
2	Process Biotechnology Fundamentals by S.N. Mukhopadhyay. Publisher: Viva Books
3	Microbiology by Bernard D. Davis, Renato Dulbecco, Herman N. Eisen and Harold S. Ginsberg. Publisher: Lippincott Williams & Wilkins.
4	Comprehensive Biotechnology by M. Moo- Young. Publisher: Pergarmon Press

INTRODUCTION TO NANOSCIENCE (IMSBT-206)

Course Title	Course Structure			Pre-Requisite
Introduction to Nanoscience's (IMSBT-206)	**L**	**T**	**P**	
	3	**1**	**0**	**Nil**

Course Objective: The objective of this course is to impart interdisciplinary education in nanoscience and nanobiotechnology. The aim of this advanced course is to provide understanding for various nanobiotechnological application.

Course Outcomes:

1.	Understand the basics concepts of nanosciences and its applications.
2.	Illustrate the synthesis process and mechanism of nanomaterials.
3.	Applications of different types of nanomaterials and its compositions.
4.	To gain knowledge about sensing technology.
5.	Understanding the toxicological effects of nanomaterials and its management.

S. No.	**Content**	**Contact Hours**
Unit 1	**Introduction:** Introduction to nanotechnology and overview of nanoscale materials, Introduction to bionanotechnology, biological and medical applications of bionanomaterials.	8
Unit 2	**Synthesis of nanomaterials**, Top-down and Bottom approaches, **Miniaturized devices in nanobiotechnology** - types and applications, MEMS, Lab on chip concepts. **Basic characterization techniques**	8
Unit 3	**Nanomaterials:** Introduction to nanomaterials, G Characteristics of nanoparticles, quantum dots, carbon nanotubes, nanostructured surfaces, liposomes, Environmental behavior of nanoparticles, biological activity of nanomaterials.	12
Unit 4	**Biosensors:** Introduction to biosensors, the biological component, the sensor surface, Immobilization of the sensor molecule, Application of various transducing elements as part of nanobiosensors	8
Unit 5	**Nanotoxicology:** Principles of toxicology; toxicology models, experimental toxicology studies of nanomaterials. **Applications, Risks and Precautions**: Environmental and Risk Prevention; Risks and Ethical considerations.	9
	Total	45

Books:

S.No	**Name of Book/Author/Publisher**
1	Nanobiotechnology: Concepts, Applications and Perspectives, Christof M.Niemeyer (Editor), Chad A. Mirkin (Editor), Wiley VCH.
2	Nanobiotechnology - II more concepts and applications, Chad A Mirkin and Christof M. Niemeyer (Eds), Wiley VCH.
3	Nanotechnology in Biology and Medicine: Methods, Devices, and Applications.
4	D.S. Goodsell, Bionanotechnology: Lessons from Nature, Wiley Press
5	G. Ozin, A. Arsenault, Nanochemistry. A Chemical Approach to Nanomaterials, RSC, London

THIRD YEAR (SEMESTER 5)

BIOPROCESS ENGINEERING (IMSBT-301)

Course Title	Course Structure			Pre-Requisite
Bioprocess Engineering (IMSBT-301**)**	**L**	**T**	**P**	
	3	**0**	**2**	

Course Objective: Introduction of bioprocess technology necessitates innovation in process development scale-up and design. An integral and cost intensive part of these processes is associated with downstream processing for product isolation and purification.

Course outcome:	
1	Understand the basics of cell culture techniques, media design and inoculum development.
2	Compare and contrast primary and secondary metabolite.
3	Apply the knowledge for understanding an industrial set up to produce products.
4	To gain knowledge about characteristics of bio products.
5	To gain insight to the working of downstream processes at an industrial scale.

S. No.	**Content**	**Contact Hours**
Unit 1	Bioprocess vs. chemical processing: Cell culture techniques, media design, Inoculum development and aseptic transfer methods.	**8**
Unit 2	Process technology: Production of primary & secondary metabolites	**9**
Unit 3	Microbial Production of industrial enzymes, Biofertilizers and Biopesticides	**8**
Unit 4	Characteristic of bioproducts: Cell disruption methods, Mechanical methods of separation, Flocculation Sedimentation, Filtration and centrifugation.	**10**
Unit 5	Downstream Processes: Solid liquid separation- Protein precipitation, aqueous two-phase extraction, Membrane based separation, Chromatography, Crystallization and drying.	10
	Total	**45**

Books :

S.No.	**Name of Book/Author/Publisher**
1	Industrial Microbiology: An Introduction by Michael J. Waites, Wiley-Blackwell (2009)

2	Principles of fermentation technology by Stanbury and Whitaker, Elsevier Science (2016)
3	Introduction to Biochemical Engineering by D.G. Rao, McGraw Hill education (2009)
4	Bioprocess Engineering Principles by P. Doran, Elsevier Science (2013).

List of Experiments:

1. Determination of growth curve of a given microorganism
2. Comparative studies of ethanol production using different substrates.
3. Determination of optimum temperature, pH for an enzyme activity.
4. Estimation of Glucose by DNS method
5. Immobilization of enzyme / cells

PLANT BIOTECHNOLOGY (ISMBT303)

Details of course:-

Course Title	**Course Structure**			**Pre-Requisite**
	L	T	P	
Plant Biotechnology (ISMBT303)	3	0	2	Nil

Course Objective: The objective of the course is to equip students with the knowledge, skills, and ethical awareness needed to contribute to advancements in plant science and agriculture through the responsible application of biotechnological principles and techniques.

Course Outcome:	
1.	Understanding the basic principles of plant tissue culture and techniques
2.	Knowledge of production means and mass cultivation using tissue culturing
3.	Imparting Knowledge about various techniques used for genetic modifications in plants
4.	Knowledge of applicability of transgenics in solving various issues faced by humanity
5.	Learning of regulatory issues and ethical concerns involved in plant genetic engineering

S. No.	Content	Contact Hours
Unit 1	Introduction to Plant Tissue culture: Historical perspectives and milestones in Plant tissue culture; Sterilization Techniques; Basic principles in Plant tissue culture	9
Unit 2	Techniques in Plant tissue culture: Micropropagation, Shoot culture, Root culture; Callus culture, Organogenesis; Somatic embryogenesis, Embryo culture;	9
Unit 3	Production of Secondary metabolites: Overview of Secondary metabolite; Classes of secondary metabolites; Role of tissue culture in production of tissue culture	9
Unit 4	Applications of Plant Tissue culture: Cryopreservation; Haploid production; Micropropagation of elite plants	9
Unit 5	Techniques in Genetic engineering; Gene transfer techniques; transgenic plants; National Regulatory Mechanism; Public Concerns Related to Plant Genetic Engineering	9
	Total	45

Books :

S.No.	Name of Book/Author/Publisher
1.	Introduction to Plant Biotechnology by H. S. Chawla Publisher: Oxford and IBH Publishing, 2009
2.	An Introduction to Plant Tissue Culture by M.K. Razdan. Publisher: Oxford and IBH Publishing, 2010
3.	Gene Cloning and DNA Analysis by T A Brown. Blackwell Publishing, 2008

Practicals:

1. Aseptic culture techniques for the establishment and maintenance of cultures
2. Preparation of plant tissue culture media
3. Establishment of shoot culture
4. In-vitro hardening technique for Tissue culture raised plants
5. To establish root suspension culture
6. To establish cell suspension culture
7. Introduction to plant specific databases

ANIMAL BIOTECHNOLOGY (IMSBT-305)

Details of course:-

Course Title	**Course Structure**			**Pre-Requisite**
	L	T	P	
Animal Biotechnology (IMSBT-305)	3	0	2	Nil

Course Objective: To impart the knowledge of the most recent techniques used in animal biotechnology and their application to animal husbandry and biomedical field

Course Outcomes:	
1	Enlist basic principles of animal cell culture.
2	Define animal diseases and outline the therapy and variation of diseases.
3	Assess the intricacies of stem cells
4	Describe the basic principle behind transgenic, knock in and knock out animal.
5	Identify monoclonal antibodies.

S. No.	**Content**	**Contact Hours**
Unit 1	Animal cell culture, basic principles, serum free and serum based media, scaling-up, characterization and preservation of cell lines, cytotoxicity and viability assays	10
Unit 2	Animal diseases, diagnosis, therapy, variations of diseases, modes of transmission of diseases, control and management of disease spreading	8
Unit 3	Stem cells, micromanipulation of embryos, generation of modified stem cells.	7
Unit 4	Transgenic animals, retroviruses and DNA microinjection method, knock in and knock out animals.	10
Unit 5	Monoclonal antibody and hybridoma technology, application of mAb in diagnostics and therapeutics, vaccinology	10
	Total	45

Practicals:

1. Trypan blue dye exclusion assay for cell viability.
2. Different steps in the development of primary cell culture.
3. Animal cell culture techniques
4. Handling of differentiated and cancer cell lines.
5. Transfection of plasmid DNA to cell lines.
6. Cell proliferation assays.

7. Diagnostics of animal based diseases

Books:

S.No.	Name of Book/Author/Publisher
1.	Gene cloning & DNA Analysis: An introduction by T A Brown, Fourth edition
2.	Animal Cell Biotechnology, Methods and Protocols Publisher: Humana Press
3.	Pinkart, C.A., "Transgenic Animal Technology", Academic Press Inc.
4.	Sasidhara, R., "Animal Biotechnology", MJP Publishers

THIRD YEAR (SEMESTER 6)

Genomics and Proteomics (IMSBT302)

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Genomics and Proteomics (IMSBT302)	3	0	2	Knowledge of DNA, RNA, proteins and gene expression

Course Objective: To impart knowledge of basic techniques in genomics, proteomics, and interact omics

Course Outcomes:	
1.	To appraise various generations of DNA sequencing technologies and genome projects
2.	To understand the fundamentals of comparative genomics and transcriptomics and to appraise various gene expression profiling techniques
3.	To comprehend genome-wide protein analysis by sequencing, electrophoretic and spectrometric techniques
4.	To get insight into various techniques for isolation and analysis of DNA-protein and protein-protein complexes
5.	To appraise the concept of personalized medicine based on pharmacogenomics

S. No.	**Content**	**Contact Hours**
Unit 1	**Genomics:** Genes and Genomes; Massive parallel DNA sequencing; Genome sequencing; Genome Projects	**9**
Unit 2	**Comparative Genomics; Transcriptomics; Functional Genomics Tools:** Database; Sequence alignment; Phylogeny; Genome annotation; ESTs; DNA microarray; SAGE; Real time PCR	**10**
Unit 3	**Techniques in Proteomics:** Protein sequencing; 2D gel electrophoresis; Mass spectrometry	**9**
Unit 4	**Interactomics:** Methods for detecting DNA-protein interactions; Methods for detecting protein-protein interactions	**9**
Unit 5	**Pharmacogenomics and Personalized Medicine:** Single nucleotide polymorphism; Principle of pharmacogenomics; Case studies for personalized medicine	**8**
	Total	**45**

Books:

S.No.	**Name of Book/Author/Publisher**
1.	Introduction to Genomics by AM Lesk. Publisher: OUP
2.	Principles of Gene Manipulation and Genomics by SB Primrose. Publisher: John Wiley
3.	From Proteins to Proteomics: Basic Concepts, Techniques, and Applications by S Srivastava. Publisher: CRC Press
4.	Genomics and Proteomics: Principles, Technologies, and Applications by D Thangadurai, J Sangeetha. Publisher: Apple Academic
5.	Proteomics Methods and Protocols by J Reinders, A Sickmann. Publishers: Humana Totowa, NJ
6.	Discovering Genomics, Proteomics and Bioinformatics by AM Campbell, LJ Heyer. Publisher: CSHL Press
7.	Functional Genomics: A Practical Approach by SP Hunt, R Livesey. Publisher: OUP
8.	Introduction to Proteomics: Tools for the New Biology by DC Liebler. Publisher: Humana Totowa, NJ
9.	Principles of Proteomics by R Twyman. Publisher: Garland Science

10.	Proteomics: From Protein Sequence to Function by S Pennington, MJ Dunn. Publisher: BIOS Scientific
11.	A Practical Approach to Microarray Data Analysis by DP Berrar, W Dubitzky, M Granzow. Publisher: Springer
12.	Introducing Proteomics: From Concepts to Sample Separation, Mass Spectroscopy and Data Analysis by J Lovric. Publisher: Willey-VCH
13.	Concepts and Techniques in Genomics and Proteomics by N Saraswathy, P Ramalingam. Publisher: Woodhead

Experiments

1. Introduction to databases
2. Retrieval of information from NCBI database
3. Pairwise sequence alignment
4. Multiple sequence alignment
5. SDS-PAGE
6. Protein structure prediction

ADVANCE IMMUNOLOGY (IMSBT-)

Course Title	**Course Structure**			**Pre-Requisite**
	L	**T**	**P**	
Advanced Immunology (IMSBT304)	**3**	**1**	**2**	**Nil**

Course Objective: To give an overview of the basic concepts in immunology and the development of diagnostic and therapeutic techniques in immunotherapy for complex disorders and infectious diseases.

Course Outcome	
1.	Understanding innate and adaptive immunity and exploring their role in immune response to pathogens.
2	Detailed understanding of the role of innate immunity as the first line of defense
3	Analysing the role of the adaptive immune system in complex immune therapeutics.
4	Learning the principles of immune tolerance, identifying the causes and mechanisms

5	Equip students with the knowledge of immunology for application in healthcare and disease management.

S.No	**Content**	**Contact Hours**
Unit 1	Introduction and overview of the Immune system Introductory concepts in immunology; Active and passive immunity; principles of the innate and active immune system; cells and organs of the immune system; and Hematopoiesis.	10
Unit 2	Innate immune system Mechanisms of the innate immune response, neutrophils, NK cells, dendritic cells, macrophages, and cytokines, as well as their role in immune response, are components of the complement pathway.	8
Unit 3	Adaptive immune system Antigen presentation by MHC class I & class II; T cell response; regulation of cellular immune response; Antibody structure and types; Antibody gene rearrangement; Clonal selection; and B& T cell epitope analysis.	**8**
Unit 4	Tolerance; Autoimmunity and Hypersensitivity Central and peripheral tolerance; Autoimmunity causes and treatment; systemic & local autoimmune disease; Hypersensitivity and its types.	**10**
Unit 5	Immune system in health and disease Immune response to infectious disease; cancer immune therapy; concept of immunodeficiency disease; development of vaccines; Antibody Engineering Immune diagnostics	**9**
	Total	**45**

Lab Experiments:

S.no.	**Aims**
1	Identify primary and secondary lymphoid organs using permanent slides and understand their histological features and functions.
2	Study of Radial Immuno diffusion as a diagnostic tool.
3	Study of Double Immuno diffusion as diagnostic tool.
4	Blood smear identification of leucocytes by Giemsa stain
5	Elucidating Antibody titre by ELISA method.
6	Elucidation of advanced techniques of immune diagnostics like Immuno-electrophoresis
7	\ Blood smear identification of leucocytes by Giemsa stain

8	Separation of mononuclear cells by Ficoll-Hypaque
9	Study of Flowcytometry; identification of T cells and their subsets using Flowcytometry
10	Identification of blood groups using agglutination

Reference Books/ links : -

S.No.	Name of Books/Authors/Publisher
1.	"Kuby Immunology" by Judy Owen; Jenni Punt; and Sharon Stranford (2018) Publisher: W.H. Freeman & Company
2.	"Janeway's Immunobiology" by Kenneth Murphy; Casey Weaver; and Allan Mowat (2016) Publisher: Garland Science
3.	Basic Immunology by A.K. Abbas and A.H. Lichtman. Third edition. Publisher: Saunders W.B. Company ;2010
4.	How the Immune System Works" by Lauren M. Sompayrac (2019) Publisher: Wiley-Blackwell
5.	"Cancer Immunotherapy"Immune Suppression and Tumor Growth 2nd Edition - June 4; 2013 Editors: George C. Prendergast; Elizabeth M. Jaffee Publisher: Academic Press
6.	Microbial Crosstalk with Immune System by Asmita Das (2022) Academic Press

Developmental Biotechnology (IMSBT-306)

Details of course:-

Course Title	Course Structure			Pre-Requisite
Developmental Biotechnology (IMSBT-306)	L	T	P	
	3	1	0	NIL

Course Objective: The course objective of Developmental Biotechnology is to explore advanced techniques and principles in biotechnology to understand and manipulate developmental processes for various applications in medicine, agriculture, and industry.

Course Outcome:	
S. No.	
1.	**Deep grasp of developmental biology**: Understand embryonic stages, signaling, gene regulation, and model organisms' roles in developmental processes.
2.	**Proficiency in cellular and molecular techniques**: Master cell culture, PCR, cloning, microscopy, gene expression analysis crucial in developmental biology research.
3.	**Apply stem cells and tissue engineering**: Use embryonic and iPSCs, tissue engineering, and biofabrication for regenerative medicine solutions.
4.	**Understanding developmental genetics and epigenetics**: Grasp genetic basis, key genes, epigenetic regulation, and environmental influences on development.
5.	**Critically analyze biotech applications**: Evaluate ethical, legal, and societal implications in agriculture, biomedicine, and drug discovery; explore emerging technologies in developmental biology.

S. No.	**Content**	**Contact Hours**
Unit 1	**Developmental Biology Overview**: Historical and modern perspectives, covering embryonic development stages, signaling pathways, gene regulation, model organisms, and ethical considerations in research.	10
Unit 2	**Cellular and Molecular Techniques**: Covers cell culture, molecular biology, imaging, gene expression analysis, and CRISPR/Cas9 technology essential for developmental biology research.	08
Unit 3	**Stem Cells and Tissue Engineering**: Focuses on embryonic and induced pluripotent stem cells, tissue engineering principles, biofabrication techniques, and their applications in regenerative medicine.	09
Unit 4	**Developmental Genetics and Epigenetics**: Explores genetic basis, developmental genetics, epigenetic regulation, environmental influences, and evolutionary developmental biology in understanding developmental mechanisms.	09
Unit 5	**Applications of Developmental Biotechnology**: Discusses biotechnology in agriculture, biomedical applications, drug discovery, and ethical, legal, and societal implications, along with future directions and emerging technologies in developmental biology and biotechnology.	09
	Total	45

FOURTH YEAR (SEMESTER 7)

Advances in Biotechnology (IMSBT-401)

Course Title	Course Structure			Pre-Requisite
Advances in Biotechnology (IMSBT-401)	L	T	P	
	3	1	0	NIL

Course Objective: The course objective of Advances in Biotechnology is to explore recent developments and emerging trends in biotechnology, preparing students to apply innovative techniques in various industries such as healthcare, agriculture, and environmental science.

Course Outcome:	
S. No.	
1.	Demonstrate a thorough understanding of genome editing technologies, particularly CRISPR-Cas9, and their applications in gene therapy, disease modeling, and agricultural biotechnology.
2.	Evaluate the principles and applications of synthetic biology and stem cell technologies, including the design of biological systems, tissue engineering, and the ethical and legal considerations surrounding stem cell research.
3.	Analyze various diagnostic and therapeutic techniques in biotechnology, including immunological diagnostic methods, vaccine development, and the application of bioinformatics in drug discovery.
4.	Apply bioinformatics and computational biology techniques to analyze large-scale biological datasets, construct computational models of biological systems, and utilize machine learning and AI in biotechnology and drug discovery.
5.	Critically assess the development and challenges of gene therapy and cell-based therapies, including gene editing technologies for treating genetic disorders and cancer, as well as the clinical translation and commercialization of these therapies.

S. No.	**Content**	**Contact Hours**
Unit 1	Genome Editing and CRISPR-Cas Technology Genome editing, including CRISPR-Cas9, enables precise DNA modification with applications in gene therapy, disease modeling, and agriculture. Includes ethical and regulatory considerations.	10

Unit 2	Synthetic Biology and Stem Cell Technologies Designing biological systems for applications. Creating artificial circuits, metabolic pathways, and organisms. Using bioengineering for renewable energy, bioremediation, and biosensing. Utilizing iPSCs in regenerative medicine, drug discovery, and disease modeling. Addressing ethical and legal concerns in stem cell research.	08
Unit 3	Diagnostics and Therapeutics Immunological diagnostic techniques - Immunodiffusion, Immuno-electrophoresis, ELISA, RIA, fluorescence activated cell sorter. Vaccines; Hybridoma technology; Antibody engineering, synthetic antibodies; Immunity to parasites and therapeutics	09
Uniit 4	Bioinformatics and Computational Biology: Analysis of large-scale biological data sets, including genomics, transcriptomics, proteomics, and metabolomics. Computational modeling of biological systems and networks. Machine learning and AI applications in biotechnology and drug discovery.	09
Unit 5	Gene Therapy and Cell-based Therapies: Development of gene editing and gene delivery technologies for treating genetic disorders and cancer. Adoptive cell therapies, such as CAR-T cell therapy for cancer immunotherapy. Challenges in clinical translation and commercialization.	09
	Total	45

Books :

S.No.	**Name of Book/Author/Publisher**
1.	Introduction to Biotechnology" by William J. Thieman and Michael A. Palladino.
2.	Biotechnology: Concepts and Applications" by R.C. Dubey.

BIORESOURCE AND BIOPROSPECTING TECHNOLOGY (IMSBT-403)

Details of course: -

Course Title	**Course Structure**			**Pre-Requisite**
	L	T	P	
Bioresource and Bioprospective Technology (IMSBT-403)	3	1	0	Nil

Course Objective:
Bioresources and bioprospecting technology focus on the sustainable utilization of biological resources for various applications, including agriculture, medicine, and industry.

Course Outcome:	
1.	Understand the concept of bioresources and their significance in various fields
2.	Knowledge and skills in the utilization of anthropogenic bio-resources and various conversion processes, contributing to sustainable waste management practices and the production of value-added products.
3.	Learning about bioprospecting techniques for discovering valuable compounds and applications
4.	Gaining practical skills in bioprospecting and bioresource utilization
5.	Knowledge about ethical, legal and environmental consideration in bioprospecting and bioresource management

S. No.	**Content**	**Contact Hours**
Unit 1	Introduction to Bioresources: Classification of bioresources; Importance of bioresources, Agriculture, Medicine, Industry; Challenges and Opportunities in Bioresource Utilization	9
Unit 2	Biodiversity conservation: Species extinction, ultimate and proximate causes of Biodiversity loss; IUCN threat categories; Red data Book; Biodiversity surrogates; In situ conservation strategies—Ex situ conservation strategies—Botanical gardens, Zoos, Aquaria, Cryo-banks.	9
Unit 3	Exploration and Collection of Bioresources: Bioresource exploration and sampling; Collection, preservation and documentation of bioresources; Data management of bioresource	9
Unit 4	Bioprospecting Techniques: Screening methods for bioactive compounds from natural sources; Isolation and purification techniques for novel compounds; Bioassay technique	9

Unit 5	Ethical, Legal and Environmental Consideration: Ethical and legal frameworks in bioprospecting and bioresource utilization; Environmental impact assessment and sustainability in bioresource management	9
	Total	45

Books:

S.No.	Name of Book/Author/Publisher
1	Bioresources and Bioprospecting by David L. Hawksworth and Alan T. Bull
2.	Bioprospecting Success, Potential and constraints by K.V. Krishnamurthy and David S. Ingram
3.	Ethical and Legal Issues in Bioprospecting" edited by Evanson C. Kamau and Githaiga M. Mbugua

Course: IPR and Biosafety (IMSBT-405

Course Title	Course Structure			Pre-Requisite
	L	T	P	
IPR and Biosafety (IMSBT-405)	3	1	0	Nil

Course Outcome

S.No.	
1.	Understanding the significance of intellectual property and biosafety principles
2.	Mastering the concept of "prior art" and proficiently conducting patent searches.
3.	Gaining knowledge of patent basics and procedures for effective patent filing.
4.	Developing practical skills in patent filing and understanding patent infringement.
5.	Comprehending biosafety principles and regulations governing production and use of GMO release

Course Objective: Provide students with a comprehensive understanding of intellectuaLperty; patent; trademarks; and biosafety principles.

S.No	Content	Contact Hours
Unit 1	**Introduction to Intellectual Property** Types of IP: Patents, Trademarks, Copyright, Industrial Design, Traditional Knowledge, Geographical Indications.	**8**
Unit 2	**Grant of Patent** Concept of the prior art; rights; and duties; PCT; IPR in bioinformatics; software; Agreement; and treaties: GATT, TRIPS Agreements, WIPO Treaties, Budapest Treaty on international recognition of the deposit of microorganisms; UPOV & Brene conventions.	**8**
Unit 3	**Patent filing procedure** Patent application- forms and guidelines; Filing of a patent application; patenting-disclosure/non-disclosure; International requirements; procedures; and costs; Procedure for filing a PCT application	**9**
Unit 4	**Biosafety** Introduction; Historical Background; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Biosafety guidelines - Government of India.	**10**
Unit 5	**Research ethics and sustainability** Ethical principles in research; researcher responsibility to the environment; Bioengineering ethics; rights and responsibility; legal protection of IPR and case studies.	**10**
	Total	**45**

Reference books/ links

S.no.	Books and Important links
1	IPR biosafety and bioethics by Goel And Parashar; publisher : Pearson Education India
2	http://www.wipo.int/portal/index.html.en
3	www.patentoffice.nic.in
4	http://www.cdc.gov/OD/ohs/symp5/jyrtext.htm
5	Intellectual property rights; biosafety and bioethics (Ethical Frontiers) by Dr. Alok kumar srivastav; Dr. Pooja Sharma; Dr. Priyanka das; Dr. Vandita Billore Parashar
6	Biosafety; Bioethics and Intellectual Property Rights; Author: Dr. Anil Dusane; Book

	ID: 2013; ISBN: 978-93-90646-23-4

FOURTH YEAR (SEMESTER 8)

Fermentation and Industrial Biotechnology (IMSBT-402)

Course Title	Course Structure			Pre-Requisite
Fermentation and Industrial Biotechnology (IMSBT-402)	L 3	T 1	P 0	

Course Objective: To provide the theoretical and practical bases to set-up, manage and improve microbial biotechnological processes, for the industrial production of compounds.

Course Outcomes:	
1	Understand the basics of Inoculum Development and Media Preparation
2	Compare and contrast Process technology for Primary metabolites.
3	Compare and contrast Process technology for Secondary metabolites
4	Summarize the Sterilization and Cell growth kinetics
5	To gain insight of the Fermentation Process

S. No.	Content	Contact Hours
Unit 1	**Inoculum Development and Media Preparation:** Media components and optimization, types of culture media, Isolation, screening, Selection of mutants; Development of inocula for industrial fermentation	9
Unit 2	**Process technology for Primary metabolites:** Production of primary metabolites - Ethanol from molasses, acetone-butanol, citric acid, amino acids, Baker's yeast, and plastics;	9

Unit 3	**Process technology for Secondary metabolites:** Production of secondary metabolites - Penicillin, Cephalosporins, Streptomycin etc., metabolites from plant cell culture	9
Unit 4	**Sterilization and Cell growth kinetics:** Thermal death kinetics of microorganisms, batch and continuous heat sterilization of liquid media, air sterilization, Microbial growth kinetics, logistic growth model, growth of filamentous organism.	9
Unit 5	**Fermentation Process:** Parts of fermenter: Body, Baffles, Sparger, valves, ports, Aeration: Oxygen requirement.	9
	Total	45

Books :

S.No.	**Name of Book/Author/Publisher**
1	Presott& Dunn's Industrial Microbiology. Ed. E.G. Reed (1987). CBS Publishers, New Delhi.
2	Microbiology, Pelzar Jr. M.J.: Chan E.C.S. and Krieg, N. R. (1993) Tata McGraw Hill, New Delhi.
3	Stanbury, Whitaker and Hall, "Principles of Fermentation Technology", Butterworth Heinemann, 2nd Ed., 1999.
4	Pauline M. Doran, "Bioprocess Engineering Principles", Academic Press, 2nd Ed., 2012.

Bioethics and Biosafety (ISMBT-404)

Details of course:-

Course Title	**Course Structure**			**Pre-Requisite**
	L	T	P	
Bioethics and Biosafety (ISMBT-404)	3	1	0	Nil

Course Objective: To discuss about various aspects of biosafety regulations, IPR and bioethic concerns arising from the commercialization of biotech products.

Course Outcome:

1.	Evaluate the international background of intellectual property, including the harmonization efforts and challenges faced in global IPR regulations.
2.	Assess the concept of biological patentability and its implications for biotechnological innovations.
3.	Identify biosafety issues and risk assessment frameworks in biotechnology.
4.	Explain concepts of biopiracy and bioprospecting and their ethical implications.
5.	Discuss ethical frameworks and principles for addressing bioethical dilemmas in biotechnological research and applications.

S. No.	**Content**	**Contact Hours**
Unit 1	General Overview of Intellectual Property Rights: History and evolution of IPR like patent, design and copyright, WIPO, WTO, Trade related Intellectual Property Right International background of intellectual property	9
Unit 2	Patents: Requirement of patentable novelty, inventive step, prior art Classifying products as patentable and non-patentable Procedure for applying for patent Patent Infringement and related case studies Biological Patentability	9
Unit 3	Biosafety and risk assessment issues; Regulatory framework; National biosafety policies and law, The Cartagena protocol on biosafety, WTO and other international agreements related to biosafety, Cross border movement of germplasm; Risk management issues - containment.	9
Unit 4	IPR and Biotechnology: Biopiracy and Bioprospecting Farmers Rights and Plant breeders rights Biodiversity, society and the environment.	9
Unit 5	Bioethics: Bioethical issues related to Healthcare & medicine Food & agriculture Genetic engineering The Human Genome Project and Genetic Testing, Environmental problems	9
	Total	45

Books :

S.No.	Name of Book/Author/Publisher
1.	WTO-Trade-related Aspects of Intellectual Property Rights Edited by P.T. Stoll, J. Busche, K. Arend (2009).
2.	Intellectual Property Rights in Agricultural Biotechnology by F.H. Erbisch and K.M. Maredia (2000).

FIFTH YEAR (9TH SEMESTER)

PLANT METABOLIC ENGG (IMSBT-501)

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Plant Metabolic Engineering (IMSBT 501)	3	1	0	Nil

Course Objective: This course provides an in-depth study of plant metabolism and metabolic engineering. Students will explore the principles and applications of manipulating plant metabolic pathways to improve crop yield, quality, and resilience.

Course Outcome:	
1	Understand the principles of plant metabolism and key metabolic pathways.
2	Learn techniques and strategies for manipulating plant metabolic pathways.
3	Explore application of plant metabolic engineering in agriculture, biotechnology and industry
4	Analyze case studies of successful plant metabolic engineering projects.
5	Conduct research and present findings on a specific topic in plant metabolic engineering.

S. No.	Content	Contact Hours
Unit 1	**Introduction to Plant Metabolism:** Overview of plant metabolic pathways; Primary and Secondary metabolism; Key metabolites and their functions	9
Unit 2	**Basics of Metabolism:** Fundamentals of carbohydrate metabolism; amino acid metabolism; lipid metabolism	9
Unit 3	**Plant Secondary Metabolism:** Overview of secondary metabolites; Alkaloids; Terpenoids; Phenolics; Engineering Secondary metabolites for pharmaceutical and industrial applications	9

Unit 4	**Metabolic engineering:** Regulation of metabolic pathways; compartmentalization; Feed-back inhibition; Rate limiting step; Metabolic engineering for enhancing nutritional quality; enhancing photosynthesis efficiency.	9
Unit 5	**Applications in Biotechnology and Industry:** Production of Valuable compounds; Biofuel and renewable energy applications; Engineering plants for pharmaceutical production	9
	Total	45

Books:

S.No.	Name of Book/Author/Publisher
1.	Dharmapalan, B. Plant Biochemistry: An Introduction. Alpha Science, 2016
2.	Hopkins, W. G and Huner, N. P. A. Introduction to Plant Physiology. John Wiley & Sons, New York, 2004
3.	Nelson, D.M. and Cox, M.M. Lehninger Principles of Biochemistry. W H Freeman, New York, 2013

Genetic Engineering (ISMBT-303)

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Genetic Engineering (ISMBT-503)	3	0	2	Nil

Course Objective: Basic understanding of genetic engineering tools, gene, manupulation, gene delivery rDNA Technology and Library construction.

Course Outcome:	
1.	Understand the construction and functions of different vectors implied in the field of Genetic engineering.
2.	Acquire knowledge on various enzymes involved in recombinant DNA technology.
3.	Acquire knowledge on cloning system and genetic engineering.
4.	Understand the various types of PCR and its application.
5.	Understand the modern genetic engineering concepts for biotechnology thereby employ the students in research.

S.No.	Name of Book/Author/Publisher
1.	Gene Cloning & DNA Analysis: An Introduction by T.A. Brown. Blackwell Publisher,
2.	Principles of Gene Manipulation & Genomics by Primrose & Twyman. Seventh edition
3.	Molecular Cloning: A Laboratory Manual (3 Volume Set) by J. Sambrook and David W. Russel. Third edition Publisher: Cold Spring Harbor Laboratory Press,
4.	Molecular Biotechnology: Principles and Applications of Recombinant DNA by B.R. Glick and J.J. Pasternak. Publisher: ASM Press
5.	Genetic Engineering by S. Rastogi and N. Pathak. Publisher: Oxford University Press
6.	Recombinant DNA by J.D. Watson et al. Publisher: W.H. Freeman and company

Practicals:

1. To isolate plant genomic DNA by CTAB method
2. Isolation of plasmid DNA from E.coli
3. Restriction digestion of plasmid DNA
4. To check the presence of DNA by agarose gel electrophoresis
5. To electro elute specific bands or regions of agarose gel separated DNA
6. To isolate RNA from mammalian cells
7. To perform PCR thermal cycler for DNA amplification.

FIFTH YEAR (SEMESTER 10)

DRUG DESIGN AND DELIVERY (IMSBT-502)

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Drug Design and Delivery (IMSBT502)	3	1	0	Nil

Course Objective: Exploring the concepts in Drug Design and Development with emphasis on the role of Bioinformatics in lead identification and lead optimization. Provides in-depth knowledge of the regulations involved in the translation of 'bench to bedside' of a new drug and its IPR regulations.

Course Outcome :	
1.	Illustrating the process of drug discovery and discussing the diverse sources of drugs
2.	Examine the traditional vs new-age drug design and development
3.	Elucidating the receptor theory and role of enzyme kinetics in drug design and development.
4.	Outline the role of clinical trials in the drug development system
5.	Demonstrating the various drug delivery mechanisms for effective active drug concentration

S. No.	**Content**	**Contact hours**

Unit 1	Introduction to drug discovery and delivery Drug Discovery and development overview, Source of drugs, molecular screening strategies, traditional drug development; concept of lead identification, Lead optimization, Rational drug design.	10
Unit 2	Drug development methods Preclinical drug development, traditional drug development; computational drug design, docking, QSAR, and pharmacophore modeling.	9
Unit 3	Pharmacology and Pharmacodynamics Concept of Receptor Theory; Enzyme kinetics, Enzyme inhibition, Allosteric modulators, Enzymes as drug targets, Agonist and antagonist, Peptidomimetics.	8
Unit 4	Clinical trials in drug development Phases of Clinical Trials IPR regulations in drug development, Biosafety regulations.	8
Unit 5	Analysis of case studies in drug development 'Bench to Bedside' translation of drugs, overview of Drug delivery systems, nanomedicine, Case studies of recent advances in drug development.	10
	Total	45

Reference books/ links-

S. No.	Name of Book/Author/Publisher
1	Comprehensive Medicinal Chemistry III 3rd Edition - June 3, 2017 Editors: Samuel Chackalamannil, David Rotella, Simon Ward, publisher Elsevier
2	"Enzyme Inhibitors as Drugs: Volume 1 and Volume 2" Author: Edited by Ernesto Fattorusso and Orazio Taglialatela-Scafati, Publisher:The Royal Society of Chemistry Publication Date: Volume 1: 2019, Volume 2: 2020
3	Textbook of Drug Design and Discovery; august 2017 Edited By Kristian Stromgaard, Povl Krogsgaard-Larsen, Ulf Madsen publisher; CRC press
4	"Drug Design: Cutting Edge Approaches" Editors: Edited by S. Joel G. Abraham, Paul A. Selzer, and Lars Olsen, Publisher: Royal Society of Chemistry Publication Date: 2019
5	Protein folding and Drug Design ,R.A Broglia and L.Serrano, publisher- IOS Press, 2007

CONCEPTS OF PUBLIC HEALTH (IMSBT-504)

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Concept of public health (IMSBT-504)	3	1	0	Nil

Course Objective: To provide a comprehensive understanding of key concepts in public health, including epidemiology, biostatistics, environmental health, social and behavioral sciences, health policy, and management.

Course Outcome:	
1.	Understanding the fundamental concepts and principles of public health, including its scope, goals, and historical evolution.
2.	Understanding basic principles of immunology in the development of herd immunity and community health
3.	Acquiring the ability to interpret epidemiological data and biostatistical findings to assess patterns of disease occurrence, risk factors, and trends over time.
4.	Describing the role of the interaction of community and environment in shaping health.
5.	Understanding the principles, theories, and frameworks of health policy and management.

S. No.	Content	Contact Hours
Unit 1	**Introduction to Public Health** History of public health; Prevention of diseases in the community; types of microorganisms- Bacteria, fungi, Viruses, Protozoans, Helminths.	**8**
Unit 2	**Concept of immunology and development of herd immunity** Immunity- innate and acquired; immunization; active and passive immunity; overview of cellular and humoral immunity; immune tolerance and immunologic memory; Herd immunity.	**12**

Unit 2	**Epidemiology & Biostatistics** Definition and aims in Epidemiological approach; types of Epidemiological studies: Observational (Descriptive, analytical); experimental; association and causation; uses of Epidemiology in Infectious disease.	**8**
Unit 3	**Environmental Health and community sustainability** Environment-human interaction; sources of pollution; methods of protection; sanitation and hygiene; food and sustainability; Industrial hazards; and biosafety.	**9**
Unit 5	**Health management and policy development** Introduction to Gaia hypothesis; social sustainability; and basis for planning health policy and management.	**8**
	Total	**45**

Books :

S.No.	Name of Book/Author/Publisher
1	Mary-Jane Schneider (2020). Introduction to Public Health (6th edition). Burlington; MA: Jones & Bartlett Learning. ISBN -13: 978-1284197594 or ISBN-10: 128419759X
2	"Introduction to Public Health" Schneider; Mary-Jane. (2016). Introduction to Public Health. Jones & Bartlett Learning
3	Principles of Epidemiology in Public Health Practice: An Introduction to Applied Epidemiology and Biostatistics Corporate Authors(s) : Centers for Disease Control and Prevention (U.S.); Office of Workforce and Career Development.

DEPARTMENT OF BIOTECHNOLOGY

DELHI TECHNOLOGICAL UNIVERSITY: DELHI

Established under Govt. of Delhi Act 6 of 2009

Shahbad Daulatpur, Bawana Road, Delhi-110042

Integrated M.Sc syllabus

(DEPARTMENT ELECTIVE COURSES)

Transgenic Technology (ISMBT-)

Details of course:-

Course Title	**Course Structure**			**Pre-Requisite**
Transgenic Technology (ISMBT-)	L	T	P	
	3	1	0	Nil

Course Objective: This course describes the methodology for generation of transformants and applications of transgenics.

Course Outcome:	
1.	Understanding basics of transgenics creation and its applications.
2.	Learning various techniques used in transgenics generation.
3.	Analyzing utility of recombinant microorganisms.
4.	Knowledge of plant and animal transgenics.

5.	Developing an understanding of risk factors and regulatory guidelines used for transgenic products.

S. No.	**Content**	**Contact Hours**
Unit 1	Basics of Recombinant DNA Technology: Bacterial, plant and animal vectors; Methods of bacterial, plant and animal transformation	9
Unit 2	Techniques Related to Generation and Applications of Transgenics: Nuclear transfer technologies; Reproductive and therapeutic cloning; Gene therapy; Gene targeting; Gene editing; Application of Cre recombinase, Recombinase mediated gene stacking; Analysis of phenotype and transgene expression	9
Unit 3	Recombinant Microorganisms: Production of recombinant biopharmaceuticals, restriction enzymes, antibiotics, Small molecules, biopolymers, recombinant vaccines; Biopesticides; Improved production of alcohol, fructose, glycerol; Improved conversion of glucose to fructose; Efficient utilization of cellulose	9
Unit 4	Plant and Animal Transgenics: Plant transgenics: Applications of transgenic technology in agriculture; Bioenergy plants; Plants as bioreactors; Edible vaccines; Animal transgenics: Application as basic research models and bioreactors; Application in molecular pharming, DNA vaccines, human gene medicines; stem cell therapy	9
Unit 5	Regulation and Public Concerns: Recombinant DNA biosafety guidelines; National regulatory mechanism for implementation of biosafety guidelines for handling GMOs; Commercialization; Public acceptance; Risk factors related to transgenic plants and animals; Bt cotton case study; Concerns and regulations related to stem cell research and human cloning	9
	Total	45

Books :

S.No.	Name of Book/Author/Publisher
1.	Molecular Biotechnology by Glick, B.R. and Pasternak, ASM Press, USA
2.	Genetic Engineering by Rastogi, S. and Pathak, N. Oxford University Press
3.	Principles of Gene Manipulation and Genomics Primrose, S.B. and Twymann, R.
4.	Understanding DNA and Gene Cloning: A Guide for the Curious by Drlica, K. 4TH Ed. Wiley
5.	Transgenic Animal Technology - A Laboratory Handbook by Pinkert, C.A. 3rd Ed. Elsevier Publ.
6.	Genetic Engineering by Rastogi, S. and Pathak, N. Oxford University Press

POPULATION GENETICS (ISMBT-)

Details of course:-

Course Title	Course Structure			Pre-Requisite
Population genetics (ISMBT-)	L	T	P	
	3	1	0	Nil

Course Objective:The course aims to provide knowledge about the genetic variation at population level thus fostering critical thinking skills and ethical awareness in the study of genetic diversity and evolution within population.

Course Outcome:	
1.	Develop a foundational understanding of population genetic theory and methods
2.	Analyze pattern of genetic variation within population
3.	Apply population genetic principles to study human genetic diversity and ancestry
4.	Knowledge about the role of evolutionary process in shaping genetic variation
5.	Examine ethical, legal and social implications of population genetic research and applications

S. No.	**Content**	**Contact Hours**
Unit 1	**Introduction to Population Genetics:** Historical perspectives and key milestones in population genetics; overview of population genetic principles and methods	9
Unit 2	**An overview on structure of Population:** Genetic variation within population, allelic frequency, Hardy-Weinberg Principle; Population size and Genetic Drift; Gene flow and Migration	9
Unit 3	**Genomics and Proteomics at Population Level:** Genomic Variation within population; Genome-wide association studies; Mendelian Disease and Population Genetics, Genetic Basis for Variation in Risk of Complex Disease	9
Unit 4	**Quantitative Genetics:** Quantitative Genetics, Quantitative Trait Loci (QTLs), Types of Quantitative Traits, Number of Genes Affecting Quantitative Traits, Methods for Mapping QTLs	9
Unit 5	**Ethical, Legal and Social Implications of Genetics:** Ethical and legal consideration in population genetics; social implications in genetic research;	9
	Total	45

Books:

S.No.	Name of Book/Author/Publisher
1.	Evolutionary Analysis, Scott Freeman, John C. Hendon, Fourth Edition Pearson Education.
2.	Molecular Genetic Analysis of Populations, Hoelzel, 2nd Edition, Oxford University.
3.	Genetics -Principles and Analysis Hartl and Jones, 5th edition Jones and Barlet.

STEM CELL AND REGENERATIVE MEDICINES (IMSBT-)

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Stem Cells and Regenerative Medicines (IMSBT-)	3	1	0	NIL

Course Objective: Introduction to stem cell technology and application.

Course Outcomes:	
1.	Explain basics of stem cells and tissue engineering.
2.	Describe regenerative medicine, repair and regeneration of tissues for therapeutic purpose.

3.	Develop understanding of molecular targeted therapies in blood disorder and malignancy.
4.	Identify latest developmental and molecular biology of regeneration.
5.	Develop knowledge of practices and principals of tissue engineering.

S. No.	Content	Contact Hours
Unit 1	**Basic elements of stem cells and tissue engineering** Definition of stem cells, historical perspectives, and various types of stem cells in use. Stem Cells – Basics, Properties and Classification,	8
Unit 2	**Regenerative Medicine: from Bench to Bedside** The repair and regeneration of tissues for therapeutic purposes, such as replacing bone marrow in leukemia, Skin , Bone, Cartilage tissue engineering.	11
Unit 3	**Molecularly Targeted Therapies in Blood Disorders Eye Disease and disorder** The discoveries of several novel regenerative treatments; Gene therapy, the potential of drugs based on RNA interference and the reprogramming of somatic cells into stem cells for regenerative medicine.	8
Unit 4	**D**evelopmental and molecular biology of regeneration, pluripotent stem cells and genome engineering for modeling human diseases	8
Unit 5	**Stem Cells: A Cure or Disease?** Recent developments in stem cell science, underlying biology behind the idea of using stem cells to treat disease	10
	Total	45

Books:

S.No.	Name of Book/Author/Publisher

1.	Stem Cells and Regenerative Medicine, Walter C Low, Catherine M Verfaillie ISBN: 978-981-4
2.	Stem Cell Repair and Regeneration; Nagy Habib, Nataša Y Levičar, Myrtle Gordon , Long Jiao, Nicholas Fisk Volume 2
3.	Developmental Biology, 6th Edition, Scott F. Gilbert
4.	Hematology, William J. Williams, Ernest Beutler, Allan JU. Erslev, Marshall A. Lichtman
5.	Stem Cell Biology by Marshak, Cold Spring Harbar Symposium Pulblication.

METABOLIC ENGINEERING (IMSBT-)

Details of course:-

Course Title	**Course Structure**			**Pre-Requisite**
Metabolic Engineering (IMSBT-)	L	T	P	
	3	1	0	Nil

Course Objective:

This course helps the student for understanding purposeful modification of metabolic pathways to achieve desired goals such as enhanced production of metabolites, creation of novel metabolites and utilization of new carbon substrates.

Course Outcome:	
S. No.	

1.	To understand and describe the fundamental principles of metabolic engineering.
2.	To analyze and evaluate the synthesis pathways of primary and secondary metabolites, understanding the regulatory mechanisms.
3.	To apply knowledge of bioconversion processes and enzyme production regulation to optimize metabolic pathways for improved yields.
4.	To assess and interpret metabolic flux distribution in cellular processes, applying experimental and analytical methods.
5.	To utilize bioinformatics tools for metabolic pathway modeling and control analysis, synthesizing data to design and optimize metabolic pathways.

S. No.	**Content**	**Contact Hours**
Unit 1	**Introduction & Applications of Metabolic Engineering:** Identification of metabolic regulation is a key point in metabolic engineering. Basic concepts of Metabolic Engineering – Overview of cellular metabolism – Different models for cellular reactions, induction – Jacob Monod model and its regulation, Differential regulation by isoenzymes, Feedback regulation. Application in pharmaceuticals, chemical bioprocess, food technology, agriculture, environmental bioremediation and biomass conversion.	9
Unit 2	**Synthesis of Primary & Secondary Metabolities:** Amino acid synthesis pathways and its regulation at enzyme level and whole cell level, Alteration of feedback regulation, Limiting accumulation of end products. Regulation of secondary metabolite pathways, precursor effects, prophase, idiophase relationship, Catabolite regulation by passing control of secondary metabolism, producers of secondary metabolites, applications of secondary metabolites.	9
Unit 3	**Bioconversions & Regulation of Enzyme Production:** Applications of Bioconversions, Factors affecting bioconversions, Specificity, Yields, Co metabolism, Product inhibition, mixed or sequential bioconversions, Conversion of insoluble substances. Strain	9

	selection, Genetic improvement of strains, Gene dosage, metabolic pathway manipulations to improve fermentation, Feed back repression, Catabolite Repression, optimization and control of metabolic activities. The modification of existing - or the introduction of entirely new - metabolic pathways.	
Unit 4	**Metabolic Flux:** Integration of anabolism and catabolism, metabolic flux distribution analysis bioprocess, material balance, kinetic types, equilibrium reaction. Experimental determination method of flux distribution, Metabolic flux analysis and its applications, Thermodynamics of cellular processes.	9
Unit 5	**Metabolic Engineering with Bioinformatics:** Metabolic pathway modeling, Analysis of metabolic control and the structure metabolic networks, Metabolic pathway synthesis algorithms.	9
	Total	45

Books :

S.No.	Name of Book/Author/Publisher
6.	“Advanced Metabolic Engineering: Synthetic and Systems Approaches", Edited by Smith, J. & Lee, H., Academic Press, 1st Edition, 2019.
7.	“CRISPR-Cas Systems in Metabolic Engineering, Thompson, A.R., Wiley-VCH, 1st Edition, 2020.
8.	“Microbial Metabolic Engineering for Biochemical Production", Chen, G.Q. & Patel, M.K., Springer, 1st Edition, 2021.
9.	“Synthetic Biology: Tools for Engineering Biological Systems", O'Malley, M.A. & Church, G.M., CRC Press, 2nd Edition, 2019.
10.	“Systems Biology and Metabolic Engineering of Microorganisms", Kim, Y., Elsevier, 1st Edition, 2022.

ECOLOGY AND EVOLUTION (IMSBT-)

Details of course:-

Course Title	**Course Structure**			**Pre-Requisite**
Ecology and Evolution (IMSBT-)	L	T	P	NIL
	3	1	0	

Course Objective: The objective is to introduce students to differences in structure and function of different types of ecosystems and familiarize them with the variety of ways that organisms interact with the environment.

Course Outcome:	
S. No.	
1.	The course outcome of ecology and evolution is to equip students with the knowledge and skills to effectively increase the understanding of the causes, processes and consequences of evolution.
2.	To impart knowledge on the concepts of ecosystem, biosphere and ecosphere
3.	To understand the sustainable development and biodiversity phenomenon
4.	To equip students with the history of evolution
5.	To gain understanding on the evolutionary changes and their effects on society

S. No.	**Content**	**Contact Hours**
Unit 1	**Introduction to Ecology**: Relevance of studying ecology, its history, species	08
Unit 2	**Ecosystem, Biome, Biosphere and Ecosphere**: Abiotic factors, Laws of limiting factors	08

Unit 3	**Population & its growth**: Ecosystem, Sustainable Development, Biodiversity, Nutrient Cycles	11
Unit 4	**Introduction to Evolution**: Understanding history of evolution, Lamarckism and Darwinism	09
Unit 5	**Evolutionary changes & Society**: Population genetics, species concept & well- being of society	09
	Total	45

Books :

S.No.	**Name of Book/Author/Publisher**
1.	Environmental Studies Benny Joseph - Tata McGrawHill, 2005
2.	Ridley, M. Evolution. III Edition. Blackwell Publishing
3.	Essentials of Ecology & Evolution, Rana, S.V.S, PHI Publications
4.	Evolution, Barton, N.H. , Briggs. Cold Spring Harbour Laboratory Press

BIOENERGY AND BIOFUELS (IMSBT-)

Details of course:-

Course Title	**Course Structure**			**Pre-Requisite**
Bioenergy and Biofuels (IMSBT-)	L	T	P	NIL
	3	1	0	

Course Objective: The objective is to introduce students to different sources of renewable energy with sustainable ecosystem

Course Outcome:

S. No.	
1.	The course outcome of bioenergy and biofuels is to equip students with the knowledge and skills of renewable energy resources
2.	To impart knowledge on the production of bio-ethanol
3.	To gain understanding on the concepts of biodiesel production
4.	To equip students on the production of biohydrogen from bacteria
5.	To understand different examples reporting biofuel production

S. No.	**Content**	**Contact Hours**
Unit 1	**Introduction to Biofuels**: Global energy outlook, Importance of bioenergy, challenges and opportunities in bioenergy sector, Current status of research in India	08
Unit 2	**Production of Bio-ethanol:** Process technology for bio-ethanol production using sugar, starch, and lignocellulosic biomass,	08
Unit 3	**Production of Biodiesel:** Lipids as source of biodiesel, methods of biodiesel production. Biodiesel production from microalgae and future prospects	11
Unit 4	**Production of Biohydrogen:** Biohydrogen production from bacteria and photosynthetic algae, factors affecting its production, detection and quantification	09
Unit 5	**Case Studies:** Studies reporting use of biofuels as renewable energy sources and their efficiency compared to fossil fuels	09
	Total	45

Books :

S.No.	**Name of Book/Author/Publisher**

1.	Environmental Studies Benny Joseph - Tata McGrawHill, 2005
2.	Jonathan R.MBiofuels- Methods and Protocols. Humana Press
3.	Lisbeth Olsson, Biofuels. Springer-Verlag Publications
4.	Biofuels Engineering Process Technology, Caye M. Drapcho, N.P. Nhuan and T. H. Walker, Mc Graw Hill Publications

GENOMICS IN MEDICINE (IMSBT-)

Details of course:-

Course Title	**Course Structure**			**Pre-Requisite**
Genomics in Medicine (IMSBT-)	L	T	P	NIL
	3	1	0	

Course Objective: The objective is to introduce students to Metagenomics of infectious diseases, Detection of genetic disorders, and Translational and clinical research.

Course Outcome:	
S. No.	
1.	Genomics Concepts Understanding: Deep grasp of omics, sequencing tech, and their applications in human and microbial genomics.
2.	Infectious Disease Genomics Expertise: Proficiency in identifying pathogens, molecular epidemiology, and combating infectious diseases using genomics.
3.	Genetic Disorder Detection Proficiency: Skills in using genomics for disorder detection, understanding molecular basis, and exploring treatment options.
4.	Epigenomics and Non-coding RNAs Understanding: Grasp roles in disease, inheritance, and disease control for medical research and practice.

5.	Genomics in Translational Medicine Application: Apply genomics in translational medicine, clinical trials, and risk assessment with successful case study exposure.

S. No.	**Content**	**Contact Hours**
Unit 1	Introduction: Omics concepts and applications, sequencing of Human and other organisms	10
Unit 2	Metagenomics of infectious diseases: Role of Genomics in identification of microbes causing infectious diseases (microbiomes study), molecular epidemiology, host resistance to infection, pathogenicity, combating infectious diseases	08
Unit 3	Detection of genetic disorders: Genomics in detection of genetic disorders and treatment, pharmacogenomics	09
Unit 4	Epigenomics and non-coding RNAs: Role of Epigenomics and non-coding RNAs in disease development, inheritance and control	09
Unit 5	Translational and clinical trials: Genomics in translational and clinical trials, and risk assessments/prediction of genetic diseases with few successful case studies	09
	Total	45

Books :

S.No.	**Name of Book/Author/Publisher**
1.	Human Molecular Genetics, Third Edition (2003) T. Strachan and A.P. Read,Garland Science Publication.
2.	Molecular Cell Biology, Sixth Edition (2007) H. Lodish, A. Berk, and C.A.Kaiser, W. H. Freeman & Co Ltd.
3.	Genomics: The Science of Technology Behind the Human Genome Project(1999), Charles R. Cantor and Cassandra L. Smith, John Wiley & Sons, Inc.

4.	Genomics, personalized medicine and oral disease(2015) First edition, 2015, Springer publisher

PROTEIN ENGINEERING (IMSBT-)

Details of course:-

Course Title	**Course Structure**			**Pre-Requisite**
	L	T	P	
Protein Engineering (IMSBT-)	3	1	0	NIL

Course Objective: To impart advance knowledge on how to engineer proteins through a detailed study of protein structure, its characteristic properties and its significance in biological Systems.

Course Outcomes:	
1	Compare and contrast between different types of bonds in protein structure.
2	Understand amino acid structure, their molecular properties and chemical reactivity.
3	Analyse and determine the structure of protein.
4	To know the relationship between structure and function of DNA binding proteins,
5	Identify and analyse protein by 2D analysis, Mass Spectrometry.

S. No.	**Content**	**Contact Hours**
Unit 1	**Bonds and Energies in protein:** Covalent, Ionic, Hydrogen, Coordinate, hydrophobic and Vander walls interactions in protein structure.	8

Unit 2	**Amino acids and their characteristics:** Amino acids- structure with three and single letter codes, molecular properties (size, solubility,charge, pKa), Chemical reactivity in relation to post-translational modification.	9
Unit 3	**Protein architecture:** Primary structure- peptide sequencing, Secondary structure- methods to determine Supersecondary structure, Tertiary structure-overview of methods to determine 3D structures.	9
Unit 4	**Structure-function relationship:** DNA binding proteins-Prokaryotic transcription factors, Eukaryotic transcription factors, Membrane proteins.	9
Unit 5	**Identification and analysis of proteins:** Identification and analysis of proteins by 2D analysis, Mass spectrometry- ion source (MALDI, spray sources), analyser and detector.	10
	Total	45

Books :

S.No.	Name of Book/Author/Publisher
1	Lehninger's Principle of Biochemistry by DL Nelson, MM Cox. Publisher: WH Freeman
2	Biochemistry by D Voet, JG Voet. Publisher: Wiley
3	Biochemistry by CK Mathews, KE Van Holde, KG Ahern. Publisher: Benjamin/Cummings
4	Biochemistry by L Stryer. Publisher: WH Freeman and Company

MEDICAL MICROBIOLOGY (IMSBT-)

Details of course:-

Course Title	Course Structure	Pre-Requisite

Medical Microbiology (IMSBT-)	L	T	P	
	3	1	0	NIL

Course Objective: The course objective of Medical Microbiology is to provide students with a comprehensive understanding of microbial pathogens, their mechanisms of infection, and their role in human disease.

Course Outcome:	
S. No.	
1.	Understanding Normal Microflora: Grasp importance, distribution, and interaction with pathogens in the body.
2.	Proficiency in Diagnostic Techniques: Master clinical sample collection, transport, and diagnostic tests principles.
3.	Knowledge of Bacterial Diseases: Identify symptoms, transmission, and control measures for bacterial infections.
4.	Knowledge of Viral Diseases: Recognize symptoms, transmission routes, and control measures for viral infections.
5.	Understanding Protozoan and Fungal Diseases: Identify symptoms, transmission, and control measures for protozoan and fungal infections.

S. No.	**Content**	**Contact Hours**
Unit 1	Normal Microflora and Host Pathogen Interaction: Importance of normal microflora; microflora of skin, throat, GI tract, urogenital tract; definitions; transmission of infection; diagnostic tests principles.	10
Unit 2	Sample Collection and Diagnosis: Clinical sample collection, transport, culturing; principles of diagnostic tests like ELISA, PCR, DNA probes.	08

Unit 3	Bacterial Diseases: List and detail diseases, e.g., Streptococcus pyogenes, Escherichia coli, with symptoms, transmission, prophylaxis, and control measures.	09
Unit 4	Viral Diseases: List and detail diseases, e.g., Polio, Hepatitis, AIDS, with symptoms, transmission, prophylaxis, and control measures.	09
Unit 5	Protozoan and Fungal Diseases: List and detail diseases, e.g., Malaria, Candidiasis, with symptoms, transmission, prophylaxis, and control measures.	09
	Total	45

Books :

S.No.	**Name of Book/Author/Publisher**
1.	Ananthanarayan R. and Paniker C.K.J. (2009) Textbook of Microbiology. 8th edition, University Press Publication
2.	Brooks G.F., Carroll K.C., Butel J.S., Morse S.A. and Mietzner, T.A. (2013) Jawetz, Melnick and Adelberg's Medical Microbiology. 26th edition. McGraw Hill Publication
3.	Goering R., Dockrell H., Zuckerman M. and Wakelin D. (2007) Mims' Medical Microbiology. 4th edition. Elsevier

BIOINFORMATICS APPROACHES IN COMPLEX DISORDERS (IMSBT-)

Details of course:-

Course Title	**Course Structure**			**Pre-Requisite**
Bioinformatics approaches in complex disorders (IMSBT-)	L	T	P	Nil
	3	1	0	

Course Objective: The objective of this course is to familiarize students with the role of bioinformatics in understanding, analyzing, and interpreting the complex biological data associated with complex disorders. Students will learn to apply bioinformatics algorithms, tools, and databases to identify genetic variations, understand molecular mechanisms, and explore therapeutic interventions for complex diseases.

Course Outcome:	
S. No.	
1.	To identify and utilize various genetic databases relevant to complex disorders, such as SNP, mutation, and genetic marker databases, for the retrieval and visualization of genetic variations.
2.	To understand the types and mechanisms of genomic variations in complex disorders and apply bioinformatics tools for mapping and analyzing these variations to assess disease risk.
3.	To apply bioinformatics tools and techniques for visualizing structural information of proteins and managing pharmacogenomic information.
4.	To conduct phylogenetic analysis and utilize prediction tools for studying genetic relationships in complex disorders.
5.	To understand the role of bioinformatics in the drug discovery and development process for complex disorders.

S. No.	**Content**	**Contact Hours**
Unit 1	**Introduction to Complex Disorders and Bioinformatics** Overview of complex disorders: Definition, characteristics, and examples. Role of bioinformatics in understanding genetic and environmental factors in complex disorders. Introduction to databases relevant to complex disorders: SNP databases, Mutation databases, Genetic marker, and microsatellite databases, Nonnuclear and somatic mutation databases. Tools for SNP and mutation visualization.	**9**
Unit 2	**Genomic Variations in Complex Disorders**	**9**

	Types and mechanisms of genetic variation in the context of complex disorders. Use of bioinformatics tools and databases for mapping genetic variations and mutations. Relationship between polymorphism and genetic variation. Genetic variation and risk of complex diseases	
Unit 3	**Bioinformatics Tools and Techniques** Application of Structure Databases (PDB, MMDB) in visualizing structural information of proteins related to complex disorders. Pharmacogenomics and Personalized Medicine: Introduction, historical perspectives, and current status. Management of pharmacogenomic information: PharmGKB, DrugBank.	**9**
Unit 4	**Molecular Phylogenetics and Genetic Analysis** Phylogenetic prediction, types, tree building methods, and tree interpretation analysis. Utilization of phylogenetic prediction tools for studying complex disorders. Differentiating between identity and similarity, orthologs, and paralogs. Identifying homology between sequences related to complex disorders.	**9**
Unit 5	**Bioinformatics in Drug Discovery and Development for Complex Disorders** Introduction to the drug discovery and development process for complex disorders. Role of bioinformatics in target identification and validation. High-throughput screening and molecular modeling. Case studies on bioinformatics applications in drug discovery for complex disorders.	**9**
	Total	**45**

Books :

S.No.	**Name of Book/Author/Publisher**
1.	Hasija, Y., "All About Bioinformatics: From Beginner to Expert", 2023.
2.	Hasija, Y., Chakraborty, R., "Hands on Data Science for Biologists Using Python", 2021.
3.	"Translational Biotechnology: A Journey from Laboratory to Clinics", Editor: Yasha Hasija, 2021.

4.	Lesk, A. M., "Introduction to Bioinformatics", Oxford University Press, Latest Edition

CONCEPTS IN NEUROBIOLOGY (IMSBT-)

Details of course:-

Course Title	**Course Structure**			**Pre-Requisite**
Concepts in Neurobiology (IMSBT-)	L	T	P	
	3	1	0	NIL

Course Objective: The objective is to introduce students to the fundamental principles of neuroscience including neuronal structure and function, neural communication, and the organization of nervous system.

Course Outcome:	
S. No.	
1.	Understand brain structure, synapses, receptors, and neurotransmitter functions.
2.	Explain molecular/cellular neurobiology, neural development, and neuroplasticity principles.
3.	Define, analyze pathophysiology, treatments, and societal impact of neurodegenerative disorders.
4.	Describe neuromuscular junctions, pathophysiology, treatments, and neuron-muscle interplay
5.	Explain neuroprotection, neuroprosthetics, neuroinformatics, treatments, and future directions.

S. No.	Content	Contact Hours
Unit 1	Introduction: Fine structure of the brain and its function, synapses, receptors and neurotransmitters	09
Unit 2	Basic neuroscience: molecular and cellular neurobiology and basic knowledge of general neurobiology	09
Unit 3	Neurodegenerative disorders: General description, Alzheimer's disease, Huntington's disease, Poly Q disorders, Amyotrophic Lateral 09Sclerosis (ALS)	09
Unit 4	Cross-talk between neurons and muscles: Parkinson's disease, Inclusion body myositis (IBM), Polymyositis (PM)	09
Unit 5	Neurotherapeutics and neuroinformatics: Action of biomolecules in neuroprotection, neuroprosthetics	09
	Total	45

Books :

S.No.	Name of Book/Author/Publisher
1.	Bear, Mark F., Barry W. Connors, and Michael A. Paradiso. Neuroscience: Exploring the Brain, 3rd ed. Baltimore, MD: Lippincott Williams & Wilkins, 2006. ISBN: 9780781760034
2.	Duane E. Haines PhD FAAAS FAAA (Author), Gregory A. Mihailoff PhD Fundamental Neuroscience for Basic and Clinical Applications, Elsevier
3.	Neuroscience (English, Hardcover, Bear Mark F.), Publisher: Lippincott Williams and Wilkins, ISBN: 9780781778176, 0781778174, Pages: 1008

PLANT BIOINFORMATICS (ISMBT-)

Details of course:-

Course Title	Course Structure			Pre-Requisite
Plant Bioinformatics (ISMBT-)	L	T	P	
	3	1	0	Nil

Course Objective: Plant Bioinformatics studies pave the way to understand plant evolution, and use this knowledge to improve crops. Plant Bioinformatics carries benefits for plant researchers. It can aid in plant breeding and genetic engineering, and allow plant scientists to produce better crops for the future.

Course Outcome:	
1.	Understand the importance of plant bioinformatics in modern biological research.
2.	Analyze genomic data pertaining to different plant species.
3.	Utilize software tools to discover phylogenies and interpret the results.
4.	Apply bioinformatic approaches to manage and analyze germplasm data.
5.	Perform manual annotations and computational annotation methods for gene structure.

S. No.	Content	Contact Hours
Unit 1	Introduction to Plant Bioinformatics:Importance of plant bioinformatics, biological databases , Protein and Gene Information Resources – PIR, SWISSPROT, PDB, genebank.	9
Unit 2	Plant specific Genomic Data and Resources: HarvEST, TARI Database, Legume Resources, GrainGenes, Maize GDB, Gramene	9
Unit 3	Phylogenetic data and phylogenies Software used to discover phylogenies, use and status of specimen data,	9

	species distribution, Current priorities in biodiversity informatics, challenges and future prospect	
Unit 4	KEGG Bioinformatic Resource for Plant Genomic Research: KEGG tools and Resources, Germplasm Data Management.	9
Unit 5	Gene Structure Annotation at Plant GDB: PlantGDB Resources, Gene Ontology Annotation, Manual Annotations, Computational Annotation Methods	9
	Total	45

Books :

S.No.	**Name of Book/Author/Publisher**
1.	Plant Genomics: Methods and Protocols, Daryl J. Somers, Peter Langridge and J. Perry Gustafson, Humana Press, 2009.
2.	Plant Bioinformatics: Methods and Protocols, David Edwards, Humana Press, 2007.
3.	Plant Genomics and Proteomics, CHRISTOPHER A. CULLIS, John Wiley & Sons, Inc. 2004

PHARMACOGENOMICS AND PERSONALISED MEDICINE(IMSBT-)

Details of course:

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Pharmacogenomics and Personalized Medicine (IMSBT-)	3	1	0	Nil

Course Objective: Pharmacogenomics and Personalized Medicine course is to educate students on the principles and applications of pharmacogenomics in tailoring medical treatments to individual genetic variations. The course aims to familiarize students with the genetic basis of drug response variability, including pharmacokinetic and pharmacodynamic factors, and to explore how genomic information can be used to optimize drug selection, dosage, and treatment strategies for improved therapeutic outcomes and reduced adverse drug reactions.

Course Outcome:	
S. No.	
1.	To demonstrate an understanding of genetic variations influencing drug response, including pharmacokinetic and pharmacodynamic factors, and their impact on individualized treatment outcomes.
2.	To apply pharmacogenomic testing and analysis techniques to predict drug response, optimize drug selection and dosing, and minimize adverse reactions based on individual genetic profiles.
3.	Develop skills in integrating pharmacogenomic information into clinical decision-making processes, including patient assessment, drug therapy management, and treatment plan optimization for personalized medicine approaches.
4.	Critically evaluate ethical, legal, and societal issues related to pharmacogenomics and personalized medicine, including genetic privacy, informed consent, healthcare equity, and the impact of genetic testing on patient care and healthcare policy.
5.	To explore current trends and advancements in pharmacogenomics research and innovative technologies, critically analyze scientific literature, and propose potential applications of pharmacogenomic strategies in improving patient outcomes and healthcare delivery.

S. No.	Content	Contact Hours
Unit 1	**Fundamentals of Pharmacogenomics:** Introduction to Pharmacogenomics: Concepts and historical perspective, Genetic Polymorphisms and Drug Metabolism, Pharmacokinetics and Pharmacodynamics.	9
Unit 2	**Technologies in Pharmacogenomics**: Genomic Technologies: DNA sequencing, microarrays, and SNP analysis; Bioinformatics Tools for Genetic Analysis: Data mining and interpretation of genetic data; Biomarkers and Their Role in Personalized Medicine	10
Unit 3	**Pharmacogenomics in Clinical Practice**: Implementing Pharmacogenomic Testing in Clinical Settings: Challenges and Considerations, Drug Labeling and Regulatory Aspects: FDA guidelines, National and International perspectives.	9
Unit 4	**Personalized Medicine:** Integrating clinical and environmental factors in personalized medicine, The Future of Personalized Medicine: Next-generation sequencing, CRISPR, Personalized Medicine in Oncology, Cardiovascular Diseases, and Psychiatric Disorders.	10
Unit 5	**Ethical, Legal, and Social Implications (ELSI)**: Privacy and Confidentiality of Genetic Information, Direct-to-Consumer Genetic Testing: Pros and cons, Ethical Considerations in Clinical and Research Settings.	7
	Total	45

Books:

S.No.	Name of Book/Author/Publisher
1.	Pharmacogenomics: Challenges and Opportunities in Therapeutic Implementation by Yui-Wing Francis Lam and Larisa H. Cavallari- Academic Press, 2019

2.	Principles of Pharmacogenetics and Pharmacogenomics edited by Russ B. Altman, David Flockhart, and David B. Goldstein- Cambridge University Press, 2012
3.	Essentials of Pharmacogenomics by Daniel L. Hartman and Daniel M. Roden.- Sinauer Associates, 2009
4.	Clinical Pharmacogenetics by Richard M. Weinshilboum and Liewei Wang- McGraw-Hill Education, 2012
5.	Pharmacogenomics in Clinical Therapeutics by Yusuke Nakamura and Urs A. Meyer- CRC Press, 2013

AGRICULTURE MICROBIOLOGY (IMSBT-)

Details of course:

Course Title	**Course Structure**			**Pre-Requisite**
Agriculture Microbiology (IMSBT-)	L 3	T 1	P 0	

Course Objective: Agriculture microbiology provides in depth knowledge about complex interaction between agriculture system and micro-organismsand introduce micro-organism in agricultural system for building a pathway for sustainable agriculture.

Course Outcomes:	
1	Understand the History and basics of Microbiology.
2	To comprehend the mechanism of ATP generation in bacteria during respiration.
3	To gain knowledge about different microbes and their roles.
4	Understand microbiology of food spoilage and food preservation.
5	Apply the benefits of microorganisms in agriculture.

S. No.	Content	Contact Hours
Unit 1	**Introduction History of Microbiology** Spontaneous generation theory, Role of microbes in fermentation, Germ theory of disease, Plant Protection against infections.	9
Unit 2	**Metabolism** Metabolism in bacteria: ATP generation, respiration, fermentation. Bacteriophages: structure and properties of Bacterial viruses–Lytic and Lysogenic cycles.	9
Unit 3	**Microbial diversity** Microbial groups in soil, microbial transformations of carbon, nitrogen, phosphorus and sulphur, Microflora of Rhizosphere and Phyllosphere,	9
Unit 4	**Food microbiology** Microbiology of food microbial spoilage and principles of food preservation.	8
Unit 5	**Microrganisms in agriculture** Beneficial microorganisms in Agriculture: Biofertilizer (Bacterial Cyanobacterial and Fungal), microbial insecticides, Biodegradable plastics, Plant– Microbe interactions.	10
	Total	45

Books :

S.No.	Name of Book/Author/Publisher
1	Industrial Microbiology: An Introduction by Michael J. Waites, Wiley-Blackwell (2009)
2	General microbiology by R.Y. Stanier, J.L. Ingraham, M.L. Wheelis and P.R. Painter. Publisher: Macmillan (1987)

3	Microbiology by Prescot Harley and Kliein. Publisher: Mc Graw Hill (2007)
4	Microbiology by M.J. Pelczar, E.C.S. Chan and N.R. Kreig. Publisher: Tata McGraw Hill (2005)

SYSTEM BIOLOGY (IMSBT-)

Details of course:

Course Title	**Course Structure**			**Pre-Requisite**
	L	T	P	
System Biology (IMSBT-)	3	1	0	Nil

Course Objective: The system biology course seeks to provide students with a holistic understanding of biological systems by integrating knowledge from biology, mathematics, computer science, and statistics. The course objectives include comprehending the complexity of biological networks, learning mathematical and computational modeling techniques, analyzing large-scale biological data, exploring applications in biomedicine and biotechnology, and discussing ethical and societal implications.

Course Outcome:	
S. No.	
1	To demonstrate proficiency in systems thinking by analyzing biological systems as interconnected networks of components, understanding emergent properties, and identifying feedback loops and system dynamics.
2	Develop skills in mathematical and computational modeling techniques, including deterministic and stochastic models, network analysis, and dynamic systems modeling, to describe and simulate biological processes.
3	Apply statistical methods, machine learning algorithms, and bioinformatics tools to analyze and interpret large-scale biological data sets, such as genomics, proteomics, and metabolomics data.

4	Integrate knowledge from biology, mathematics, computer science, and statistics to address complex biological questions, design experiments, and develop computational models for understanding and predicting biological phenomena.
5	Critically evaluate ethical, legal, and societal implications of systems biology research and applications, considering issues related to data privacy, genetic engineering, healthcare decision-making, and the responsible use of technology in biomedicine and biotechnology.

S. No.	**Content**	**Contact Hours**
Unit 1	**Introduction to Systems Biology:** Overview of Systems Biology: Definitions, scope, and importance. Historical Perspectives and Key Concepts. Systems Biology vs. Traditional Molecular Biology Approaches.	8
Unit 2	**Biological Networks and Systems**: Types of Biological Networks: Metabolic, Genetic, Protein-Protein Interaction (PPI) Networks. Network Properties and Analysis: Topology, Motifs, and Modules. Introduction to Network Visualization Tools.	10
Unit 3	**Omics Technologies and Systems Integration:** Overview of Omics Technologies: Genomics, Transcriptomics, Proteomics, Metabolomics, Integrative Analysis of Omics Data.	8
Unit 4	**Modeling Biological Systems:** Mathematical Modeling in Systems Biology: Deterministic and Stochastic Models, Dynamic Systems and Kinetic Modeling, Simulation of Biological Processes.	10
Unit 5	**Systems Biology in Health and Disease**: Systems Pharmacology and Drug Discovery, Systems Biology Approaches to Understanding Disease Mechanisms, Personalized Medicine and Systems Biology.	9
	Total	45

Books:

S.No.	Name of Book/Author/Publisher
1.	An Introduction to Systems Biology: Design Principles of Biological Circuits by Uri Alon - Chapman and Hall/CRC, 2006
2.	Systems Biology: A Textbook by Edda Klipp, Wolfram Liebermeister, Christoph Wierling, Axel Kowald, Hans Lehrach, and Ralf Herwig- Wiley-Blackwell, 2016 (2nd Edition)
3.	Systems Biology: Simulation of Dynamic Network States by Bernhard Palsson- Cambridge University Press, 2011
4.	Ingalls, Brian P. Mathematical Modeling in Systems Biology: An Introduction (1st edition). MIT Press, 2013.
5.	Wilkinson, Darren J. Stochastic Modelling for Systems Biology. Chapman & Hall, 2006.

CROP PROTECTION AND PEST MANAGEMENT (IMSBT-)

Details of course: -

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Crop protection and pest management (ISMBT-)	3	1	0	Nil

Course Objective: To provide a basic knowledge of pest control and yield enhancement.

Course Outcome:	
1.	Understanding the issue related to crop protection and role of pests

2.	Identification of pathogens causing damages to crops and their solutions
3.	Learning the role of genetic engineering in enhancing crop yield and pest management
4.	Knowledge of various control methods and stress resistance in protecting crop from various damages
5.	Analyzing the role of technology and learning about integrated pest management

S. No.	Content	Contact Hours
Unit 1	**Introduction to crop protection:** Losses in crops due to pests, Importance of plant diseases, Classification of plant diseases, Causes and symptoms of plant diseases, Disease epidemics, Prevention of epidemics	9
Unit 2	**Pathogenecity:** Genetics of pathogenocity, Pathotypes, Mechanism of disease resistance, breeding for disease and insect resistance	9
Unit 3	**Genetic engineering and stress resistance:** Genetic engineering for improvement of disease resistance, Genetic manipulation of Crops for insect resistance, herbicide resistance, abiotic stress resistance	9
Unit 4	**Chemical and Biological control-** Concepts and techniques, Bio-organism for pest Management, Bt based pesticides, Baculovirus pesticides, Mycopesticides, production and formulation technologies.	9
Unit 5	**Integrated pest management:** Principles of integrated Pest Management (IPM), IPM practices for important crops	9
	Total	45

Books :

S.No.	Name of Book/Author/Publisher
1.	Brock T.D. and Modigaa M.T. (Latest edition) Biology of Microorganisms, Prentice Hall, New Jersey Pelczar M.J; Chan E.C.S. and Kreig N.R. 1993.
2.	Microbiology, Tata Mc-Graw HTK Publishing Co., New Delhi. Stainer, R.Y; Ingram J; Wheelis, M.G. and Paintor, P.R. 1986
3.	The Microbial World-Prentice Hall-New Jersey Alexander M. 1985
4.	Introduction to soil Microbiology John Wileys & Sons, New York Rangaswamy. G and Bagyaraj, D.I. (1992)
5.	Agricultural Microbiology, Asia Publishing House, New York. Subba Rao N.S. 1987Advance in Agricultural Microbiology, Oxford & IBH.

MOLECULAR THERAPEUTICS (IMSBT-)

Details of course:-

Course Title	Course Structure			Pre-Requisite
Molecular Therapeutics	L	T	P	
	3	1	0	NIL

Course Objective: The course objective of Molecular Therapeutics is to examine the principles and applications of molecular techniques in the development and implementation of therapeutic interventions for human diseases.

Course Outcome:	
S. No.	
1.	Understanding Molecular Therapeutics Importance: Grasp significance, focusing on molecular targets and drug discovery principles.
2.	Knowledge of Molecular Disease Basis: Explore genetic causes, pathology, and biomarker applications in major diseases.
3.	Proficiency in Pharmacogenomics and Personalized Medicine: Understand genetic variations' impact and apply molecular profiling for personalized treatment.
4.	Expertise in Molecular Targets and Therapeutic Approaches: Identify targets, comprehend drug design principles, and therapeutic mechanisms.
5.	Awareness of Emerging Trends: Learn about nanomedicine, CRISPR/Cas9, and navigate ethical/regulatory challenges in molecular therapeutics advancement.

S. No.	**Content**	**Contact Hours**
Unit 1	**Molecular Therapeutics Overview**: Define and highlight importance, focusing on molecular targets and drug discovery principles.	10
Unit 2	**Molecular Basis of Disease**: Explore genetic causes, molecular pathology, and biomarker use in major diseases.	08
Unit 3	**Pharmacogenomics and Personalized Medicine**: Understand genetic variations' role, molecular profiling, and personalized treatment with case studies.	09
Unit 4	**Molecular Targets and Therapeutic Approaches**: Target identification, small molecule and biologic therapeutics, emphasizing drug design and mechanisms.	09
Unit 5	**Emerging Trends and Future Directions**: Cover nanomedicine, CRISPR/Cas9, and ethical/regulatory challenges in advancing molecular therapeutics.	09
	Total	45

Books:

S.No.	Name of Book/Author/Publisher
1.	Molecular and Cellular Therapeutics, WILEY-BLACKWELL
2.	Molecular Therapeutics: 21st Century Medicine, PAMELLA GREENWELL

STRUCTURAL BIOLOGY AND BIOPHYSICS (IMSBT-)

Details of course:-

Course Title	Course Structure			Pre-Requisite
Structural biology and biophysics (IMSBT-)	L	T	P	
	3	1	0	

Course Objective: To study the Protein structure folding mechanism and structures of DNA RNA. Advanced biophysics technique for studying the structure of biological components

Course Outcomes:	
1.	Gain knowledge on the structure of Proteins, DNA RNA
2.	Enlist the different types of techniques used to study the structure and characteristics of Protein.
3.	Aquire knowledge about optical techniques used.
4.	Compare and identify the methods of potentials energy optimization
5.	Aquire knowledge on protein modelling

S. No.	Content	Contact Hours
Unit 1	**Introduction**: Peptide Bonds,hydrogen bonding, ionic and hydrophobic interactions. Protein Structure, Analysis and manipulation of structures, Ramachandran plots, Chaperones and Chaperonins, Structure Determination, Dynamics Simulation, Protein Folding, Nucleic Acid Structure- DNA/RNA, Structural Biology for the Optimization of Gene Therapy Vectors,	8
Unit 2	**X-Ray Crystallography Computing & NMR Structure Determination:** X-ray Crystallography Computing, NMR Structure Determination: Nuclear Magnetic Resonance, Structural Analysis	11
Unit 3	**Optical spectroscopy:** Absorbance spectrum and melting of a protein, circular dichroism, Thermodynamics of macromolecular transitions, Mass spectroscopy, crystallographic statistics	8
Unit 4	**Potential Energy Minimization:** Potential Energy Function, Local Optimization, Global Optimization, Energy Transformation	8
Unit 5	**Knowledge-based Protein Modeling:** Sequence/Structural Alignment, Fold Recognition/Inverse Folding, Knowledge-based Structural Refinement, Structural Computing, Comparative and *ab initio* modelling	10
	Total	**45**

Books:

S.No.	Name of Book/Author/Publisher
1.	Principles of Biochemistry, D. L. Nelson and M.M. Cox, Lehninger, W. H. Freeman; Fourth Edition, 2004.
2.	Structural Genomics and High-Throughput Structural Biology, Michael Sundström, Martin Norin, Aled Edwards, CRC Press, 2006.
3.	The Physical Basis of Biochemistry: The Foundations of Molecular Biophysics, P.R. Bergethon Springer, Corrected edition, 2000.
4.	Principles of Physical Biochemistry K.E van Holde, C.Johnson, and P.Shing Ho, Prentice Hall, Second edition, 2005.

5.	Lecture Notes on Computational Structural Biology, Zhijun Wu, World Scientific Publishing Co. Pte. Ltd. 2008.

GENE THERAPY (IMSBT-)

Details of course:-

Course Title	**Course Structure**			**Pre-Requisite**
	L	T	P	
Gene Therapy (IMSBT-)	3	1	0	Knowledge of genes, their expression and genetic engineering

Course Objective: To get insight into the mechanisms of genetic manipulation for disease treatment

Course Outcomes:	
1.	To understand the concept of gene therapy
2.	To gain insight into the gene delivery systems
3.	To compare and contrast *in vivo* and *ex vivo* gene therapy
4.	To appraise the mechanism of gene therapy for cancer treatment
5.	To comprehend gene therapy mechanisms for various disorders

S. No.	**Content**	**Contact Hours**
Unit 1	Introduction: Overview of gene therapy; Somatic gene therapy; Germline gene therapy, Gene editing; Gene replacement; Gene addition; Gene therapy vs cell therapy	**10**

Unit 2	Vehicles for Gene Transfer: Vector considerations; Expression vectors; Vector design; Viral vectors; Nonviral vectors; DNA vaccines; Liposomes; Lipoplexes; Naked DNA; Transposon; Transgenic animal models	**8**
Unit 3	*In vivo* and *Ex vivo* Gene Therapy: Vectors for *in vivo* and *ex vivo* gene therapy; *In vivo* gene therapy indications; Vector delivery for *in vivo* gene therapy	**8**
Unit 4	Genome Editing and Targeting: CRISPR-Cas9; TALEN; ZnF; Meganucleases; Genome targeting	**9**
Unit 5	Gene Therapy and Diseases: Cancer Gene Therapy; Cystic fibrosis; Duchnne muscular dystrophy; Bleeding disorders; Tyrosinemia; Severe combined immunodeficiency syndrome; Nonheritable disorders	**10**
	Total	**45**

Books:

S.No.	Name of Book/Author/Publisher
1.	The Development of Human Gene Therapy by T Friedman. Publisher: CSHL Press
2.	Fields Virology by DM Knipe, PM Howley. Publisher: Lippincott
3.	Gene Therapy: Therapeutic Mechanisms and Strategies by NS Templeton, DD Lasic. Publisher: Taylor & Francis
4.	Genetic Engineering by S Rastogi, N Pathak. Publisher: OUP

DATABASE MANAGEMENT IN BIOTECHNOLOGY (IMSBT-)

Details of course:-

Course Title	Course Structure			Pre-Requisite
Database Management in Biotechnology (IMSBT-)	L 3	T 1	P 0	Nil

Course Objective:

1.Understand the principles of database management and data organization.

2.Learn to design, implement, and manage databases for biological data.

3.Gain proficiency in SQL and other data manipulation languages.

4.Explore the use of bioinformatics databases and tools in biotechnology.

5.Develop skills in data mining and analysis for biotechnological applications.

Course Outcome:	
S. No.	
1	To grasp the essentials of DBMS and recognize their importance and application in biotechnology.
2	Understanding the types and uses of bioinformatics databases and the significance of data retrieval tools in biotech research.
3	Learn database design principles and modeling techniques suitable for managing complex biological data.
4	Acquire skills in data warehousing, data mining, and their application in biotechnological data analysis.
5	Explore advanced database management topics including big data analytics, cloud computing, and ethical considerations in data handling.

S. No.	Content	Contact Hours

Unit 1	**Introduction to Database Management Systems:** Definition, importance, and applications in biotechnology, Types of Databases: Relational, NoSQL, and their relevance to biotech data, Data Models: Hierarchical, Network, Relational, and Object-oriented models	9
Unit 2	**Bioinformatics Databases**: Biological Data Types: Genomic, proteomic, metabolomic, and phenotypic data, Public Bioinformatics Databases: NCBI, EMBL-EBI, DDBJ, and their applications, Data Retrieval and Analysis Tools: BLAST, FASTA, and their usage in biotech research	9
Unit 3	**Database Design and Data Modeling:** Entity-Relationship (ER) Model: Conceptual design with ER diagrams, Normalization: Purpose, processes, and implications for biological data, SQL: Basics of Structured Query Language for creating and managing databases.	9
Unit 4	**Data Warehousing and Data Mining in Biotechnology:** Data Warehousing Concepts: Architecture, OLAP operations, and use cases in biotech, Data Mining Techniques: Classification, clustering, association analysis in genomic and proteomic databases, Case Studies: Applications of data mining in drug discovery, genomics, and disease prediction.	9
Unit 5	**Advanced Topics in Database Management:** Big Data Analytics: Handling large-scale biotech data, tools, and technologies, Cloud Computing and Databases: Cloud storage solutions for bioinformatics data, Ethical and Legal Aspects: Data privacy, security concerns, and regulations in biotechnology data management.	9
	Total	45

Books :

S.No.	Name of Book/Author/Publisher
1.	Vince Buffalo – Bioinformatics Data Skills– O'Reilly Media 2015.
2.	Abraham Silberschatz, Henry F. Korth, and S. Sudarshan– Database System Concepts – 7th Ed McGraw-Hill Education, 2020

3.	Jake Chen and Amandeep S. Sidhu– Biological Database Modeling– Artech House, 2007

DEPARTMENT OF BIOTECHNOLOGY

DELHI TECHNOLOGICAL UNIVERSITY: DELHI
Established under Govt. of Delhi Act 6 of 2009
Shahbad Daulatpur, Bawana Road, Delhi-110042

Integrated M.Sc syllabus

(GENERIC ELECTIVE COURSES)

Current Topics in Biotechnology (IMSBT-)

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Current Topics in Biotechnology (IMSBT-)	3	1	0	Knowledge of basic Biotechnology techniques

Course Objective: To make the students aware of the thrust research areas in Biotechnology

Course Outcomes:	
1	To gain insight into the latest in the field of stem cell research
2	To appraise the significance of RNA as therapeutics and vaccines
3	To comprehend the genome wide editing and protein engineering tools
4	To understand the role of biomaterials and biosensors in the field of medicine
5	To appraise the concept of personalized medicine

S. No.	Content	Contact Hours
Unit 1	**Stem Cell Research:** Advancements in stem cell research; Stem cell banks; Cellular reprogramming; Tissue engineering; Organ transplantation; Organoids; Regulations and ethical considerations	**10**
Unit 2	**Genome Editing and Protein Engineering:** CRISPR-Cas9; TALEN; ZnF; Meganucleases; Design of new enzymes with new or desirable functions; Site directed mutagenesis	**10**
Unit 3	**Omics Revolution:** Lipidomics; Metabolomics; Metagenomics, Transcriptomics	**8**
Unit 4	**Biomaterials and Drug Delivery:** Types and applications of biomaterials; Biomimetics; Advancements in drug delivery	**8**

Unit 5	**RNA-Based Therapeutics &Vaccines and Precision Medicine:** RNA therapeutics; mRNA vaccines; Pharmacogenomics; DNA banks; Case studies	**9**
	Total	**45**

Books:

S.No.	Name of Book/Author/Publisher
1.	Essentials of Stem Cell Biology by RP Lanza, A Atalla. Publisher: Academic Press
2.	Stem Cells and Biomaterials for Regenerative Medicine by MJ Los, A Hudecki, E Wiechec. Publisher: Elsevier
3.	Stem Cell Engineering Principles and Applications by GM Artmann, S Minger, J Hescheler. Publisher: Springer
4.	The Science of Stem Cells by JMW Slack. Publisher: Wiley-Blackwell
5.	Principles of Gene Manipulation and Genomics by SB Primrose. Publisher: John Wiley
6.	RNA Therapeutics by PH Giangrande, V de Franciscis, JJ Rossi. Publisher: Elsevier
7.	RNA Vaccines: Methods and Protocols by T Kramps, K Elbers. Publisher: Humana Press
8.	Genome Editing by K Turksen. Publisher: Springer Cham
9.	Genome Editing: Current Technology Advances and Applications for Crop Improvement by Wani SH, G Hensel. Publisher: Springer Cham
10.	Genome Editing and Engineering by K Appasani. Publisher: CUP
11.	Lipidomics: Current and Emerging Techniques by W Griffiths, Y Wang. Publisher: Royal Society of Chemistry
12.	Metabolomics: From Fundamentals to Clinical Applications by A Sussulini. Publisher: Springer Cham
13.	Metagenomics Methods and Protocols by WR Streit, R Daniel. Publisher: Humana NY
14.	Biomaterials And Nanotechnology for Tissue Engineering by E Arendse. Publisher: Scitus Academics
15.	Biomaterials: An Introduction by Park J, RS Lakes. Publisher: Springer Science & Business Media
16.	Pharmacogenomics: Social, Ethical and Clinical Dimensions by MA Rothstein. John Wiley & Sons
17.	Pharmacogenomics in Drug Discovery & Development by Q Yan. Humana Totowa, NJ
18.	Pharmacogenomics - Challenges and Opportunities in Therapeutic Implementation by YWF Lam, SR Scott. Publisher: Elsevier

Biopolymers (IMSBT)

Details of course:-

Course Title	Course Structure			Pre-Requisite
Biopolymers (IMSBT-)	L 3	T 1	P 0	

Course Objective: To introduce students to various classes of biopolymers and to develop understanding regarding the characteristics of the materials and its application.

Course Outcomes:	
1.	Understand the structure, function and use of biopolymers.
2.	Identify the molecular architecture for biological structures
3.	Illustrate the biomedical materials and "drug delivery" formulations.
4.	Analyze the degradation mechanisms in polymeric materials.
5.	Demonstrate the environmental issues when using polymers.

S. No.	Content	Contact Hours
Unit 1	Structure, function, properties and use of biopolymers.	9
Unit 2	Molecular architecture for some biological structures such as collagen, tissue, silk, wool, spider's thread, shell.	9
Unit 3	Introduction to biomedical materials and "drug delivery" formulations. Biocomposites and biominerals	9
Unit 4	Degradation mechanisms in polymeric materials. Degradation products in different environments.	9
Unit 5	Environmental issues when using polymers. Polymer characterization in environmental analysis	9
	Total	45

Books :

S.No.	Name of Book/Author/Publisher
1	Advances in Physicochemical Properties of Biopolymers: Edited by Martin Masuelli, Denis Renard
2	Handbook of Biopolymers Edited by Sabu Thomas, Ajitha AR, Cintil Jose Chirayil, Bejoy Thomas.

Course: Cancer Biology

Course title	Course structure	Pre-requisite

	L	P	T	
Cancer Biology (IMSBT-)	3	1	0	Nil

Course Objective
Cancer management and support services in oncology.

Course Outcome	
S.No.	
1.	Understanding the fundamental concepts and terminology related to cancer biology.
2.	Identifying the molecular mechanisms underlying cancer initiation; progression; and metastasis.
3.	Elucidating the various diagnostic methods used in cancer detection and treatment of cancer.
4.	Evaluating different treatment options available for cancer patients and analyzing the role of personalized medicine in oncology.
5.	Recognizing and analyzing ethical issues and considerations in cancer research; patient care; and policymaking

S.no	**Content**	**Contact Hours**
Unit 1	**Introduction to Cancer** Understanding cancer: Definition and its types; Causes and risk factors for cancer development; Basic concepts in cellular biology: Cells, DNA; and genetics in oncology.	**10**
Unit 2	**Fundamentals of Cancer Biology** Molecular mechanisms of cancer initiation and progression; Role of genetic mutations in cancer development; Overview of tumor formation and growth; Introduction to the tumor microenvironment and its Influence on Cancer Progression.	**10**

Unit 3	**Diagnostic Methods and Cancer Treatment** Methods for detecting cancer: Screening programs and diagnostic tests; Imaging techniques in cancer diagnosis: X-ray, MRI, CT scan, Biopsy procedures and their role in cancer diagnosis; Overview of cancer treatments: Surgery, Chemotherapy, and Radiation therapy	**10**
Unit 4	**Cancer Medicine and Personalized Approaches** Basics of pharmacology in cancer medicine; Introduction to targeted therapy and immunotherapy; challenges in cancer therapeutics and new approaches; case studies.	**7**
Unit 5	**Policies, Ethics, and Patient Management in Oncology** Formulation of cancer policies and regulations; Ethical considerations in cancer research and patient care; Patient management and support services in oncology; Palliative care oncology	**8**
	Total	**45**

Reference books/ links

S.no	**Name of book/author/publisher**
1.	"Cancer: A Very Short Introduction" by Nick James - Part of the "Very Short Introduction" series
2.	"Hallmarks of Cancer: The Next Generation" by Douglas Hanahan and Robert A. Weinberg
3.	"The Biology of Cancer" by Janice Ann Gabriel

Biomaterials (IMSBT-)

Details of course:-

Course Title	**Course Structure**			**Pre-Requisite**
Biomaterials (IMSBT-)	L	T	P	
	3	1	0	NIL

Course Objective: To study the structure and characteristics of different types of biomaterials of natural and synthetic origin. This course will give an idea on the effective uses of these materials in medical science

Course Outcomes:	
1.	Explain biomaterials definition, requirements, properties, biological responses involved in biomaterials.
2.	Differentiate various metallic implant material
3.	Distinguish between different types of composite implant materials.
4.	Classify of different polymeric implant material.
5.	Interpret the biocompatibility of biomaterials

S. No.	**Content**	**Contact Hours**
Unit 1	**Introduction:** Definition, requirements of biomaterials, Comparison of properties of some common biomaterials, effects of physiological fluid, biological responses, physical and surface properties.	8
Unit 2	**Metallic implant materials:** Stainless steel- Co-based alloys- Ti and Ti-based alloys, corrosion behaviour, Hard tissue and soft tissue replacement implant.	11
Unit 3	**Ceramic and composite implant materials:** Types of bioceramics, Importance of wear resistance, Composite implant materials-	8
Unit 4	**Polymeric implant materials:** Classification, Biodegradable polymers for medical purposes, Synthetic polymeric membranes and their biological applications.	8
Unit 5	**Testing of Biomaterials:** Biocompatibility, blood compatibility Toxicity tests, *In-vitro* and *In-vivo* testing.	10
	Total	**45**

Books:

S.No.	**Name of Book/Author/Publisher**
1.	S. V. Bhat. Biomaterials, Springer.
2.	J.B. Parkand, JD Boonzino. Biomaterials: Principles and Application, CRC Press.
3.	J. Black. Biological Performance of materials, Taylor & Francis.
4.	J. B. Parkand, R. S. Lakes. An Introduction to Biomaterials, Springer.
5.	B. D. Ratner, F. J. Schoen, A. S. Hoffman, J. E. Lemons. Biomaterials Science: An introduction to Materials in medicine, Academic Press.

Pharmaceutical Sciences (IMSBT-)

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Pharmaceutical Sciences (IMSBT-)	3	1	0	Nil

Course Objective: The course objectives of pharmaceutical sciences typically aim to provide students with a comprehensive understanding of the principles, practices, and advancements in the field of pharmacy and pharmaceutical sciences.

Course Outcome:	
1.	Understanding fundamental principles of pharmaceutical sciences
2.	Learning about drug discovery and development
3.	Knowledge about global impact of pharmaceutical sciences on public health and healthcare system
4.	Application of Biotechnology in Pharmaceutical Sciences
5.	Knowledge about regulatory requirements and ethical considerations in pharmaceutical industry

S. No.	Content	Contact Hours
Unit 1	Introduction to Pharmaceutical Chemistry: organic pharmaceutical compounds; medicinal chemistry; drug design and synthesis	9
Unit 2	Understanding the metabolism of drug: Phase I metabolism; oxidation, reduction, hydrolysis; Factors affecting drug metabolism; metabolism driven drug interaction	9
Unit 3	Role of Physicochemical Properties on Biological Activity: Pharmacokinetics and Pharmacodynamics; Drug-receptor interactions; Mechanism of drug action	9
Unit 4	An overview of different drug classes: Drug Classification, Drug classes based on therapeutic use, Drug based on	9

	chemical structure, drug based on mechanism of action; Emerging therapeutic trends	
Unit 5	The complexities of drug Effects: Drug toxicity; Drug tolerance; Drug dependence; Drug addiction	9
	Total	45

Books :

S.No.	Name of Book/Author/Publisher
1.	Medicinal Chemistry: An introduction by G. Thomas. Publisher: John Wiley and Sons Medicinal Chemistry: The Role of Organic Chemistry in Drug
2.	Research by C. R. Ganellin and S. M. Roberts. Publisher: Academic Press
3.	Ansel's Pharmaceutical Dosage Forms and Drug Delivery Systems by H.C. Ansel, L. V Allien, N.G. Popovich. Publisher: Lippincott Williams and Wilkins Publishers.

Basic Epidemiology (IMSBT-)

Details of course:-

Course Title	Course Structure			Pre-Requisite
Basic Epidemiology(IMSBT-)	L	T	P	
	3	1	0	

Course Objective: To introduce students to the principles and methods of epidemiologic research in order to enable them to design, conduct, analyze, and interpret epidemiologic research.

Course Outcomes:	
1.	Understand the History, Scope and Uses of epidemiology
2.	Identify the achievements of epidemiology and clinical practice
3.	Analyze the distribution and determinants of disease.
4.	Elucidate the measurements in epidemiology.
5.	Demonstrate the health services and public policy.

S. No.	Content	Contact Hours
Unit 1	History, Evolution, Scope and Uses of epidemiology	9
Unit 2	Achievements of epidemiology and clinical practice	9
Unit 3	Distribution and determinants of disease, Dynamics of disease transmission.	9
Unit 4	Measurements in epidemiology, Disease cause and identification	9
Unit 5	Evaluation of health services and public policy, Ethical and professional issues in epidemiology, Concepts of disease control, elimination, and eradication	9
	Total	45

Books :

S.No.	Name of Book/Author/Publisher
1	Basics of epidemiology by Dr. Anil Mishra, Notion press publication, 1st edition, 2018
2	An Essential in Public Health and Epidemiology, by Mihir Bhatta, Notion press publication, 1 st edition, 2022

Principles of Image processing in medicine

Details of course:-

Course Title	Course Structure			Pre-Requisite
Principles of Image processing in medicine (IMSBT-)	L 3	T 1	P 0	NIL

Course Objective: To study Image processing Image enhancement and image analysis in various diagnostics in medical sciences.

Course Outcomes:	
1.	Identify the different parts of the human visual system,image processing systems
2.	Enlist the different types of imaging techniques used in medical imaging .
3.	Analyze and identify the different mathematical operations applied on digital images

4.	Compare the different methods of image enhancement, deduce mathematical solutions for the same
5.	Identify the type of mathematical operation(s) to be digital image processing

S. No.	Content	Contact Hours
Unit 1	**Photography and film image:** Principle of photography and radiographic film image, Introduction to digital image processing:	8
Unit 2	**Image enhancement:** Spatial Domain-Point processing techniques,. Image Compression: Fundamentals of Image compression models,.	11
Unit 3	**Basic principles of image segmentation and its transforms**: Representation and description in image processing,	8
Unit 4	**Introduction to computed tomography:** Principle and configurations/generations, detectors, data acquisition system, spiral CT, scanner parameters, Image quality and artifacts	8
Unit 5	**Radiation therapy:** Radiotherapy principles, dosage data for clinical applications (ISODOSE charts)	10
	Total	**45**

Books:

S.No.	Name of Book/Author/Publisher
1.	Digital Image Processing, Gonzalez and Woods- Pearson Education
2.	Fundamentals of Digital Image Processing, A.K. Jain –P.H.I
3.	Digital Image Processing and Analysis, Chanda Majumder- Printice Hall India.
4.	Digital Image Processing and Computer Vision, Sonka, Hlavac,Boyle- Cenage earning.
5.	Digital Image Processing, William Pratt- John Wiley
6.	Dowsett, Kenny & Johnston, "The Physics of Diagnostic Imaging", Chapman & Hall Medical,
7.	Massey & Meredith, "Fundamental Physics of Radiology", John Wright & Sons.

Rehabilitation Engineering (IMSBT-)

Details of course:-

Course Title	Course Structure			Pre-Requisite
Rehablitation Engineering (IMSBT-)	L 3	T 1	P 0	NIL

Course Objective: To study the structure and characteristics of different types of biomaterials of natural and synthetic origin. This course will give an idea on the effective uses of these materials in medical science .

Course Outcomes:	
1.	Explain Key entities of rehabilitation and ergonomics
2.	Understanding of rehbilation-related project designs and assistive devices
3.	Acquire knowledge on Orthopedic prosthetics and orthotics in rehabilitation technology
4.	Discuss about sensory augmentation and assistive devices
5.	Gain knowledge about quality assurance and future developments.

S. No.	Content	Contact Hours
Unit 1	Introduction to rehabilitation: Rehabilitation acts and legislations, Principles involved in the Assistive technology assessment, Misconceptions in field of assistive technology	8
Unit 2	Rehabilitation engineering concepts: Rehabilitation Engineering project design, Categories of assistive devices, Engineering concepts in sensory rehabilitation, motor rehabilitation, Rehabilitation in communication disorders.	11
Unit 3	Orthopedic prosthetics and orthotics in rehabilitation technology: Upper limb prosthesis, lower limb prosthesis, Intelligent limb prosthesis, Problems in limb prosthesis,	8
Unit 4	Sensory augmentation and substitution: Visual System: Visual Auditory-Vision substitution; Auditory system: Auditory augmentation, Visual-Auditory substitution, Tactual-Auditory substitution.	8
Unit 5	Principles of application in rehabilitation engineering technology:Education and quality assurance; Future development	10
	Total	45

Books:

S.No.	Name of Book/Author/Publisher
1.	The Biomedical Engineering Hand Book. Second Edition, Edited by Joseph D. Bronzino Boca Raton: CRC Press LLC. 2000.
2.	Rehabilitation Engineering. Edited by Tan Yen Kheng: InTech, Chapters. 2009
3.	An Introduction to Rehabilitation Engineering. First Edition. Edited by Rory A Cooper et al. CRC Press.2006
4.	Rehabilitation Engineering Applied to Mobility and Manipulation. First Edition. Edited by Rory A Cooper. CRC Press. 1995

Green energy Technology (IMSBT-)

Details of course:-

Course Title	Course Structure			Pre-Requisite
Green energy Technology (IMSBT-)	L	T	P	Nil

	3	1	0	

Course Objective: Green Technology subject will enhance the knowledge and describe the production of knowledge-based products or provide services that improve operational performance, productivity, or efficiency, while reducing costs, inputs, energy consumption, waste, and pollution.

Course Outcomes:	
1.	To equip students with multi-disciplinary skills and knowledge in the areas of green energy generation and green processes
2.	To impart knowledge on energy, environment, chemistry, management, and other GET-related fields.
3.	To provide understanding on various energy conversion technologies and methods to generate energy from waste.
4.	To impart knowledge on different forms of energy used and their sustainability.
5.	To equip students with recent technologies for green energy advancements and challenges

S. No.	**Content**	**Contact Hours**
Unit 1	**Energy, Environment, renewable energy, and sustainable development**: Understanding sustainable development goals, fundamentals of energy, environment, renewable energy, and sustainable development, energy scenario in the national and global level.	11
Unit 2	**Solar Thermal Technology & Energy Conversion Systems:** Solar thermal energy conversion processes, storage and the utilization of solar thermal energy.	8
Unit 3	**Wind/Ocean/Tidal Energy Technology/ Small Hydropower Systems**: Source of energy in the wind, its characterization and various methods of harnessing the same, energy generation from hydropower, electric energy from ocean waves	8
Unit 4	**Bio-energy and conversion systems:** Energy from waste, microalgal biomass culture, biodiesel generation, bioprospecting of lignocellulosic resource for bio-energy, biofuel generations	9
Unit 5	**Energy and Economy:** Gross domestic product (GDP) and energy – energy market, energy efficiency, environmental sustainability index and global measure	9
	Total	**45**

Books:

S.No.	**Name of Book/Author/Publisher**
1.	Energy and the Challenge of Sustainability, World Energy assessment, UNDP, N York, 2000
2.	Energy and the Environment, Ristinen, Robert A. Kraushaar, Jack J. AKraushaar, Jack P. Ristinen, Robert A., 2nd Edition, John Wiley, 2006

3.	Energy and Environment Set: Mathematics of Decision Making, Loulou, Richard; Waaub, Jean- Philippe; Zaccour, Georges (Eds.), 2005.

Basics of Computer Application (IMSBT-)

Details of course: -

Course Title	**Course Structure**			**Pre-Requisite**
Basics of computer application (IMSBT-)	L	T	P	
	3	1	0	Nil

Course Objective: To provide an overview of the application of computer science in bioinformatics, focusing on sequence analysis, bioinformatics databases, data management, and protein structure prediction.

Course Outcome:	
S. No.	
1.	Understand sequence analysis and alignment algorithms.
2.	Navigate and utilize major bioinformatics databases.
3.	Implement data management and mining techniques in bioinformatics.
4.	Predict and analyze protein structures using computational tools.
5.	Analyzing expression data and understanding systems biology, using relevant tools for practical insights into biological networks

S.No.	**Content**	**Contact Hours**
1	Introduction to Bioinformatics and Sequence Analysis: Sequence Alignment, BLAST, ClustalW	9
2	Bioinformatics Databases: NCBI, GenBank, EMBL, DDBJ, PDB	9
3	Data Management and Mining in Bioinformatics: Storage, Retrieval, Data Mining	9

4	Protein Structure Prediction and Analysis: Structural Prediction, Pymol	9
5	Transcriptomics and Systems Biology: Basics of Gene Expression Analysis; Introduction to Systems Biology; Network Analysis in Systems Biology	9
	Total Contact Hours	45

Books :

S.No.	Name of Book/Author/Publisher
1	Yasha Hasija – All About Bioinformatics From Beginner to Expert 2023
2	Bibekanand Mallick and Zhumur Ghosh – Bioinformatics: Principles and Applications
3	R. Sundaralingam, N. Arumugam, V. Kumaresan, A. Gopi, A. Meena– Biostatistics, Computer Application and Bioinformatics

Food Nutrition and Hygiene (IMSBT-)

Details of course:-

Course Title	Course Structure			Pre-Requisite
Food nutrition and hygiene (IMSBT-)	L	T	P	
	3	1	0	NIL

Course Objective: To equip students with knowledge of medical terminology and words, as well as how to create a diet plan based on the medical circumstances of the patients

Course Outcomes:	
1.	To interpret and apply nutrition concepts to improve the nutritional health of communities.
2.	To identify and apply food principles to food and nutrition systems
3.	To demonstrate a variety of Nutrients, Sources, Functions, Deficiency
4.	To integrate knowledge and skills in food and nutrition with professional issues.
5.	To understand community Health Concept.

S. No.	Content	Contact Hours
Unit 1	Concept of Food and Nutrition, Definition of Food, Nutrients, Nutrition, Health, Balance Diet.	9
Unit 2	Types of Nutrition, Meal planning, Food Groups and Functions of Food.	9
Unit 3	Nutrients: Sources, Functions, Deficiency and Excess of Carbohydrate, Fats, Protein, Minerals, Vitamins, Water, Dietary Fibre	9
Unit 4	Nutrition: Requirement, Factors affecting Growth	9
Unit 5	Community Health Concept, Causes of common diseases prevalent in the society and Nutrition requirement	9
	Total	45

Books :

S.No.	Name of Book/Author/Publisher
1	Dr. M Swaminathan , Advanced Text Book On Food & Nutrition - Volume 2 , THE BANGALORE PRESS, 2nd edition, 2015
2	Prateek Kumar, Nutrition And Food Hygiene, Orange books international, 2017
3	Jim McLauchlin , Christine Little, HOBBS' FOOD POISONING AND FOOD HYGIENE, Hodder Arnold publication, 7th edition, 2007

Principles of Toxicology (IMSBT-)

Details of course:-

Course Title	Course Structure			Pre-Requisite
Principles of Toxicology (IMSBT-)	L 3	T 1	P 0	NIL

Course Objective: The overall objective is to provide an introductory overview of the field of toxicology covering the basic principles, target organ toxicity, the toxicity of a limited group of compounds, and an introduction to modern molecular toxicology. The principal learning objective is for the students to gain familiarity with basics of toxicology.

Course Outcomes:	
1.	Understand the principle of toxicology and its mechanism of toxicokinetics.
2.	Acquire knowledge on Toxicodynamics and Biotransformation of xenobiotics.
3.	Discuss about toxicological effects of xenobiotics on vital organs.
4.	Understanding of the molecular mechanism of toxicity.
5.	Develop knowledge of nanotoxicology forensic and eco toxicology.

S. No.	Content	Contact Hours
Unit 1	Principles of Toxicology, Mechanisms of Toxicity, Toxicokinetics: Routes of Administration, Absorption, Distribution, and Excretion	8
Unit 2	Toxicodynamics--Receptors, Bonds, Dose Response, Membrane Structure and Transport, Biotransformation of Xenobiotics: Biotransformation/Metabolism-Phase I and Phase II reactions	11
Unit 3	Toxicology of the Liver, kidney, Lung Neurotoxicology, Cardiovascular Toxicology, Intestine, Skin Chemical Carcinogenesis & Genetic Toxicology	8
Unit 4	Molecular Toxicology & Toxicogenomics Immunotoxicology, Toxic Effects of Pesticides Reproductive Toxicology & Teratology	8
Unit 5	Toxicology of Metals, Nanotoxicology, Ecotoxicology, Analytical/Forensic Toxicology, Risk Assessment	10
	Total	**45**

Books:

S.No.	Name of Book/Author/Publisher
1	Casarett and Doull's Toxicology-The Basic Science of Poisons, 6th Edition. Klaassen CD, ed. New York: McGraw-Hill, 2001
2	Introduction to Toxicology, 3rd edition, Ed. John Timbrell
3	Principles of Forensic Toxicology, 2nd edition (revised & updated) Ed. Barry Levine, 2003
4	Essentials of Toxicology. Klaassen CD, Watkins JB III, eds. New York: McGraw-Hill, 2003.
5	A Textbook Of Modern Toxicology, Ernest Hodgson, John Wiley & Sons, Inc., Publication

Computer Aided Drug Design (IMSBT-)

Details of course:-

Course Title	Course Structure			Pre-Requisite
Computer Aided Drug Design (IMSBT-)	L	T	P	
	3	1	0	Nil

Course Objective: The course objective for CADD is to equip students with the foundational knowledge and practical skills necessary to apply computational methods in drug discovery and development.

Course Outcome:

S. No.	
1.	To explore the principles of CADD.
2.	To analyze protein structures using various in silico methods.
3.	To apply knowledge of molecular docking to identify potential drug candidates.
4.	To evaluate and interpret QSAR models.
5.	To synthesize information from molecular mechanics and dynamics simulations.

S. No.	**Content**	**Contact Hours**
Unit 1	**Introduction to CADD** Fundamentals of drug design and development, including protein structure classification and key databases like PDB, PubChem, and DrugBank.	9
Unit 2	**Preparation of Protein Structure** Protein structure preparation, homology modeling, threading, fold recognition, ab initio modeling, model refinement, binding site prediction, and visualization tools.	9
Unit 3	**Virtual Screening and Molecular Docking** Virtual Screening methods, Library design; concept of pharmacophore mapping and pharmacophore based screening, Molecular Docking.	9
Unit 4	**Quantitative Structure Activity Relationship (QSAR)** SAR versus QSAR, approaches for the determination of physicochemical parameters, Hansch analysis, Free Wilson analysis, 3D-QSAR approaches.	9
Unit 5	**Molecular Mechanics and Dynamics** Molecular mechanics; energy minimization, Molecular dynamics simulation, Understanding the structural stability of protein and protein-ligand complex	9
	Total	45

Books :

S.No.	**Name of Book/Author/Publisher**
1.	"Computer-Aided Drug Design of Bioactive Natural Products" by Xiang Simon Wang and Quentin Liu, Springer, 1st Edition, 2019.
2.	"Artificial Intelligence in Drug Design: The Storm Before the Calm" by Mark Chang, CRC Press, 1st Edition, 2020

3.	"Molecular Modeling and Simulation for Drug Design" by B. Jayaram, CRC Press, 1st Edition, 2021.
4.	"Machine Learning in Drug Discovery: From Quantum Chemistry to Clinical Studies" by Anuraj Nayarisseri and Sanjeev Kumar Singh, Wiley, 1st Edition, 2021.

Food Biotechnology (IMSBT-)

Details of course:-

Course Title	**Course Structure**			**Pre-Requisite**
Food Biotechnology (IMSBT-)	L 3	T 1	P 0	

Course Objective: T**o** provide knowledge of Principles of Food Quality & Quality Control , Food Safety and its Management and also the various Food Laws and regulations pertaining to these.

Course Outcomes:	
1.	Understand the basics of Food chemistry.
2.	Identify the significance of microorganisms in foods and their growth pattern.
3.	Summarize the various Fermentation products.
4.	Analyze the principles underlying spoilage of food.
5.	Compare and contrast the techniques involved in Food processing

S. No.	**Content**	**Contact Hours**
Unit 1	**Food chemistry:** Definition and importance, Composition of foods and function of carbohydrates, proteins, amino acids, lipids, vitamins.	9
Unit 2	**Food Microbiology:** History and significance of microorganisms in foods. Microbial growth pattern. Biochemical changes caused by micro-organisms,	9
Unit 3	**Fermentation products:** Dairy products: Production of starter cultures; Cheese - principles of cheese making. *Fermented foods*: *Fermented vegetables*: *Distilled beverages, Food additives*: organic acid.	9
Unit 4	**Food Preservation and storage:** General principles underlying spoilage. Principles of food preservation	9

Unit 5	**Food process technology:** Packaging and canning of foods – preparation for packaging, thermal processing of foods: freezing and thawing of foods, dehydration,; Methods of quality, assessment of food materials	9
	Total	45

Books :

S.No.	Name of Book/Author/Publisher
1	Frazier, W.S. and Weshoff, D.C., Food Microbiology, 4th Edn., McGraw Hill Book Co., New York, 1998
2	Mann &Trusswell , Essentials of human nutrition. 3rd edition .oxford university press, 2007

Introduction to Biomedical Engineering (IMSBT)

Details of course:-

Course Title	Course Structure			Pre-Requisite
Introduction to Biomedical Engineering (IMSBT-)	L 3	T 1	P 0	NIL

Course Objective: The course objective of Introduction to Biomedical Engineering is to provide students with a foundational understanding of the principles and applications of engineering in medicine and healthcare.

Course Outcome:

S. No.	
1.	Understand principles and workings of biomedical equipment.
2.	Recognize safety hazards and codes for electromedical devices.
3.	Learn techniques for measuring vital signs and cardiac functions.
4.	Gain insight into patient monitoring systems and telemetry.
5.	Familiarize with audiometry, blood flow measurement, and device design.

S. No.	Content	Contact Hours
Unit 1	Basic principle, working and technical specifications of ECG, EMG and EEG machines, LEAD configurations, 10-20 electrode system measuring techniques for EOG, ERG and phonocardiography, Patient Safety: Electric shock hazards, leakage currents, safety codes for electromedical equipment.	10
Unit 2	Arrhythmia and Patient monitoring: Cardiac arrhythmias, Stress test measurement, ambulatory monitoring instruments such as holter monitor. Basics of Telemetry, Multi-channel Telemetry.	08
Unit 3	Basic principle and working of Patient Monitoring Systems Measurement of heart rate, pulse rate, blood pressure, temperature and respiration rate, apnea detector. Heart rate variability measurement. Point of care devices and their design considerations for homecare devices: glucometer.	09
Unit 4	Basic principle and working of Audiometers and hearing aid Basic audiometer, pure tone and speech audiometer, evoked response audiometry, introduction to hearing aids and cochlear implants.	09
Unit 5	Basic principle and working of Blood flowmeters Electromagnetic, ultrasonic, NMR and laser doppler flowmetry, Measurement of Cardiac Output Indicator dilution, dye dilution and thermal dilution techniques. 05on. Pearson International Edition.	09
	Total	45

Books :

S.No.	Name of Book/Author/Publisher
1.	Handbook of Biomedical Instrumentation (Third edition): R S. Khandpur. (PH Pub)
2.	Introduction to Biomedical Equipment Technology: Carr –Brown. (PH Pub)
3.	Encyclopedia of Medical Devices and Instrumentation: J G. Webster. Vol I- IV (PH Pub)

Biosensors (IMSBT-)

Details of course:-

Course Title	Course Structure	Pre-Requisite

Biosensors (IMSBT-)	L	T	P	
	3	0	2	

Course Objective: This course will present an overview of the fundamental principles, technologies, methods and applications of biosensors. The objective of this course is to link engineering principles to understanding of biosystems in sensors and bioelectronic. Furthermore the application of fundamentals of measurement science to optical, electrochemical, mass and pressure signal transduction.

Course Outcomes:	
1.	Define biosensors and understand its history, properties, design features and the biological component.
2.	Distinguish between different type of biosensors like amperometric and potentiometric biosensors and detecting of various cations using calirometric biosensor
3.	Show overview of sensors and transducers measurement systems their Classification and Important design considerations
4.	List examples of biosensors with the relatable opportunities and obstacles. And also learning about miniaturized devices in nanobiotechnology
5.	Discuss the Future of Biosensors and Transducers and The importance of computers in sensor and transducer technology,

S. No.	**Content**	**Contact Hours**
Unit 1	**Introduction**: Biosensors: Definition, History, Properties of biosensors, Design features of biosensors, The biological component.	8
Unit 2	**Signal Transduction**: Amperometric Biosensors, Potentiometric biosensors, Calorimetric biosensors, Optical biosensors, , Measuring luminescence, Piezo-electric biosensors, Immunosensors.	11
Unit 3	**Biomedical Sensors:** Sensors and transducers: an overview, measurement systems, Classification of biomedical sensors and transducers,	8
Unit 4	**Commercial Examples of Biosensors**: Biosensors markets: Opportunities and obstacles. **Miniaturized devices in nanobiotechnology** - types and applications, MEMS, Lab on a chip concept	8
Unit 5	**The Future of Biosensors and Transducers**: Recent engineering solutions to health care using biosensors and transducers, Modern health care solutions.	10
	Total	**45**

Books:

S.No.	**Name of Book/Author/Publisher**
1.	Affinity Biosensors: Techniques and Protocols by K.R. Rogers and A. Mulchandani. Publisher: Humana Press.

2.	Biosensors and their Applications by V.C. Yang and T.T. Ngo. Publisher: Springer.
3.	Chemical Sensors and Biosensors by B.R. Eggins. Publisher: John Wiley and Sons Inc.
4.	Sensors and Sensing in Biology and Engineering by F.G. Barth, et al. Publisher: Springer Verlag.

Healthcare and Diagnostics (IMSBT-)

Course title	**Course structure**			**Pre-requisite**
	L	**T**	**P**	
Healthcare and Diagnostics	**3**	**1**	**0**	**Nil**

Course Objective
To equip students with the knowledge and skills to develop diagnostic and therapeutic techniques in healthcare.

Course Outcome	
1.	Demonstrating an understanding of healthcare systems and their components.
2.	Explaining the principles and applications of common diagnostic techniques.
3.	Analysing ethical issues related to healthcare and diagnostics.
4.	Elucidating basic data analysis techniques for healthcare data.
5.	the role of clinical trials and biosafety

S.no	**Content**	**Contact hours**
Unit 1	**Introduction to Healthcare Systems** Overview of healthcare systems: Global perspectives; Components of healthcare systems: Providers, payers, and patients; Healthcare delivery models: Primary care, secondary care, and tertiary care	**9**

Unit 2	**Diagnostic Techniques in Healthcare** Overview of diagnostic methods: Imaging, laboratory tests, and procedures; Diagnostic imaging techniques: X-ray, MRI, CT scan, and ultrasound; Laboratory diagnostic tests: Blood tests, urine analysis, and genetic testing.	**10**
Unit 3	**Ethical Considerations in Healthcare and Diagnostic** Ethical principles in healthcare: Autonomy, beneficence, non-maleficence, and justice; Ethical dilemmas in healthcare: End-of-life care, patient confidentiality, and informed consent; Regulatory frameworks and guidelines for healthcare professionals	**9**
Unit 4	**Healthcare Data Analysis and Technology** Introduction to healthcare data: Types, sources, and collection methods; Basic data analysis techniques: Descriptive statistics and data visualization; Role of technology in healthcare: Electronic health records, telemedicine, and wearable devices.	**10**
Unit 5	**Clinical trials and principles of Biosafety** Phases of clinical trials; development of clinical trial protocols, policies, cohorts, Biosafety prospects, case studies.	**7**
	Total	45

Reference books/ link

S.No	**Name of the author/book/publisher**
1.	"Introduction to Health Care Management" by Sharon B. Buchbinder and Nancy H. Shanks
2.	"Health Care Information Systems: A Practical Approach for Health Care Management" by Karen A. Wager; Frances Wickham Lee; and John P. Glaser
3.	"Introduction to Healthcare Quality Management" by Patrice L. Spath

WASTEWATER TREATMENT (IMSBT-)

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Wastewater Treatment (ISMBT-)	3	1	0	Nil

Course Objective: To provide detailed understanding on the industrial waste water and its treatment using recent techniques

Course Outcome:	
1.	To impart knowledge on different sources of industrial waste effluents
2.	To gain understanding on different treatment methodologies for industrial wastewater treatment
3.	To analyze small and large scale industries for waste remediation and reduction
4.	To analyze economic sustainability and government initiatives for waste reduction
5.	To understand microbiological techniques for wastewater treatment

S. No.	Content	Contact Hours
Unit 1	**Waste Disposal & Methods:** Waste disposal management, Methods of waste disposal, effect of industrial wastes on streams and sewerage systems	9
Unit 2	**Wastewater Sources**: Characteristic features of wastes (solid, liquid and gaseous emission), toxic byproducts generated from paper and pulp industries, thermal power station, distillery, textile industry	9
Unit 3	**Waste reduction & Remediation**: Small and large scale industries for waste reduction and remediation, various methods for waste alteration, recycling plants, material restoration and conservation	9
Unit 4	**Microbiology of Wastewater treatment**: Different microbes responsible for Wastewater treatment, Advanced technologies	9

	of Wastewater treatment: Softening, Ion exchange, Reverse Osmosis Technologies	
Unit 5	**Reduction & Sustainability**: Economic sustainability and government support for joint treatment of raw effluent, municipal sewage and debris	9
	Total	45

Books :

S.No.	Name of Book/Author/Publisher
1.	S. P. Mahajan, "Pollution Control in Process Industries", Tata McGraw Hill Publications
2.	W. Wesley Eckenfelder Jr.," Industrial Water Pollution Control", McGraw Hill Publications

Algal Biotechnology (ISMBT-)

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Algal Biotechnology (ISMBT-)	3	1	0	Nil

Course Objective: To provide knowledge on the fundamentals of algal biotechnology and its environmental relations and knowledge about industrial application of algae.

Course Outcome:	
1.	Understand the habitat diversity of algae and their ecological significance.
2.	Explore basic culturing and analytical measurement techniques for algae isolation and characterization.

3.	Identify challenges and prospects associated with algal biofuels production.
4.	Implement strategies for improving algal strains and lipid content through genetic engineering, chemical genetics, and nutrient stress.
5.	Evaluate the potential of algae-based bioremediation in addressing environmental pollution challenges.

S. No.	**Content**	**Contact Hours**
Unit 1	**Algae- Overview:** Habitat; Classification of algae; Body organization; Cell Structure; Metabolism-Nutrition & respiration; Reproduction; Life cycle. Algae as a source of food and feed; Algae as a source of pigments, fuel and bio-fertilizers.	9
Unit 2	**Algae isolation techniques :** Basic culturing and analytical measurement techniques; Cultivation methods-Ponds and photobioreactors; Design of cultivation vessels; Harvest techniques; Drying techniques; Cell disruption techniques.	9
Unit 3	**Algal biofuels:** Challenges and prospects; Algal biofuels production techniques-Biodiesel, Bioethanol, Biogas &Biohydrogen; Market of algal biofuels and other products-Indian & Global scenario; India Biofuels Policy.	9
Unit 4	**Applications:** Single cell proteins (SCP): Spirulina as single cell protein-production and harvesting of algal biomass – factors affecting biomass production. Algal strain and lipid improvement strategies-genetic engineering, chemical genetics and nutrient stress.	9
Unit 5	**Bioremediation by algae**: Heavy metal removal and nutrient recovery; Commercial algal species of industrial production-Chlorella, Spirulina, Dunaliella, Hematococcus, Chlamydomonas.	9
	Total	45

Books :

S.No.	Name of Book/Author/Publisher
1.	Micro algae: biotechnology and microbiology. Becker and wolf gang, Cambridge University Press.
2.	Microalgae biotechnology for development of biofuel and waste water treatment. Springer nature.

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Integrated M.Sc syllabus

(SKILL ENHANCEMENT COURSES)

Aquaculture (ISEC-)

Details of course:-

Course Title	**Course Structure**			**Pre-Requisite**
Aquaculture	L	T	P	Nil
	2	0	4	

Course Objective: To give first-hand training on various aspects of Aquaculture, to enhance quality aqua crops production

Course Outcomes:	
1	Gain working knowledge of economically aquatic organisms.
2	Acquire skills for setting up an aquarium and cultivating ornamental fishes.
3	Understand the role of fishes in environmental management.
4	Well versed in technology-based aquaculture systems like recirculating aquaculture systems
5	Acquire knowledge of aquaponics systems, and advances in seed production and feed production processes.

S. No.	**Content**	**Contact Hours**
Unit 1	**Introduction to Aquaculture:** Designing (layout) and drawing of a self sustainable Aquaculture farm, Identification of cultivable finfishes and shellfishes, Collection and identification of various freshwater aquatic plants, Understanding of the role of different aquatic plants in aquaculture	9
Unit 2	**Recirculating Aquaculture System (RAS) and water Quality management:** Designing of a Recirculating Aquaculture System (RAS) and understanding of functions of its various parts in the maintenance of water quality. Designing of an Aquaponics System and its role in the sustainable aquaculture development. Fish Breeding, Construction of a fish aquarium, Maintenance of one Aquarium with fish during the Course tenure, Value addition in aquacrops and their preservation.	11
Unit 3	**Water Quality Parameters**: Study of major water quality parameters	8

	viz., temperature, pH, dissolved oxygen, free carbon dioxide, alkalinity and ammonia in a fish culture pond.	
Unit 4	**Live Feed Culture and Feed Formulation:** Culture of live food organisms, Culture of any fish larvae and their feeding, Selection of non-conventional ingredients for the formulation of fish feed, The study of biochemical composition (protein, lipid, carbohydrates, ash) contents of the ingredients, Formulation of fish feed using locally available ingredients, Feeding techniques: hand feeding, bag feeding, demand feeding etc.	8
Unit 5	**Aquaculture in Practice**: First hand working experience with fish in a fish farm/institute/laboratory, Preparation of a project proposal in any area of aquaculture for financial support.	9
	Total	**45**

Books:

S.No.	Name of Book/Author/Publisher
1.	AOAC, Association of Official Analytical Chemists. 2000. Official Methods of Analysis. Washington, DC: Association of Official Analytical Chemists Inc.
2.	APHA, American Public Health Association. 2012. Standard Methods for the Examination of Water and WasteWater. 22 nd ed. Washington DC: American Public Health Association, American Water Works Association, Water Environment Federation.
3.	Pillay, T. V. R. 2005. Aquaculture. Principles and Practices. Blackwell Publishing, New Delhi, India.
4.	Chakrabarti, R. and Sharma, J. G. 2008. Aquahouse. New Dimension of Sustainable Aquaculture. DIPAS, Indian Council of Agricultural Research, New Delhi, India.

Diagnostic Techniques (ISEC-)

Details of course: -

Course Title	Course Structure			Pre-Requisite
Diagnostic Techniques	L	T	P	
	0	0	4	

Course Objective: Basic understanding of diagnostic techniques and instrumentation involved, analysisng data nad underacting of cause and effect of diseases.

Course Outcomes:	
1	Understanding of basics of diagnostic methods
2	Application and analysis of data using instruments for basic diagnostics instrumentation
3	Acquire knowledge of biochemical estimations
4	Acquire knowledge of hematological estimation
5	Acquire knowledge of basic microbiological methods in diagnostics

S. No.	Content	Contact Hours
Unit 1	Fundamental of basic Diagnostic Techniques	8
Unit 2	Basic instrumentation techniques in Medical Diagnostics. Centrifuge, spectrophotometer, Microscope, and basic instruments in pathological diagnostics	11
Unit 3	Basic Biochemical estimations Diabetes and Blood glucose analysis (GOD/POD). SGOT, SGPT, ALP, Albumin, Bilirubin total and direct, Total Protein.	8
Unit 4	Basic Hematological estimations Complete Blood Count (DLC, TLC, TPC, Hb, PCV) and its clinical significance, Blood grouping, and Rh factor	8
Unit 5	Basic Microbiological estimations, Sterilization: Hot Air Oven, Autoclave, Incubator, Staining Technique: Gram stain, Zn Stain, Media Preparation, Culture & Isolation process of bacteria	10
	Total	**45**

Books:

S.No.	Name of Book/Author/Publisher
1	Text book of Medical Laboratory Technulogy (2nd Edition) by P. B. Godker, PublisherBhalani
2	Kuby's Immunulogy (7th Ed) - by J. Owen, J. Punt, S. Strandford. Macmillan Higher Education, England.
3	Prescott, Harley, and Klein's Microbiulogy (Seventh Edition)- by Joanne M. Willey, Linda M. Sherwood, Christopher J. Woulverton. McGrawHill
4	Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, Peter Walter (2015) Mulecular Biulogy of the cell, 6th edition, Taylor and Francis Group.

Cell culture Techniques (ISEC-)

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Cell culture Techniques (ISEC)	0	0	4	Nil

Course Objective: The course should provide the student with knowledge such that the student can carry out basic cell-culture techniques properly and safely, and explain factors of significance in the cultivation of cells in vitro.

Course Outcome:	
1.	Identify different types of cells used in cell culture and their applications.
2.	Initiate and establish cell cultures using appropriate techniques and selection criteria.
3.	Apply techniques for cell adhesion and suspension culture based on specific experimental requirements
4.	Explain the principles of cryopreservation and select appropriate cryoprotectants for cell freezing.
5.	Evaluate cell differentiation protocols and their applications in tissue engineering and regenerative medicine.

S. No.	**Content**	**Contact Hours**
Unit 1	I**ntroduction to Cell Culture Techniques**: Overview of cell culture techniques, Historical perspective and importance of cell culture in research, Basic cell biology review	9
Unit 2	**Cell Culture Media and Initiation:** Composition and types of cell culture media, Growth factors and supplements, aseptic techniques, Types of cell culture media for plants, animals and microbial cells.	9
Unit 3	**Basics of Plant Cell Cultures Techniques**: Cell Theory, Concept of Cell Culture, Plant Tissue Culture Laboratory: Equipments and Instruments, Precautions to maintain Aseptic Conditions	9
Unit 4	**Basics of Animal Cell Cultures Techniques**: Nutritional and Physiological: Growth Factors	9

	and Growth Parameters. Primary Cell Cultures, Application of Cell Cultures	
Unit 5	**Basics of Microbial Culture Techniques:** Basic requirements for microbial cell culture: media, equipment, and aseptic techniques, Subculture and preservation methods for microbial cultures, Industrial Applications of Microbial Cultures	9
	Total	45

S.No.	**Name of Authors /Books / Publishers**
1.	Culture of Animal Cells by R Ian Freshney
2.	Cell culture technology: Recent advances and future prospects (Euroscicon Meeting Reports Book 1) by Bruserud, Øystein and Astrid Englezou
3.	Vertebrate Cell Culture II and Enzyme Technology: Volume 39 (Advances in Biochemical Engineering/ Biotechnology) by A.F. Bückmann and G. Carrea
4.	Animal Cell Culture and Technology (The Basics) (Garland Science)) by Michael Butler
5.	The Immortal Life of Henrietta Lacks by Rebecca Skloot

Machine Learning in Bioinformatics (ISEC-)

Details of course: -

Course Title	**Course Structure**			**Pre-Requisite**
Machine Learning in Bioinformatics	L	T	P	
	0	0	4	Nil

Course Objective:To introduce the fundamentals of machine learning and its application in bioinformatics. This includes understanding data structures, analysis, visualization, and the implementation of various machine learning algorithms for bioinformatics data.

Course Outcome:

S. No.	
1	Understand and apply data analysis techniques using Python
2	Perform data visualization and principal component analysis
3	Implement machine learning algorithms for pattern recognition.
4	Utilize deep learning and neural networks in bioinformatics applications.
5	Apply machine learning techniques to bioinformatics data.

S.No.	**Content**	**Contact Hours**
1	Basics of Data and Operations: Introduction to Python, Data Types, Data Structures, NumPy, Pandas	9
2	Data Visualization and Principal Component Analysis: Matplotlib, Seaborn, PCA Theory and Application	9
3	Machine Learning Algorithms: Supervised vs Unsupervised Learning, Logistic Regression, Decision Trees	9
4	Deep Learning and Neural Networks: Fundamentals, TensorFlow, Keras, CNNs, RNNs	9
5	Applications in Bioinformatics: NLP, Clustering, Classification, Gene Expression Analysis	9
	Total Contact Hours	45

Books :

S.No.	**Name of Book/Author/Publisher**
1	Yasha Hasija and Rajkumar Chakraborty– Hands-On Data Science for Biologists Using Python, 2021
2	Yasha Hasija – All About Bioinformatics From Beginner to Expert, 2023

Bioinstrumentation (ISEC-)

Course Title	Course Structure			Pre-Requisite
Bioinstrumentation	L	T	P	
	0	0	4	Nil

Course Objective: Development of technologies that measure and manipulate biological systems. It involves the use of instruments to record and transmit physiological information.

Course Outcomes:	
1.	Discuss the principle of centrifugation and its types.
2.	List uses of electrophoretic techniques underlying electrophoresis systems.
3.	Discuss chromatographic methods.
4.	Explain spectroscopic and diffraction techniques.
5.	Define optical techniques like microscopy.

S. No.	Content	Contact Hours
Unit 1	**Centrifugation: Basic principle and application,** Analytical and Preparative centrifuges and ultra centrifugation.	8
Unit 2	**Electrophoretic Techniques:** Paper and gel electrophoresis, Immuno electrophoresis, isoelectric focusing, two-dimensional electrophoresis, capillary electrophoresis.	11
Unit 3	**Chromatographic Methods:** Paper, TLC gas chromatography, gel filtration, ion exchange chromatography, affinity chromatography and HPLC, FPLC.	8
Unit 4	**Spectroscopy:** UV, visible and NIR, spectrofluorimetry, Atomic absorption spectrophotometry, Mass Spectrometry, Infrared Spectroscopy,	8
Unit 5	**Microscopy:** Principle, parts, types and functioning of Microscope, Optical and Electron Microscopy, Transmission and Scanning Electron Microscopy, Fluorescence microscopy, Confocal microscopy.	10
	Total	**45**

Books:

S.No.	Name of Book/Author/Publisher
1	Principles and Techniques of Practical Biochemistry by Keith Wilson and JohnWalker, Cambridge University Press.
2	Biophysical Chemistry: The conformation of Biological Macromolecules by C.R.Cantor and P.R. Schimmel. Publisher: W.H. Freeman.

3.	Essentials of Biophysics by P. Narayanan. Publishers: New Age InternationalPublishers.
4.	Introduction to Spectroscopy by D.L. Pavia, G.M. Lampman and G. S. Kriz. Publisher: Brooks Cole
5.	Physical Chemistry of Macromolecules by C. Tanford. Publisher: John Wiley and Sons Inc.

DEPARTMENT OF BIOTECHNOLOGY

DELHI TECHNOLOGICAL UNIVERSITY: DELHI
Established under Govt. of Delhi Act 6 of 2009
Shahbad Daulatpur, Bawana Road, Delhi-110042

Integrated M.Sc syllabus

(VALUE ADDITION COURSES)

ETHICS IN SCIENCE (IVAC-)

Details of Course

Course Title	**Course Structure**			**Pre-Requisite**
	L	T	P	
Ethics in science (IVAC-)	2	0	0	Nil

Course Objective:
To introduce students to the basic concept of ethics in different fields of science and the social responsibility of scientific research.

Course Outcome:

1. Understanding the fundamental concepts and theories of ethics and their relevance to scientific inquiry and practice.
2. Identifying and applying ethical principles, including integrity, honesty, and respect for research participants in scientific research and decision-making.
3. Identifying the ethical principles in environmental protection and sustainability.
4. Applying ethical reasoning skills to navigate complex ethical issues, conflicts of interest, and competing values in scientific decision-making.
5. Exploring different case studies from ethical and legal perspectives.

S. No.	**Content**	**Contact Hours**
Unit 1	**Introduction to ethics and science** Overview of Ethics: Definition; branches, and principles Relationship between Ethics and Science: Historical perspective and contemporary issues Importance of Ethical Conduct in Scientific Research;	**6**
Unit 2	**Ethical Principles in Scientific Misconduct**	**6**

	Integrity and Honesty: Data fabrication, falsification, and plagiarism; Informed consent, privacy, and confidentiality; Animal Welfare; Morality and ethics	
Unit 3	**Ethics in Environmental sustainability** Ethics in the use of nuclear technologies and disposal of nuclear plant effluent; chemical and Hazardous waste management.	**6**
Unit 4	**Ethical Issues in Emerging Technologies** Biotechnology and Genetic Engineering: Ethical implications of gene editing and genetically modified organisms; Artificial Intelligence and Robotics: Nanotechnology: Ethical considerations in nanomedicine, environmental impacts, and societal implications Bioethics in Healthcare: Patient rights, end-of-life care, and access to medical treatment.	**6**
Unit 5	**Analysis of Case Studies** Discuss case studies in bioethics, legal, and social perspectives	**6**
	Total	**30**

Reference Books/ links :

S.No.	**Name of Book/Author/Publisher**
1	Bernard E. Rollin; *Science and Ethics* (New York: Cambridge University Press; 2006): pp. 1-10 (Ch. 1); pp. 11-30 (Ch. 2); pp. 247-274 (Ch. 10)
2	Ethics in Science: Ethical Misconduct in Scientific Research; Second Edition: 9781138035423: D'Angelo; John: Books.
3	Altinok; Ozan (2023). Conceptual and Ethical Challenges of Evolutionary Medicine. Springer Nature Switzerland.

BIOTECHNOLOGY FOR SOCIETY (IVAC-)

Details of course:-

Course Title	**Course Structure**			**Pre-Requisite**
	L	**T**	**P**	
Biotechnology for Society (IVAC-)	2	0	0	Nil

Course Objective: To impart knowledge and make students aware about the Problems and benefits of using biotechnology in Society

Course Outcomes:	
I	To impart and make students aware about the Problems in Society
II	To acquaint the students with concepts of Globalization, Ecology and Environment
III	To foster knowledge on advancements in biotechnology sector
IV	To impart knowledge on concepts of ethics, and IPR for biotechnology
V	To impart importance of sustainable development and biotechnology

S. No.	**Content**	**Contact Hours**
Unit 1	**Globalisation and Indian Society**: Understanding the concepts of liberalization, privatization and globalization;Growth of information technology and communication and its impact manifested in everyday life	6
Unit 2	**Ecology and Sustainable Development**: Importance of Environment Studies in the current developmental context; Understanding concepts of Environment, Ecology and their interconnectedness	6
Unit 3	**Biotechnology and Environment**: Environmental Degradation causes and impact on human life; Sustainable development, concept and components; poverty and environment	6
Unit 4	**Conflicts and Ethical Implications**: Significance of values, ethics and prejudices in developing the individual; Stereotyping and prejudice as significant factors in causing conflicts in society.	6
Unit 5	**Advancements in Society:** Biotechnological advancements in society, challenges and opportunities	6
	Total	**30**

Books:

S.No.	**Name of Book/Author/Publisher**
1.	Fundamentals of Molecular Biology, (2009), Pal J.K. and Saroj Ghaskadbi, Oxford University Press
2.	Enzymes: Biochemistry, Biotechnology & Clinical chemistry, (2001) Palmer Trevor, Publisher: Horwood Pub. Co., England.

SCIENCE OF WELL BEING (IVAC-)

Details of course:-

Course Title	**Course Structure**			**Pre-Requisite**
	L	T	P	
Science of well being (IVAC-)	2	0	0	Nil

Course Objective: This course will examine and interpret the latest research in social, personality, and clinical psychology on well-being, character strengths, and personal growth.

Course Outcomes:	
I	To interpret the latest research in social, personality, and clinical psychology on well-being, character strengths, and personal growth
II	Emphasis will be placed on the ways in which scientists generate hypotheses regarding the nature of positive psychological trait
III	To overview what psychological science says about happiness
IV	Discover how cognitive biases impact daily life
V	To overview what activities have been proven to increase happiness along with strategies to build better habits

S. No.	**Content**	**Contact Hours**
Unit 1	**Introduction to science of well being**: What is science, relation of science to well being	6
Unit 2	**Personal Growth**: Misconceptions About Happiness, well being and strengths, personal growth	6
Unit 3	**Putting Strategies into Practice:** Strategies for well being and happiness, societal exposure, practicing science	6
Unit 4	**Mind and Science**: Putting science into practice, practicing happiness using technology tools	6
Unit 5	**Final Rewirement Challenge**: Practicing the goals, science and case studies for happiness and personal growth	6
	Total	30

Books:

S.No.	**Name of Book/Author/Publisher**
1.	Boniwell, I., David, S., & Ayers, A. (Eds.), Oxford Handbook of Happiness. : Oxford University Press
2.	Lopez, S., & Snyder, C. (Eds.), The Oxford Handbook of Positive Psychology. : Oxford University Press

HUMAN NUTRITION (IVAC-)

Details of course:-

Course Title	**Course Structure**			**Pre-Requisite**
Human Nutrition	L	T	P	
	2	0	0	NIL

Course Objective: The course objective of Human Nutrition is to educate students about the principles of nutrition and their application in promoting health and preventing disease across the lifespan.

S. No.	Course Outcome
1.	To demonstrate comprehensive knowledge of nutrition principles, including the distinction between macronutrients and micronutrients, and the role of energy balance and metabolism in human health.
2.	To identify and analyze the functions and dietary sources of key biomolecules such as carbohydrates, proteins, lipids, vitamins, minerals, and water, understanding their essential roles in maintaining health.
3.	Apply various methods of nutritional assessment, including dietary intake assessment, anthropometric measurements, and biochemical markers, to evaluate nutritional status accurately.
4.	Evaluate the relationship between diet and chronic diseases, including their impact on mental health and cognitive function, and propose evidence-based dietary strategies for disease prevention and management.
5.	To demonstrate an understanding of lifespan nutrition, including recognizing nutritional needs across different life stages and populations, and designing appropriate nutrition interventions for special considerations such as pregnancy, infancy, and aging.

S. No.	Content	Contact Hours
Unit 1	Fundamentals of Human Nutrition: Introduction to nutrition principles; Macronutrients vs. micronutrients; Energy balance and metabolism	6
Unit 2	Biomolecules and Dietary Sources: Carbohydrates, proteins, lipids: functions and sources; Vitamins and minerals: roles in health; Water: importance and sources	6
Unit 3	Nutritional Assessment Methods: Dietary intake assessment: diaries, recalls, questionnaires; Anthropometric measurements: BMI, waist circumference; Biochemical markers of nutritional status	6
Unit 4	Nutrition and Disease Prevention: Relationship between diet and chronic diseases; Impact of nutrition on mental health and cognitive function; Dietary strategies for disease prevention	6

Unit 5	Lifespan Nutrition: Nutritional needs across the lifespan; Special considerations: pregnancy, infancy, aging; Nutrition interventions for specific populations	6
	Total	30

Books :

S.No.	Name of Book/Author/Publisher
1.	Biochemical, Physiological, and Molecular Aspects of Human Nutrition" by Martha H. Stipanuk and Marie A. Caudill
2.	Principles of Human Nutrition" by Mukund Sabnis
3.	Lehninger Principles of Biochemistry by David L.Nelson and Michael M.Cox

INTRODUCTION TO BIOLOGICAL SCIENCES (IVAC-)

Details of course:-

Course Title	**Course Structure**			**Pre-Requisite**
	L	**T**	**P**	
Introduction to Biological Sciences	2	0	0	Nil

Course Objective: To understand various domains of biological sciences

Course Outcomes:	
I	To understand life and the role of computers in Biology
II	To be able to compare and contrast various cell types and biomolecules and design their genome manipulation
III	To comprehend the role of microbes in health and disease
IV	To gain insight into the basics of genetics and immunology
V	To appraise the significance of environmental protection

S. No.	**Content**	**Contact Hours**

Unit 1	**Concepts of Biology and Impact of Computers:** Origin of life and evolution; Characteristics of living organisms; Recent developments in Biology; Role of Computers in Biology	6
Unit 2	**Biological Systems and Manipulation of Cells:** Cell as the structural and functional unit of living beings; Tissues; Organs; Physiology of biological systems; Manipulation of cells	6
Unit 3	**Basics of Microbiology:** Types of microbes; Microbes in health; Microbes and diseases	6
Unit 4	**Basics of Human Genetics and Immunology:** Gene, Genome, Genotype; Phenotype; Mendel's Law; Linkage; Antigen; Antibody; Immune response; Immunity	6
Unit 5	**Basics of Ecology and Environmental Biology:** Introduction to ecology; Environmental biology; Mitigation of pollution using Biotechnology; Sustainable energy	6
	Total	**30**

Books:

S.No.	Name of Book/Author/Publisher
1.	Molecular Biology of the Cell by B Alberts, R Heald, A Johnson, D Morgan, M Raff, K Roberts, P Walter. Publisher: Garland Science
2	All About Bioinformatics: From Beginner to Expert 1st Edition by Y Hasija. Publisher: Academic Press
3	Lehninger's Principle of Biochemistry by DL Nelson, MM Cox. Publisher: WH Freeman
4	Biochemistry by JM Berg, JL Tymoczko, GJ Gatto Jr, L Stryer. Publisher: Macmillan Learning
5	Molecular Biology of the Gene by JD Watson et al. Publisher: Pearson
6	Genetic Engineering by S Rastogi, N Pathak. Publisher: OUP
7	Microbiology by J Pelczar et al. Publisher: Tata McGraw Hill
8	Cell in Development and Inheritance by EB Wilson. Publisher: MacMilan
9	Microbiology by MJ Pelczar, ECS Chan, NR Krieg Publisher: Tata McGraw Hill
10	Microbiology by GJ Tortora et al. Publisher: Pearson Education
11	Concepts of Genetics by William Klug, Michael Cummin. 11th edition. Publisher: Pearson
12	Kuby Immunology by J Owen, J Punt, S Stranford. Publisher: WH Freeman
13	Concepts in Biotechnology by D Balasubramanian, CFA Bryce, K Dharmalingam, J Green, K Jayaraman. Publisher: Universities Press (India) Pvt. Ltd
14	Fundamentals of Ecology and Environment by P Kumar, U Mina. Publisher: Pathfinder Publication
15	Environmental Biotechnology: Principles and Applications by BE Rittmann, PL McCarty. Publisher: McGraw-Hill Education