DEPARTMENT OF BIOTECHNOLOGY
ANNA UNIVERSITY, CHENNAI

Vision:

The Department of Biotechnology is committed to evolve as a world class science and technology centre by integrating quality and ethics in teaching and research

Mission:

The mission of the department is

- Empowering students with an unique multidisciplinary learning experience and fostering the young minds to develop as a researcher, entrepreneur, etc.
- Enhancing academic and industrial collaborative research initiatives for the development of biotechnological, food and therapeutic products.
- Emphasizing and equipping the students towards innovative industrial and research developments.
- Serving the society with utmost commitment, integrity, enthusiasm, and dedication.

Sl.No.	PROGRAM EDUCATIONAL OBJECTIVES (PEOs)
1.	Graduates shall have proficiency in scientific and technological skills that enables and motivates them to pursue further education, leading to careers in research and other fields related to biotechnology.
2.	Graduates shall have leadership ability, Entrepreneurship skills, and excellence in their field of interest.
3.	Graduates shall have competency in handling bio-industrial processes and recent advancements in research.
4.	Graduates shall have the ability to serve as valuable consultants in biotechnological industries and other related industries.
5.	Graduates shall be capable of fostering innovative techniques and solutions for societal problems in biotechnology and allied fields.

PROGRAM OUTCOMES (POs)

PO#	Graduate Attribute
1	Ability to independently carry out research/investigation and development work to solve practical problems.
2	Ability to write and present a substantial technical report/document.
3	Able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor programme.
4	Able to achieve leadership skills and the latest update with in-depth knowledge in various fields of biotechnology
5	Able to apply the appropriate techniques for the upstream and downstream processes, sample analysis from laboratories, and industrial processes.
6	Ability to manage and maintain the biotechnology industries focusing on Bioprocess, Immunotechnology, Microbial technology, and computational biology along with the handling of various sophisticated techniques.

PEO/PO Mapping:

PEO	PO1	PO2	PO3	PO4	PO5	PO6
1	3	2	2	3	1	2
2	2	1	1	3	2	2
3	3	3	2	1	3	3
4	3	2	3	2	3	3
5	2	2	3	2	3	3

PROGRESS THROUGH KNOWLEDGE

MAPPING OF COURSE OUTCOMES AND PROGRAMME OUTCOMES

Average of CO- PO mapping value obtained in each course are to be filled here to arrive the program articulation matrix

		COURSE NAME	PROGRAMME OUTCOMES					
			PO1	PO2	PO3	PO4	PO5	PO6
YEAR I	SEMESTER I	Applied probability and statistics	3	3	3	3	2	2
		Research Methodology and IPR						
		Advanced Bioprocess Engineering	3	3	2.8	3	2.25	2.2
		Immunotechnology	2.5	2.6	2.4	2	2.33	3
		Professional Elective I						
		Professional Elective II						
		Professional Elective III						
		Immunotechnology Lab	3	3	2	2.33	2.33	2
	SEMESTER II	Animal Cell culture technology	3	3	2.5	2	2.5	2.5
		Advanced Bioseparation Technology	2	2	2	2	3	3
		Computational Biology	2	3	3	2	-	1
		Techniques in MolecularBiology and Genetic Engineering	-	3	2	2	2	2
		Professional Elective IV						
		Professional Elective V						
		Computational BiologyLaboratory	2	2	3	2	-	-
		Animal cell culture technology Lab	2.3	-	1.6	2	3	3
YEAR II	SEMESTER III	Integrated bioprocess development laboratory	3	3	3	3	3	3
		Sophisticated analytical techniques Lab	3	3	3	2	3	3
		Molecular Biology and Recombinant DNA Technology Lab	3	2	3	3	3	2
		Project Phase I	3	3	3	3	3	3
	SEMESTER IV	Project Phase II	3	3	3	3	3	3

PROGRESS THROUGH KNOWLEDGE

ANNA UNIVERSITY, CHENNAI: 600 025

UNIVERSITY DEPARTMENTS

M. TECH. BIOTECHNOLOGY

REGULATIONS – 2023

CHOICE BASED CREDIT SYSTEM (CBCS)

SEMESTER I

S. NO.	CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA3158	Applied Probability and Statistics	FC	4	0	0	4	4
2.	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3
3.	BT3101	Advanced Bioprocess Engineering	PCC	3	0	0	3	3
4.	BT3102	Immunotechnology	PCC	3	0	0	3	3
5.		Professional Elective I	PEC	3	0	0	3	3
6.		Professional Elective II	PEC	3	0	0	3	3
7.		Professional Elective III	PEC	3	0	0	3	3
PRACTICALS								
8.	BT3111	Immunotechnology Laboratory	PCC	0	0	6	6	3
			TOTAL	**21**	**1**	**6**	**28**	**25**

SEMESTER II

S. NO.	COURSECODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	BT3252	Animal Cell Culture Technology	PCC	3	0	0	3	3
2.	BT3251	Advanced Bioseparation Technology	PCC	3	0	0	3	3
3.	BT3201	Computational Biology	PCC	3	0	0	3	3
4.	BT3253	Techniques in Molecular Biology and Genetic Engineering	PCC	3	0	0	3	3
5.		Professional Elective IV	PEC	3	0	0	3	3
6.		Professional Elective V	PEC	3	0	0	3	3
PRACTICALS								
7.	BT3211	Computational Biology Laboratory	PCC	0	0	4	4	2
8.	BT3261	Animal cell Culture Technology Laboratory	PCC	0	0	6	6	3
			TOTAL	**18**	**0**	**10**	**28**	**23**

SEMESTER III

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	BT3311	Integrated Bioprocess Development laboratory	PCC	0	0	6	6	3
2.	BT3361	Sophisticated Analytical Techniques Laboratory	PCC	0	0	6	6	3
3.	BT3312	Molecular Biology and Recombinant DNA Technology Laboratory	PCC	0	0	6	6	3
4.	BT3313	Project Work I	EEC	0	0	12	12	6
			TOTAL	**0**	**0**	**30**	**30**	**15**

SEMESTER IV*

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	BT3411	Project Work II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL NO. OF CREDITS: 75

PROGRESS THROUGH KNOWLEDGE

PROFESSIONAL ELECTIVE COURSES

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1	BT3052	Environmental Biotechnology	PEC	3	0	0	3	3
2	BT3053	Enzyme Engineering and Technology	PEC	3	0	0	3	3
3	BT3057	Nanobiotechnology	PEC	3	0	0	3	3
4	BT3001	Biofuels and Platform Chemicals	PEC	3	0	0	3	3
5	BT3056	Molecular Pathogenesis of Infectious Diseases	PEC	3	0	0	3	3
6	BT3058	Plant Design and Practice	PEC	3	0	0	3	3
7	BT3059	Human Heredity and Genetics	PEC	3	0	0	3	3
8	BP3054	Biogenerics and Biopharmaceuticals	PEC	3	0	0	3	3
9	BP3052	Clinical Trials and bioethics	PEC	3	0	0	3	3
10	BP3051	Chemistry of natural products	PEC	3	0	0	3	3
11	BT3002	Biosafety and Bioethics	PEC	3	0	0	3	3
12	BT3060	Biosensors and Diagnostic Applications	PEC	3	0	0	3	3
13	BT3003	Bioprocess Modeling and Simulation	PEC	2	0	2	4	3
14	BP3053	Molecular Diagnostics	PEC	3	0	0	3	3
15	BT3051	Applied Genomics and Proteomics	PEC	3	0	0	3	3
16	BT3004	Tissue Engineering and Regenerative Medicine	PEC	3	0	0	3	3
17	BT3005	Plant Genetic Engineering and Biotechnology	PEC	3	0	0	3	3
18	BT3006	Computational Fluid Dynamics	PEC	3	0	0	3	3
19	BT3054	GMP and Validation in Bioprocess Industries	PEC	3	0	0	3	3
20	BT3055	Metabolic Engineering	PEC	3	3	0	3	3
21	BP3055	Molecular Medicine and Mechanism	PEC	3	3	0	3	3
22	BC3051	Synthetic Biology	PEC	3	0	0	3	3
23	FD3051	Functional Foods	PEC	3	0	0	3	3

PROFESSSIONAL CORE (PCC)

Sl. No.	CODE NO	COURSE TITLE	L	T	P	CREDITS
1	MA3158	Applied Probability and Statistics (FC)	4	0	0	4
2	BT3101	Advanced Bioprocess Engineering	3	0	0	3
3	BT3102	Immunotechnology	3	0	0	3
4	BT3111	ImmunotechnologyLaboratory	0	0	6	3
5	BT3252	Animal Cell Culture technology	3	0	0	3
6	BT3251	Advanced Bioseparation Technology	3	0	0	3
7	BT3201	Computational Biology	3	0	0	3
8	BT3253	Techniques in MolecularBiology and Genetic Engineering	3	0	0	3
9	BT3211	Computational BiologyLaboratory	0	0	4	2
10	BT3261	Animal Cell Culture Technology Lab	0	0	6	3
11	BT3311	Integrated Bioprocess Development Laboratory	0	0	6	3
12	BT3361	Sophisticated Analytical Techniques Lab	0	0	6	3
13	BT3312	MolecularBiology and Recombinant DNA Technology Laboratory	0	0	4	2

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. No.	Code no.	COURSE TITLE	PERIODS PER WEEK			CREDITS
			L	T	P	
1	RM3151	Research Methodology and IPR	2	1	0	3

PROGRESS THROUGH KNOWLEDGE

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. No.	Code No.	Course name	L	T	P	Credits
1	BT3313	Project Work Phase – I	12	0	0	6
2	BT3411	Project Work Phase – II	24	0	0	12

SUMMARY

	Name of the Programme: M.E Biotechnology					
	SUBJECT AREA	**CREDITS PER SEMESTER**				**CREDITS TOTAL**
		I	II	III	IV	
1.	FC	4	-			4
2.	PCC	9	17	9		35
3.	PEC	9	6			15
4.	RMC	3	-			3
5.	EEC	-	-	6	12	18
6.	**TOTAL CREDIT**	**25**	**23**	**15**	**12**	**75**

PROGRESS THROUGH KNOWLEDGE

MA3158 APPLIED PROBABILITY AND STATISTICS L T P C
4 0 0 4

OBJECTIVES

The course aims to

- Provide the basics of random variables with emphasis on the standard discrete and continuous distributions.
- Introduce the concepts of sampling distributions and the test statistics.
- provide an understanding of the statistical methods and concepts by which real life problems are analyzed.
- Make the students to analyze various data using statistical techniques.
- Train the students in design experiments and use these concepts for research.

UNIT I PROBABILITY THEORY 12

Random variables – probability density and distribution functions-moment generating and characteristic functions – Binomial, Poisson, Normal distributions and their applications.

UNIT II SAMPLING THEORY 12

Sampling distributions – Standard error – t, F, Chi square distributions – applications.

UNIT III ESTIMATION THEORY 12

Interval estimation for population mean, standard deviation, difference in means, preparation ratio of standard deviations and variances.

UNIT IV TESTING OF HYPOTHESIS AND ANOVA 12

Hypothesis testing – Small samples – Tests concerning proportion, means, standard deviations – Tests based on chi square – and Redistribution test -Design of experiments.

UNIT V ANOVA 12

Design of experiments – One, Two factor Models

TOTAL: 60 PERIODS

OUTCOMES:

At the end of the course, the student will be able to

- Analyze the performance in terms of probabilities and distributions achieved by the determined solution.
- Analyze and interpret statistical analysis for the samples.
- Develop an ability to apply statistical tests in experiments as well as to analyze and interpret data.
- Use the statistical tools for their project and future research.
- Use the concepts in design of experiments in real life problems.

REFERENCES:

1. Gupta and Kapoor, “Fundamentals of Applied Statistics”, Sultan Chand and sons, 4th Edition, New Delhi, 2019.
2. Hooda, “Statistics for Business and Economics”, Macmillan, 3rd Edition, India, 2003.
3. John.E.Freunds, “Mathematical statistics with applications”, Pearson Education, 8th Edition, New Delhi, 2013.
4. Levin and Rubin, “Statistics for Management”, Pearson Education India, 7th Edition, New Delhi, 2013.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2

RM3151 RESEARCH METHODOLOGY AND IPR L T P C
2 1 0 3

UNIT I RESEARCH PROBLEM FORMULATION 9

Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II RESEARCH DESIGN AND DATA COLLECTION 9

Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING 9

Sampling, sampling error, measures of central tendency and variation,; test of hypothesis-concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for wring thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV INTELLECTUAL PROPERTY RIGHTS 9

Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; , IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V PATENTS 9

Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

TOTAL: 45 PERIODS

REFERENCES:

1. Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
2. Soumitro Banerjee, “Research methodology for natural sciences”, IISc Press, Kolkata, 2022,
3. Catherine J. Holland, “Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets”, Entrepreneur Press, 2007.
4. David Hunt, Long Nguyen, Matthew Rodgers, “Patent searching: tools & techniques”, Wiley, 2007.
5. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, “Professional Programme Intellectual Property Rights, Law and practice”, September 2013.

BT3101 ADVANCED BIOPROCESS ENGINEERING

L	T	P	C
3	0	0	3

OBJECTIVES

The course aims to

- Provide in depth knowledge about bioreactor and its types.
- impart the importance of optimization and control strategies.

UNIT I BIOREACTION ENGINEERING FUNDAMENTALS 9

Thermodynamics of Biosystems - Principles of Cellular Metabolism and - Principles of Metabolic flux analysis. - Biochemical pathway engineering - Rational manipulation of biosystems through metabolic and genetic engineering techniques to provide new biocatalysts/bioproducts/value added products. New approaches for design of cellular systems: Integration of recombinant technology and process design, as well as bioinformatics and process systems engineering

UNIT II BIOREACTORS AND OPERATIONAL MODES 9

Background of bioreactors, Modelling and Design of bioreactors: batch, fed batch, and continuous flow types (Airlift bioreactors, Airlift pressure cycle bioreactors, Loop bioreactor, stirred tank bioreactors, Fluidized bed bioreactor, Packed-bed reactors, Trickle bed bioreactor, Bubble column fermenter, Multiphase bioreactors, Disposable bioreactors and Wave bioreactor.

UNIT III BIOREACTOR ENGINEERING 9

Design of Stirrers and impellers. Design, development and scale up of bioreactors for production of antibiotics, enzymes, vaccines, therapeutic products and biofuels.

UNIT IV BIOPROCESS OPTIMIZATION STRATEGIES 9

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

UNIT V BIOPROCESS MONITORING AND CONTROL STRATEGIES 9

Sensors and transducers for different bioprocess – review of general fermentation measurement instruments – Important process variables like pressure, torque, speed, temperature, pH, dissolved oxygen, metabolites' concentration - Principles of Chemical Sensors and Their Application to Bioprocess Monitoring - Fiberoptic Chemical Sensors for bioprocess monitoring-Process Integration and Sustainable Bioprocessing- Control strategies – Proportional – PI – Cascade control – Advanced control strategies

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1 Understand the characteristics of biochemical pathways and their manipulation for higher productivity

CO2 Analyse the reactor operation for optimal productivity

CO3 Design and analyse the reactor performance for optimal bioreactor operation and scale up

CO4 Explain the design and operating condition of bioreactor

CO5 Understand and apply the knowledge for monitoring and control of bioreactors

REFERENCES:

1. Shuler and Kargi, "Bioprocess Engineering" Second edition, Prentice Hall India, 2001
2. Pauline Doran, "Bioprocess Engineering Principles" Second Edition, Academic Press, 2015.

3. Peter F. Stanbury, Stephen J. Hall & A. Whitaker, “Principles of Fermentation Technology”, 3rd Ed., Butterworth Heinemann, 2016
4. Harvey W. Blanch, Douglas S. Clark, Biochemical Engineering, Marcel Dekker, Inc, 1996
5. Lydersen, Bjorn K. “Bioprocess Engineering Systems, Equipment and Facilities” John Wiley, 1994.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3		2	1
CO2		3	3			3
CO3			3	3	3	3
CO4			3	3	3	3
CO5	3	3	2		1	1
OVERALL CO	3	3	2.8	3	2.25	2.2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

BT3102 IMMUNOTECHNOLOGY L T P C
3 0 0 3

OBJECTIVES

The course aims to

- Provide the knowledge for the development of diagnostics, therapeutics, and vaccine development
- Impart utilization of immunotechnology for clinical applications and regulatory issues.

UNIT I INTRODUCTION 9

Review on Cells of the immune system and their development; primary and secondary lymphoid organs; humoral immune response; cell mediated immune responses; complement, classification of T cells and B cells, cell markers. Hypersensitivity reactions.

UNIT II ANTIBODIES 9

Development and production of Monoclonal antibodies and their applications; ELISA — types; IFT (direct and indirect) Agglutination tests; Antigen detection assay; Plaque Forming Cell Assay, Development of rapid immunodiagnostics - Immuno- lateral flow / flow through assays. Total Ig and antigen specific IgE antibody assay, assay for haemolytic diseases, assay for immune complex, skin tests for DTH response.

UNIT III DEVELOPMENT OF IMMUNOASSAYS 9

PBMC separation from the blood; identification of lymphocytes based on CD markers; FACS; Lympho proliferation assay; Mixed lymphocyte reaction; Cr51 release assay; macrophage cultures; cytokine bioassays- IL2, gamma IFN, TNF alpha.; HLA typing.

UNIT IV VACCINE TECHNOLOGY 9

Principles of vaccine development, types; Strategies for the development of vaccines for bacterial, viral and parasitic diseases, Regulatory requirements for vaccine development and testing, ethical issues, protein based vaccines; sub-unit vaccines, DNA vaccines; Plant based vaccines; recombinant antigens as vaccines; T and B cell epitope based vaccine development reverse vaccinology, cancer diagnosis, cancer vaccines, customized

therapeutic cancer vaccines.

UNIT V DEVELOPMENT OF IMMUNOTHERAPEUTICS 9

Development of effective immuno drug targets for infectious diseases, engineered antibodies; catalytic antibodies; idiotypic antibodies; (scFv) antibodies and molecular evolution of scFv for enhanced sensitivity and specificity,dendritic cells based immunotherapy, combinatorial libraries for antibody isolation, CAR T-cell therapy, Immune check point inhibitors.

TOTAL: 45 PERIODS

OUTCOMES

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

CO1 Understand the basic science of immunology

CO2 Understand and analyse the disease conditions and the antibody Mechanism against antigen.

CO3 Understand and apply the technology for the development of Immune therapeutics and diagnosis.

CO4 Apply their knowledge for vaccine production and development processes

CO5 Develop their skills in diagnosis, production and entrepreneurship.

REFERENCES

1. Peter J. Delves, Seamus J. Martin, Dennis R.Burton, Ivan M. Roitt, “Essential Immunology” 9th Edition., Blackwell Scientific, 13th edition, 2017
2. Roitt I., Brostoff J. and Male D. Immunology, 6th ed. Mosby, 2001
3. Goldsby , R.A., Kindt, T.J., Osbome, B.A. and Kerby J. Immunology, 6th ed., W.H.Freeman, 2006
4. Kenneth M. Murphy, Casey Weaver, Janeway’s “Immunobiology”, Ninth Edition, 2017
5. Lippincott Illustrated Reviews: “Immunology”, 2nd ed., 2012

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	2	-	-	-
CO2	3	3	1	3	-	-
CO3		3	3	1	2	3
CO4	3	3	3	1	2	3
CO5	1	1	3	3	3	3
OVERALL CO	2.5	2.6	2.4	2	2.33	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

BT3111 IMMUNOTECHNOLOGY LABORATORY

L	T	P	C
0	0	6	3

OBJECTIVES

The course aims to

- Make the students skilled in the fundamental techniques in immunology
- Teach them the latest techniques required for developing skills in Immunotechnology

LIST OF EXPERIMENTS

1. Ethics, selection and handling of animals for immunological experiments (Eg. Mice,Rats, Rabbits).
2. Preparation of antigens for immunisation and Routes of immunisation (Eg. Intra-peritonial, Sub-cutaneous, Intra-muscular,Intra-nasal).
3. Methods of bleeding (Eg. Tail bleeding, Intravenous, intraorbital)
4. Collection of serum, storage and purification of total IgG (salt precipitation; Protein A).
5. Evaluation of Antibody titre by direct ELISA.
6. Evaluation of Antigen by Sandwich ELISA.
7. Characterisation of antigens by native, SDS-PAGE.
8. Characterisation of antigens by Immunoblotting.
9. Conjugation of Immunoglobins (Streptavidin/colloidal gold/enzyme conjugation).
10. Methods for prototype development of Immunodiagnostics (Lateral flow or rapid immunoflow-through assays).
11. Identification of leucocytes by Giemsa stain from blood smear.
12. Outline the process of monoclonal antibody production (batch demonstrations)
13. Screening of lymphocytes by FACS
14. Separation of mononuclear cells by Ficoll-Hypaque.

Separation of spleenocytes and proliferation against mitogens (MTT assay) (abattoir specimens or voluntary specimens from research projects under CPCSEA guidelines and the procedure will be demonstrated).

TOTAL: 90 PERIODS

OUTCOMES:

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

CO1 Have an understanding of the experimental aspects of immunotechnology
CO2 Apply basics skills for the development of immunotherapeutics and diagnosis
CO3 Designing immunotech experiments and interpretation

REFERENCES:

1. Ed Harlow, David P Lane, “Antibodies: A Laboratory Manual”, Cold Spring Harbor Laboratory Press, 2nd Edition, 1998 and updated editions
2. Joseph Sambrook, David W. Russell, “Molecular cloning : A laboratory manual “, 3rd ed. Cold Spring Harbor, N.Y. : Cold Spring Harbor Laboratory, 2001
3. John E. Coligan .et al, “Current protocols in immunology”, New York : Wiley Interscience, 2003

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	2	1
CO2	3	3	1	3	3	2
CO3	3	3	3	1	2	3
OVERALL CO	3	3	2	2.33	2.33	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate

(Medium) andSubstantial (High) respectively.

BT3252 ANIMAL CELL CULTURE TECHNOLOGY L T P C
3 0 0 3

OBJECTIVES

The course aims to

- Provide advanced knowledge on the principles of utilizing recombinant cells/ transgenic animals for clinical/industrial applications

UNIT I INTRODUCTION 9

Scope of Animal Biotechnology, Animal Biotechnology for production of regulatory proteins, blood products, vaccines, hormones and other therapeutic proteins.

UNIT II VIRAL EXPRESSION SYSTEMS 9

Biology of animal viral vectors- SV40, adeno virus, retrovirus, vaccinia virus, herpes virus, adeno associated virus and baculo virus.

UNIT III CELL CULTURE TECHNOLOGY 9

Culturing of cells, primary and secondary cell lines, Cell Culture-Scaling up of animalcell culture-monolayer culture, suspension culture; Various bio-reactors used for animal cell culture-Roller bottle culture; Bioreactor process control, stirred animal cell culture, Air-lift fermentor, Chemostat/Turbidostat; High technology vaccines: Hybridoma technology; Cell lines and their applications

UNIT IV GENETIC ENGINEERING 9

Gene therapy-prospects and problems; Knockout mice and mice model for human genetic disorder; Baculo virus in biocontrol; Enzymes technology, Somatic manipulation of DNA, Nucleic acid hybridization and probes in diagnosis- preparation of probes, evaluation and applications.

UNIT V APPLICATIONS 9

Rumen manipulation- probiotics embryo transfer technology, invitro fertilization,transgenesis-methods of transferring genes into animal oocytes, eggs, embryos and specific tissues by physical, chemical and biological methods; Biopharming - Transgenic animals (Mice, Cows, Pigs, Sheep, Goat, Birds and Insects); Artificial insemination and embryo transfer, cryopreservation and CRISPR.

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1 Acquire knowledge on animal biotechnology.
CO2 Use molecular biology tools for viral vector based gene delivery.
CO3 Understand scaling up cell culture in industry.
CO4 Describe the importance of genetic engineering in animal biotechnology.
CO5 Apply animal biotechnology knowledge in livestock industry.

REFERENCES

1. Watson, J.D., Gilman, M., WitowskiJ. and Zoller, M, “Recombinant DNA”, 3rd ed., Scientific American Books, 2007
2. Glick, B.R. and Pasternack, J.J., “Molecular Biotechnology”, 3rd ed., ASM Press, 2003
3. Lewin, B. “Genes VIII” , Pearson Prentice Hall, 2004
4. Davis J.M.”Basic Cell Culture: A Practical Approach”, IRL Press, 2nd ed., 2002
5. Freshney R.I., “Animal Cell Culture- a practical approach”, 6th ed., 2010

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2		2	
CO2		3	3		2	3
CO3	3	3	2	1		3
CO4	3	3	3		3	1
CO5		3		3	3	3
OVERALL CO	3	3	2.5	2	2.5	2.5

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) andSubstantial (High) respectively.

BT3251 ADVANCED BIOSEPARATION TECHNOLOGY L T P C
3 0 0 3

OBJECTIVES

The course aims to

- Train the students with all techniques required in the purification of proteins
- Provide knowledge about downstream processing of large biomolecules and also important antibiotics.

UNIT I GENERAL ASPECTS DOWNSTREAM PROCESS DESIGN AND DEVELOPMENT 9

Introduction to Bioproducts and their Characterization – Purification process flow charting – Economics of Bioproduct Purification – Design of bioseparation process – Thermodynamics - Material and Energy balances -General Schema of Purification strategy – Case studies.

UNIT II INTRODUCTION TO ADSORPTIVE BIOSEPARATIONS 9

Introduction, Theory and chemistry of adsorption. Chromatographic Fundamentals: Retention, Band Spreading, Resolution; Dynamics of Chromatography: Basic mass transfer equations, Method of moments, Linear dispersion model, Linear staged models for chromatography; Instrument Requirements for Chromatography: System design, Column packing techniques; Fundamentals of Adsorption: Gibbs adsorption isotherm, Adsorption isotherm models, Local equilibrium theory and solute movement plots; Expanded bed adsorption.

UNIT III MEMBRANE SEPARATION PROCESSES 9

Principles of membrane separation, Membrane Materials, Transport phenomena of species, molecular and ionic, in porous or dense, charged or not, membranes. Membrane separation processes: Reverse Osmosis, Ultrafiltration, Microfiltration, Nanofiltration, Dialysis, Electrodialysis, Gas Permeation, Pervaporation, Liquid membranes, Membrane modules and design, cost estimation.

UNIT IV CHROMATOGRAPHIC SEPARATION PROCESS DESIGN 9

Preparative Chromatography: Preparative elution, Frontal, Gradient, Displacement chromatography, Optimization; Hydrodynamic design of adsorbent: Particle size, pore size, surface area and pore volume etc. Thermodynamic design of adsorbent: Ligand design through Molecular modeling, retention mechanisms. Modes of Chromatography: Reversed phase and hydrophobic interaction, Ion exchange and Ion exclusion, Size-exclusion, Group specific and biospecific affinity, IMAC, Supercritical fluid chromatography; Isocratic and Gradient Elution preparative chromatography.

UNIT V BIOLOGICAL PRODUCT STABILIZATION AND FORMULATION DEVELOPMENT 9

Factors influencing the peptide and amino acid stability –pre-formulation and development of stability-indicating assays: biophysical characterization techniques- development of a formulation for solid and liquid dosage form - development of a formulation for lyophilized dosage form; Protein Stability During Bioprocessing, Purification, Formulation and Filling; Drying operations - Spray drying - and Freeze drying.

TOTAL: 45 PERIODS

OUTCOMES

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

CO1 Have a comprehensive understanding of the physicochemical properties of biotechnological products and economics of downstream processing.

CO2 Apply their knowledge about equipment selection and design of mechanical Separation process for recovery of biotechnological products.

CO3 Identify and optimize the suitable bioproduct isolation process at laboratory and pilot scale.

CO4 Understand and apply the knowledge of chromatographic separation processes in industrial application and equipment selection.

CO5 Design and apply principles of various unit operations used in downstream processing and enhance problem solving technique.

REFERENCES:

1. Roger Harrison, Paul Todd, Scott Rudge and Dimitri Petrides, “Bioseparations Science andEngineering”, Oxford University Press, 2003.
2. Ghosh, Raja “Principles of Bioseparations Engineering”. World Scientific, 2006.
3. Georgios Carta and AloisJungbauer, “Protein Chromatography: Process Development and Scale-up”, Wiley-VCH, 2010.
4. Belter, P.A., E.L. Cussler and Wei-Houhu “Bioseparations – Downstream Processing forBiotechnology”, John Wiley, 1988.
5. Michael C Flickinger, “Encyclopedia of Downstream Industrial Biotechnology”, John Wiley&Sons, 2010.
6. Michael R. Ladisch, Bioseparations Engineering, Wiley Interscience, 2001.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	2	3	-
CO2	1	1	2	-	3	3
CO3	2	2	2	-	3	3
CO4	3	2	2	-	3	3
CO5	2	3	2	-	3	3
OVERALL CO	2	2	2	2	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BT3201 COMPUTATIONAL BIOLOGY L T P C
3 0 0 3

OBJECTIVES

The course aims to

- Introduce the student to biological data and sequence analysis, phylogenetics, next generation sequencing data analysis and get familiarized with protein three dimensional structure, modeling, docking and molecular dynamics simulations
- Provide the basics concepts in Machine learning, Systems Biology approaches and informatics techniques for protein identification

UNIT I INTRODUCTION TO COMPUTATIONAL BIOLOGY AND SEQUENCE ANALYSIS 9

Biological databases, Molecular sequences, Sequence Alignment, Local and Global Alignment, Needleman Wunch Algorithm, Smith Waterman Algorithm, BLAST family of programs, Progressive and Iterative methods for Multiple sequence alignment, Functional Annotation.

UNIT II BIG DATA IN BIOLOGY, NEXT GENERATION SEQUENCING DATA ANALYSIS 9

Introduction to Big Data in Biology, GEO and SRA databases, Next Generation Sequence data analysis, Exome sequencing, Single cell sequencing, Methylome sequencing, MiRNA sequencing and CHiP sequencing. RNA-Seq Data Analysis.

UNIT III PHYLOGENETICS AND MODELS OF EVOLUTION 9

Introduction to Phylogenetics, Models of Evolution, Distance and Character based methods for phylogenetic tree construction: Unweighted Pair Group Method of Arithmetic Averages, Neighbour joining Trees, Ultrametric and Additive trees, Maximum Likelihood and Maximum Parsimony methods of tree generation, Assessing the reliability of phylogenetic trees-Bootstrapping.

UNIT IV PROTEIN STRUCTURE, MODELLING AND SIMULATIONS 9

Protein Structure Basics, Visualization, Prediction of Secondary Structure and Tertiary Structure, Homology Modeling, Molecular Docking principles and applications, Molecular dynamics simulations

UNIT V MACHINE LEARNING, SYSTEMS BIOLOGY AND OTHER ADVANCED TOPICS 9

Machine learning techniques: ANN and HMM for biological data analysis, Introduction to Systems Biology, Biological networks: Protein interaction and Gene regulatory networks Microarrays and Clustering techniques for microarray data analysis, Informatics techniques for analysis of Mass spectrometry data: protein identification.

TOTAL: 45 PERIODS

OUTCOMES

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

CO1 Understand basic bioinformatics and computational biology concepts and tools
CO2 Understand and apply various omics technologies and data
CO3 Understand and analyse the evolutionary relationship using phylogenetic analysis.
CO4 Examine, Analyze, discover, evaluate and develop tools for protein structural data
CO5 Design and interpret the experimental data with machine learning techniques

REFERENCES:

1. Arthur M. Lesk, “Introduction to Bioinformatics”, Oxford University Press, 2014.
2. Dan Gusfield, “Algorithms on Strings Trees and Sequences”, Cambridge University Press,1st ed., 1997.
3. David W. Mount, “Bioinformatics: Sequence and Genome Analysis”, Cold Spring

HarborLaboratory Press, 2nd ed., 2004.
4. Baldi, P., Brunak, S. "Bioinformatics: The Machine Learning Approach", East West Press,2nd 2001.
5. Durbin, R. Eddy S., Krogh A., Mitchison G. "Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids", Cambridge University Press, 1998.
6. Shui Qing Ye, "Big Data Analysis for Bioinformatics and Biomedical Discoveries", CRC Press, Taylor and Francis Group, 2015.
7. Andrew R. Leach, "Molecular Modeling Principles And Applications", Prentice Hall, 2009
8. S.R.Pennington and M.J.Dunn, "Proteomics: From protein sequence to function", Taylor and Francis Group , 2001
9. Uri Alon, "An Introduction to System Biology Design Principles Of Biological Circuits", Chapman & Hall/CRC, Taylor and Francis Group ,2006.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	-	-	-
CO2	2	2	2	2	-	-
CO3	1	3	2	2	-	-
CO4	3	3	2	2	-	1
CO5	3	3	3	3	-	1
OVERALL CO	2	3	3	2	-	1

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BT3253 TECHNIQUES IN MOLECULAR BIOLOGY AND GENETIC ENGINEERING **L T P C 3 0 0 3**

OBJECTIVES

The course aims to

- Enlighten students with key molecular biology and genetic engineering techniques
- Provide knowledge to apply the latest techniques in current biological research as well as in biotechnology industries.

UNIT I VECTOR SYSTEMS **9**

Overview of tools in recombinant DNA technology. Artificial chromosomes – YACs and BACs. Principles for maximizing gene expression – expression vectors, pMal, GST, pET-based vectors. Protein purification – His-tag, GST-tag and MBP-tag. Intein-based vectors; Inclusion bodies; methodologies to reduce formation of inclusion bodies; mammalian expression and replicating vectors; Baculovirus and Pichia vectors system, plant based vectors, Ti and Ri plasmids as vectors, yeast vectors, shuttle vectors.

UNIT II ASSAY TECHNIQUES IN MOLECULAR BIOLOGY **9**

Nuclease protection assays, Nuclease S1 mapping, Reporter assays – Mono and dual reporter assays, Electrophoretic mobility shift assay (EMSA)/Gel shift assay, Run-off transcription assay, Phage display, Ribosome display, Gene silencing – siRNA and Morpholino.

UNIT III HIGH-THROUGHPUT DNA SEQUENCING **9**

Preparation of Next Generation Sequencing (NGS) libraries: Fragmentation versus tagmentation, end repair, clonal amplification – Bridge PCR and emulsion PCR. Basics and

steps involved in NGS platforms: Illumina/Solexa, Roche 454, Ion-torrent and Pacific biosciences. Current status of Oxford nanopore sequencing. Principles of Mate pair sequencing, ChIP-seq, RIP/CLIP-Seq, Methyl seq – Restriction enzyme, enrichment and bisulfite treatment strategies.

UNIT IV GENE EXPRESSION ANALYSIS 9

Overview of gene expression analysis and its significance. Hybridization methods: Southern and Northern. PCR methods: Reverse transcriptase PCR, End point Vs. Real time PCR, Relative quantitation, Absolute quantification – Standard curve method and digital PCR. Endogenous/loading controls. High throughput analysis: Multiplex PCR, Microarray, Serial analysis of gene expression (SAGE) and Small Amplified RNA-SAGE (SAR-SAGE), Total analysis of gene expression (TOGA), Gene calling, RNA-seq and Ribosome profiling.

UNIT V GENOME EDITING TECHNOLOGIES 9

Basics and applications of genome editing methods - Zinc-finger nuclease (ZFN), Transcription activator-like effector nucleases (TALEN), Meganucleases, CRISPR-Cas systems – Types and applications, Homing endonucleases, Transposons and Cre/lox P systems. Gene delivery systems – Physicochemical methods and viral vectors.

TOTAL: 45 PERIODS

OUTCOMES:

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

- **CO1** Understand strength and limitations of tools and techniques used in molecular biology and genetic engineering
- **CO2** Understand basic principles and steps involved in DNA/RNA sequencing methods and current protocols of specific vs global gene expression analysis
- **CO3** Understand and apply the current techniques involved in gene editing to generate appropriate genetically modified organisms
- **CO4** Analyse and interpret the results of molecular techniques and genetic engineering
- **CO5** Design experiments and interpret data using current genome editing tools

REFERENCES

1. Steven R. Head, Phillip Ordoukhanian, Daniel R. Salomon. “Next Generation Sequencing: Methods and protocols”1st Edition, Humana Press, 2018
2. KrishnaraoAppasani. “Genome Editing and Engineering” Cambridge University press 2018.
3. Raghavachari Nalini, Garcia-Reyero Natàlia. “Gene expression analysis: Methods and protocols” 1st Edition, Humana Press, 2018.
4. Primrose SB and Twyman RB. “Principles of Gene manipulation and Genomics”. 7th Edition, Wiley-Blackwell, 2006.
5. Green MR and Sambrook J. “Molecular Cloning: A Laboratory Manual”. 4th Edition, CSHL press, 2012.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	3	2	2	-	1
CO2	-	3	2	2	1	2
CO3	-	3	-	2	-	-
CO4	-	3	2	2	-	2
CO5	-	3	-	-	1	2
OVERALL CO	-	3	2	2	2	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BT3211 COMPUTATIONAL BIOLOGY LABORATORY

L	T	P	C
0	0	4	2

OBJECTIVES

The course aims to

- Provide knowledge on biological databases and bioinformatics tools.
- Develop skills in protein structural studies including docking and molecular dynamicssimulations and next generation sequencing data.

LIST OF EXPERIMENTS **60**

1. Introduction to Multiuser Operating System Linux
2. Biological databases Data Retrieval
3. Sequence Analysis- Local and Global alignment Tools
4. HMMER - Building Hidden Markov Models for Protein And Gene Families
5. Protein Structure: Data, Visualization, Alignment, Pocket detection, Homology Modeling
6. Molecular Docking : Protein-Protein and Protein Small molecule/drug
7. Molecular Dynamics Simulation: GROMACS
8. Building and Visualizing Protein Interaction Networks
9. Proteomics Tools at ExPasy Identifying proteins from mass spectrometry data
10. Next Generation Sequencing Data resources

Bioconductor package for RNA-Seq Data Analysis: Differential Gene ExpressionAnalysis, ncRNAs miRNA target prediction.

TOTAL: 60 PERIODS

OUTCOMES:

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

CO1 discover, demonstrate and impart knowledge on biological databases and bioinformatics tools.

CO2 analyze, interpret, compare and develop skills in protein structural studies including docking and molecular dynamics simulations.

CO3 identify, classify, apply and examine next generation sequencing data.

REFERENCES:

1. Dan Gusfield. “Algorithms on Strings Trees and Sequences”, Cambridge UniversityPress, 1997.
2. David W. Mount, “Bioinformatics: Sequence and Genome Analysis”, Cold Spring Harbor Laboratory Press, Second Edition, 2004.
3. Arthur M. Lesk, “Introduction to Bioinformatics” by Oxford University Press, 2008.
4. Tisdall, James, “Beginning PERL for Bioinformatics”, O’Reilley Publications”, 2001.
5. Andrew R. Leach, “Molecular Modeling Principles And Applications”, Second Edition, Prentice Hall, 2009.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	2	-	-
CO2	1	2	3	3	-	-
CO3	3	1	3	-	-	-
OVERALL CO	2	2	3	2	-	-

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BT3261 ANIMAL CELL CULTURE TECHNOLOGY LAB

L	T	P	C
0	0	6	3

OBJECTIVES

The course aims to,

- Train the students on the techniques of culturing animal cell lines.
- Provide in depth knowledge of preservation and propagation of animal cell lines

LIST OF EXPERIMENTS

1. Preparation of media and sterilization techniques for animal cell culture.
2. Preparation of primary cell culture.
3. Preparation of continuous Cell lines (Eg. CHO, cancer cell lines, SP2O, etc).
4. Staining of Animal Cells and Cell Counting.
5. Viability of animal cells by MTT assay.
6. Various methods of cell perseveration and propagation.
7. Transfection of animal cell vectors (Eg. pBUD, pVAXetc) in mammalian expression system.
8. Cultivation of recombinant CHO cell lines in bioreactor.
9. Cell separation from medium by centrifugation, filtration.
10. Purification and concentration of recombinant proteins by ammonium sulphate / aqueous two- Phase methods.
11. Evaluation of post-translational modification by SDS-PAGE-Shiff staining and other methods.
12. Demonstration of hybridoma fusion and propagation.
13. Cultivation of monoclonal antibodies in bioreactor.
14. Expression and purification of prototype therapeutic proteins insect cell lines.
15. Culture of virus in chick embryo.

TOTAL: 60 PERIODS

OUTCOMES:

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

CO1 Perform cell culture techniques

CO2 Handle animals and perform recombinant gene techniques

CO3 Design and perform experiments on recombinant proteins and monoclonal antibodies production

REFERENCES:

1. Animal Cell Culture and Technology, The Basics, Garland Science, 2nd Edition, Taylor and Francis, 2004.
2. Freshney, Culture of Animal Cells, 5th Edition, Wiley-Liss, 2005.
3. John R.W. Masters, Animal Cell Culture - Practical Approach, 3rd Edition, Oxford University Press, 2000.
4. Ed. Martin Clynes, Animal Cell Culture Techniques., Springer, 1998.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	1	2	3	3
CO2	3	-	2	2	3	3
CO3	2	-	2	2	3	3
OVERALL CO	2.3	-	1.6	2	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BT3311 INTEGRATED BIOPROCESS DEVELOPMENT LABORATORY L T P C
0 0 6 3

OBJECTIVES

The course aims to

- Provide knowledge on the fundamentals of bioprocessing of products
- Give the students hands on experience with the Bioprocess skills in both upstream and downstream processing for Biotechnology industry

1. Enzyme kinetics, inhibition, factors affecting reaction pH, temp.
2. Enzyme immobilization studies – Gel entrapment, adsorption and covalent Immobilisation.
3. Bioprocess media optimization techniques – Plackett burman, Response surface methodology.
4. Batch cultivation – recombinant *E.coli* – growth rate, substrate utilization kinetics, plasmid stability, product analysis after induction, Metabolite analysis by HPLC
5. Fed batch cultivation *E.coli, Pichia pastoris*
6. Continuous cultivation — x - d construction, kinetic parameter evaluation, gas analysis,carbon balancing, Pulse and shift techniques.
7. Bioreactor studies : Sterilization kinetics, kLa determination, residence time distribution,sensors for bioprocess monitoring
8. Animal cell culture production: T-flask, spinner flask, bioreactor
9. Cell separation methods; Centrifugation and microfiltration Cell disruption methods: Chemical lysis and Physical methods Product concentration: Precipitation, ATPS, Ultrafiltration
   High resolution purification; Ion exchange, affinity and Gel filtration, Freeze drying

TOTAL : 90 PERIODS

OUTCOMES:

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

CO1 Evaluate kinetic parameters of free enzyme and perform different methods of enzyme immobilization

CO2 Optimize medium for cultivation and design sterlization conditions

CO3 Perform different modes of cultivation in bioreactor, Mass transfer coefficient determination and bioreactor scaleup

CO4 Design biomolecules recovery operations in Biotechnology industry.

CO5 Understand and apply purification techniques

REFERENCES:

1. Pauline M Doran “Bioprocess Engineering Principles” 2nd Edition Academic Press 2012
2. Juan A. Aseknjo - “Separation Processes in Biotechnology”, CRC Press, 2020
3. Bioreactors: Animal Cell Culture Control for Bioprocess Engineering Paperback,Goutam Saha, Alok Barua, Satyabroto Sinha, CRC Press,2017
4. “Protein Purification Handbooks”, Amersham Biosciences, 2001

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	-	-
CO2	3	3	3	3	3	3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3
CO5	3	3	3	-	-	3
OVERALL CO	3	3	3	3	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High)

respectively

BT3361 SOPHISTICATED ANALYTICAL TECHNIQUES LABORATORY L T P C
0 0 6 3

OBJECTIVES

The course aims to

- Acquaint students with skills needed for understanding the theory, operation and applications of sophisticated analytical laboratory instruments

LIST OF EXPERIMENTS

1. Estimation of DNA/protein concentration by conventional and NanoDrop methods.
2. Preparative and qualitative estimation of biomolecules by HPLC analysis.
3. Evaluation of proteins by SDS-PAGE and Western blot (Chemiluminescence Fluorescence detection methods).
4. Evaluation of proteins by 2D Gel electrophoresis (demo).
5. Protein mass determination by MALDI-TOF analysis- demo.
6. Determination of pathogens by Mass spectrometry.
7. Analysis by Real-time PCR (SYBR green method) with melting curve analysis.
8. Determination of protein aggregation by Dynamic Light Scattering (DLS).
9. Evaluation of cells by Confocal microscopy.
10. FTIR analysis of biomolecules.
11. GC-MS on small molecule analysis- demo.
12. Flow cytometry analysis of cell cycle- demo.

TOTAL: 90 PERIODS

OUTCOMES

At the end of the course the student will be able to,

CO1 Have knowledge on widely used techniques in the analysis of biomolecules.

CO2 Interpret and analyse the experimental data associated with proteomics such as protein separation by 2D-gel and characterization using mass spectrometer.

CO3 Experience fluorescence based real-time PCR, cell/tissue confocal imaging and separation using flow cytometer.

REFERENCES

1. Skoog, D.A., West, D.M., and Holler, F. “Fundamentals of Analytical Chemistry”, 7th Edition. Brooks Cole, 2015.
2. Primrose S.B., Twyman R.H., and Old R.W. “Principles of Gene Manipulation”, 6 th Edition., Blackwell Science, 2001.
3. Chapman J. R. “Mass Spectrometry of Proteins and Peptides” (Methods in Molecular Biology – Vol 146) Humana Press. 2000.
4. Simpson R. J. “Proteins and Proteomics - A Laboratory Manual”, Cold Spring Harbour Laboratory Press, 2002.
5. Rosenberg I. M. “Protein analysis and Purification – Benchtop Techniques”, Springer, 2005.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	3	2
CO2	3	3	2	3	3	2
CO3	2	3	3	2	2	3
OVERALL CO	3	3	3	2	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium)

andSubstantial (High) respectively

BT3312 MOLECULAR BIOLOGY AND RECOMBINANT DNA TECHNOLOGY LAB

L T P C
0 0 6 3

OBJECTIVES

The course aims to,

- Train the students with skills needed for understanding the theory and operation of molecular biology tools
- make the students to apply the theoretical knowledge of techniques in molecular biology and genetic engineering in biotechnological academic and industrial research.

1. [a] Isolation of RNA
   [b] Assessment of RNA quality and quantity using Nanophotometer
2. cDNA synthesis
3. Primer designing
   [3a] Tm and G:C content calculation
   [3b] Hairpin, Self-dimer and heterodimer prediction
   [3c] Specificity prediction
4. Real-time RT-PCR/qRT-PCR
5. SDS-PAGE
6. Western blot Chemiluminescence detection
7. Touchdown PCR

Assembly PCR / Site directed mutagenesis

TOTAL :90 PERIODS

OUTCOMES:

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

CO1 Understand the strength and limitations of tools and techniques used in molecular biology and genetic engineering

CO2 Perform experiment related to DNA/RNA sequencing

CO3 Apply their knowledge in molecular and genetic engineering techniques, gene editing and PCR techniques

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	2	2	2
CO2	2	2	2	1	3	3
CO3	2	1	3	3	3	3
OVERALL CO	3	2	3	3	3	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BT3313 **PROJECT WORK I** **L T P C**
0 0 12 6

OBJECTIVES:
The course aims to enable the students to identify the research problem relevant to their field of interest, search databases to define the problem, design experiment, conduct preliminary study and report the findings.

COURSE CONTENT
Individual students will identify a research problem relevant to his/her field of study with the approval of project review committee. The student will collect, and analyze the literature and design the experiment. The student will carry out preliminary study, collect data, interpret the result, prepare the project report and present before the committee.

TOTAL: 180 PERIODS

OUTCOMES:
At the end of the course the students will be able to
CO1: Identify the research problem
CO2: Collect, analyze the relevant literature and finalize the research problem
CO3: Design the experiment, conduct preliminary experiment, analyse the data and conclude
CO4: Prepare project report and present

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	3	3	3	3	3	3
CO2	3	3	3	3	3	3
CO3	3	3	2	3	3	3
CO4	3	3	3	3	3	3
Avg	3	3	3	3	3	3

BT3411 **PROJECT PHASE II** **L T P C**
0 0 2412

OBJECTIVES

I. Continuation of Project Work I (at Institution/Industry)

OBJECTIVES:
The course aims to enable the students to conduct experiment as per the plan submitted in Project work I to find solution for the research problem identified.

COURSE CONTENT
The student shall continue Project work I as per the formulated methodology and findings of preliminary study. The student shall conduct experiment, collect data, interpret the result and provide solution for the identified research problem. The student shall prepare the project report and present before the committee.

TOTAL: 360 PERIODS

OUTCOMES:
At the end of the course the students will be able to
CO1: Conduct the experiment and collect data
CO2: Analyze the data, interpret the results and conclude
CO3: Prepare project report and present

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	1	2	3	4	5	6
CO1	3	3	3	3	3	3
CO2	3	3	3	3	3	3
CO3	3	3	3	3	3	3
Avg	3	3	3	3	3	3

II. Not the continuation of Project Work I (at Industry)

OBJECTIVES:
The course aims to enable the students to identify the research problem at the company, search databases to define the problem, design experiment, and conduct experiment to find the solution.

COURSE CONTENT
Individual students will identify a research problem relevant to his/her field of study at the company and get approval of project review committee. The student will collect, and analyze the literature and design the experiment. The student will carry out the experiment, collect data, interpret the result, prepare the project report and present before the committee.

TOTAL: 360 PERIODS

OUTCOMES:
At the end of the course the students will be able to
CO1: Identify the research problem
CO2: Collect, analyze the relevant literature and finalize the research problem
CO3: Design and conduct the experiment, analyse the data and conclude
CO4: Prepare project report and present

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	1	2	3	4	5	6
CO1	3	3	3	3	3	3
CO2	3	3	3	3	3	3
CO3	3	3	2	3	3	3
CO4	3	3	3	3	3	3
Avg	3	3	3	3	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BT3052 ENVIRONMENTAL BIOTECHNOLOGY

L	T	P	C
3	0	0	3

OBJECTIVES
The course aims to

- Teach students the scientific and technological principles to treat and minimize global environmental problems.
- Provide knowledge on sustainable technologies with modern biotechnological principles.

UNIT I FUNDAMENTALS OF ENVIRONMENTAL BIOTECHNOLOGY 9

Microbial flora of soil, Ecological adaptations, Interactions among soil microorganisms, biogeochemical role of soil microorganisms. Biodegradation, Microbiology of degradation and its mechanism, Pollution- Sources of pollutants for Air, Water (groundwater, marine), Noise, Land and its characteristics, Bioaugmentation, Biosorption, Bioleaching, Bioremediation- Types of Bioremediation, Bioreactors for Bioremediation, Metabolic pathways for Biodegradation for specific organic pollutants.

UNIT II ENVIRONMENTAL POLLUTION AND CONTROL 9

Pollution control and management- Environmental monitoring & sampling, Physical, chemical and biological methods and analysis- Air pollution- control and treatment strategies. Domestic l Wastewater treatment---Modes of Biological treatment for wastewater- aerobic and Anaerobic treatment, Activated sludge process-- Design and modeling of activated sludge process, Sequencing batch reactor, Membrane bioreactor.

UNIT III INDUSTRIAL WASTETWATER AND WASTE MANAGEMENT 9

Industrial wastewater management--Dairy, Paper and Pulp, Textile, Tannery, Hospital and Pharmaceutical wastewater management, Methods of Biological treatment, Industrial Hazardous waste disposal, e-waste- radioactive and nuclear power waste management, Resource recovery.

UNIT IV MODERN TOOLS FOR BIOREMEDIATION 9

Molecular biology tools for Environmental management, rDNA technology in waste treatment, Genetically modified organisms in Waste management, Genetic Sensors, Metagenomics, Bioprospecting, Nanoscience in Environmental management, Phytoremediation for heavy metal pollution, Biosensors development to monitor pollution.

UNIT V RENEWABLE ENERGY AND ENERGY MANAGEMENT 9

Alternate Sources of Energy, Biomass as a source of energy, Biocomposting, Vermiculture, Biofertilizers, Organic farming, Biofuels, Biomineralization, Bioethanol and Biohydrogen, Bio-electricity through Microbial fuel cell, Bioenergy and Biorefinery, Energy management and safety.

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1 Explain the types of bioremediation
CO2 Classify pollutants and explain about pollution control methods
CO3 Explain about waste management
CO4 Develop biosensors to monitor pollution
CO5 Acquire knowledge on management of renewable energy sources

REFERENCES:

1. Mark Y. Herring, “Genetic Engineering”, Bloomsbury Publishing Plc, 2005.
2. Bruce E. Rittmann and Perry L Mc Carty,”Environmental Biotechnology”, (2nd Ed) 2020, Mc Graw Hill Publ.
3. Young-Cheol Chang, “Microbial biodegradation of xenobiotic compounds”,Taylor and Francis Ltd. 2021
4. Franklin Burton and H. David Stensel, “Wastewater Engineering: Treatment and Reuse by George Tchobanoglous”, McGraw Hill Publ., 2017
5. Shree Nath Singh (Ed), “Microbial degradation of Xenobiotics”, Springer Publ., Heidelberg, 2012.
6. Garima Kaushik, “Applied Environmental Biotechnology: Present Scenario and Future Trends” Springer Publ., New Delhi (2015).

7. J. Sangeetha, D. Thangadurai, M. David and M. A. Abdullah, "Environmental Biotechnology: Biodegradation, Bioremediation and Bioconversion of xenobiotics for Sustainable Development", Apple Academic Press Inc., Canada, 2017.
8. Richard M. Twyman, and Sandy B. Primrose, S.B., "Principles of Gene Manipulation and Genomics", Wiley Blackwell. 2014.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	3	2	2	-	1
CO2	2	3	2	1	1	2
CO3	-	3	-	2	-	-
CO4	2	3	2	2	2	2
CO5	-	3	-	-	-	-
OVERALL CO	2	3	2	2	2	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BT3053 ENZYME ENGINEERING AND TECHNOLOGY L T P C
3 0 0 3

OBJECTIVES

The course aims to

- Teach principles of enzyme engineering and enzyme technology.
- Impart knowledge about immobilization techniques and kinetics in enzyme technology.

UNIT I ENZYMES, COENZYMES AND COFACTORS 9

Enzymes: Enzyme as biological catalysts; activation energy, specificity, Enzyme action, active site, enzyme substrate complex, cofactors, Classification, Source of enzymes; production, isolation and purification of enzymes; Characterization in terms of pH, temperature, ionic strength, substrate and product tolerance, effects of metal ions; Coenzymes and cofactors: Coenzymes, classification of vitamins, role and mechanism of action of some important coenzyme (NAD+/NADP+, FAD, lipoic acid, tetrahydrofolate, B12-coenzyme), role of cofactors with specific examples

UNIT II ENZYME KINETICS 9

Methods for investigating the kinetics of Enzyme catalysed reactions – order of reaction, initial velocity studies. Michaelis-Menten equation, Km and Vmax, enzyme inhibition; methods of plotting enzyme kinetics data; Enzyme turnover number, Solution of numerical problems. competitive, non-competitive, uncompetitive, irreversible; order of reaction, methods of plotting enzyme kinetics data; determination of Kcat, Km, Vmax, Ki, Half Life, effect of pH and Temperature on enzyme activity Multi Substrate enzymes and kinetics mechanisms; Enzyme induction, repression, covalent modification, Isoenzymes, allosteric effects

UNIT II ENZYME ENGINEERING 9

Introduction, Random and rational approach of protein engineering; Directed evolution and its application in Biocatalysis; various approaches of creating variant enzyme molecules; Future of Biocatalysis; Ideal biocatalyst.

UNIT IV IMMOBILIZED ENZYME TECHNOLOGY 9

Different techniques of immobilization of enzymes and whole cells; Advantages and

disadvantages of immobilization; Cross linked enzymes, enzyme crystals, their use and preparation Kinetics of immobilized enzymes, design and operation of immobilized enzymes reactors; Type of reactors, classification, retention of enzymes in a reactor, kinetics of enzyme reactors; Reactor performance with inhibition, operation of enzyme reactors; case studies; Application and future of immobilized enzyme technology

UNIT V ENZYMATIC TRANSFORMATION 9

Functional group interconversion using enzymes (hydrolysis reaction, oxidation/reduction reactions, C-C bond formations). Reaction engineering for enzyme-catalyzed biotransformations. Catalytic antibodies. Biocatalysts from extreme Thermophilic and Hyperthermophilic microorganisms (extremozymes). The design and construction of novel enzymes, artificial enzymes, Biotransformation of drugs (hydroxylation of Steroids), Host Guest Complexation chemistry, enzyme design using steroid templates, enzymes for production of drugs, fine chemicals and chiral intermediates.

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1 Understand basics such as enzyme's classification, action and factors affecting its activity.

CO2 Understand and analyze enzyme kinetics and different types of enzyme inhibition.

CO3 Apply the concept of biocatalysts in industrial processes

CO4 Perform and optimize enzyme engineering process and immobilization.

CO5 Design enzymes for industrial applications

REFERENCES:

1. Stryer, L., "Biochemistry" Freeman. New York, 2002
2. Lehninger, A. L., "Principles of Biochemistry, 4th ed., Worth. New York, NY, 2004
3. Voet, D., &Voet, J. G., "Biochemistry", 4th ed., Wiley & Sons. Hoboken, NJ:, 2004
4. Rehm, H. & J. Reed, G., "Enzyme Technology", Volume 7a. John Wiley & Sons, 1986
5. Irwin H. Segel, "Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry", 2nd revised Ed. John Wiley & Sons.1976
6. Biotol, "Bioreactor Design & Product Yield", Butterworth-Heinemann, 1992
7. Wang, D. I. C, Fermentation and Enzyme Technology. Wiley. New York, 1979
8. Trevor Palmer , Enzymes IInd Horwood Publishing Ltd, 2007
9. Faber K ,Biotransformations in Organic Chemistry, IV edition , Springer, 2018

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	3	2	2	-	1
CO2	2	3	2	1	1	2
CO3	-	3	-	2	-	-
CO4	2	3	2	2	2	2
CO5	-	3	-	-	-	-
OVERALL CO	2	3	2	2	2	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BT3057 NANOBIOTECHNOLOGY

L	T	P	C
3	0	0	3

OBJECTIVES

The course aims to

- Compact Knowledge on fundamental concepts of nanobiotechnology
- The application of nanobiotechnology including nanomedicine.

UNIT I NANOSCALE PROCESSES AND NANOBIOTECHNOLOGY 9

Introduction to Nanoscience and Nanotechnology; Milestones in Nanotechnology; Overview of Nanobiotechnology and Nanoscale processes; Physicochemical properties of materials in Nanoscales.

UNIT II FABRICATION AND CHARACTERIZATION OF NANOMATERIALS 9

Types of Nanomaterials (Quantum dots, Nanoparticles, Nanocrystals, Dendrimers, Buckyballs, Nanotubes); Gas, liquid, and solid –phase synthesis of nanomaterials; Lithography techniques (Photolithography, Dip-pen and Electron beam lithography); Thin film deposition; Electrospinning. Bio-synthesis of nanomaterials.

UNIT III PROPERTIES AND MEASUREMENT OF NANOMATERIALS 9

Optical Properties: Absorption, Fluorescence, and Resonance; Methods for the measurement of nanomaterials; Microscopy measurements: SEM, TEM, AFM and STM. Confocal and TIRF imaging.

UNIT IV NANOBIOLOGY AND BIOCONJUGATION OF NANOMATERIALS 9

Properties of DNA and motor proteins; Lessons from nature on making nanodevices; Reactive groups on biomolecules (DNA & Proteins); Surface modification and conjugation to nanomaterials. Fabrication and application of DNA nanowires; Nanofluidics to solve biological problems.

UNIT V NANO DRUG DELIVERY AND NANOMEDICINE 9

Properties of nanocarriers; drug delivery systems used in nanomedicine; Enhanced Permeability and Retention effect; Blood-brain barrier; Active and passive targeting of diseased cells; Health and environmental impacts of nanotechnology.

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1 Understand fundamental concepts of nanoscale processes and nanobiotechnology

CO2 Analyse and interpret the fabrication and characterization of nanomaterials in various applications

CO3 Designing novel nanomaterials for appropriate applications

CO4 Apply the knowledge for making of nanodevices and applications

CO5 Design nano-based drug delivery and nanomedicine

REFERENCES:

1. Nanobiotechnology: Concepts, Applications and Perspectives, Christ of M. Niemeyer(Editor), Chad A. Mirkin (Editor) , Wiley-VCH; 1 edition, 2004.
2. Nano Biotechnology: BioInspired Devices and Materials of the Future by Oded Shoseyovand Ilan Levy, Humana Press; 1 edition 2007.
3. NanoBiotechnology Protocols (Methods in Molecular Biology) by Sandra J Rosenthal andDavid W.W right , Humana Press; 1 edition, 2005.
4. Bio-Nanotechnology Concepts and applications. Madhuri Sharon, Maheshwar Sharon,SunilPandey and Goldie Oza, Ane Books Pvt Ltd, 1 edition 2012
5. Microscopy Techniques for Material Science. A. R. Clarke and C. N. Eberhardt (Editors)CRC Press. 1st Edition, 2002.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	-	-	-	-
CO2	-	3	-	1	2	2
CO3	2	3	3	3	3	3
CO4	-	3	3	3	2	3
CO5	-	-	3	-	-	3
OVERALL CO	2	3	3	2.33	2.5	2.75

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BT3001 BIOFUELS AND PLATFORM CHEMICALS L T P C
3 0 0 3

OBJECTIVES

The course aims to

- Build a solid foundation of knowledge and skills to study about the conversion and production of biomass to biofuels.
- Make the students to understand the importance of value added products, renewable materials and implementation of technologies in an innovative way for the enhanced production of biofuels and chemicals.

UNIT I INTRODUCTION 9

Cellulosic Biomass availability and its contents. Lignocellulose as a chemical resource. Physical and chemical pretreatment of lignocellulosic biomass. Cellulases and lignin degrading enzymes.

UNIT II ETHANOL 9

Ethanol as transportation fuel and additive; bioethanol production from carbohydrates; engineering strains for ethanol production from variety of carbon sources to improved productivity.

UNIT III BIODIESEL 9

Chemistry and Production Processes; Vegetable oils and chemically processed biofuels; Biodiesel composition and production processes; Biodiesel economics; Energetics of biodiesel production and effects on greenhouse gas emissions Issues of ecotoxicity and sustainability with ; expanding biodiesel production.

UNIT IV OTHER BIOFUELS 9

Biodiesel from microalgae and microbes; biohydrogen production; biorefinery concepts.

UNIT V PLATFORM CHEMICALS 9

Case studies on production of C3 to C6 chemicals such as Hydroxy propionic acid, 1,3 - propanediol, propionic acid, succinic acid, glucaric acid, cis-cis muconic acid.

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1 Acquire knowledge about the sources of biomass for alternative energies
CO2 Understand ethanol and its production from variety of carbon sources
CO3 Design new products by the use of cost effective and sustainable feed stocks
CO4 Apply technologies to replace the depleting energy with other energy such as

biohydrogen and bio refinery
CO5 Apply and design the strategy for optimized production of platform chemicals

REFERENCES:

1. Lee, Sunggyu; Shah, Y.T. "Biofuels and Bioenergy". CRC / Taylor & Francis, 2013.
2. S. Saravanamurugan, Hu Li, Anders Riisager, Ashok Pandey, "Biomass, Biofuels, Biochemicals- Recent Advances in Development of Platform Chemicals",1st Ed., Elsevier, 2019.
3. Prakash Kumar Sarangi, "Biorefinery Production of Fuels and Platform Chemicals", Wiley-Scrivener, 2023

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	-	-	-	-
CO2	2	3	3	-	1	3
CO3	-	3	-	1	3	1
CO4	-	3	3	-	2	-
CO5	-	3	1	-	-	-
OVERALL CO	2.5	3	2.33	-	2.5	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BT3056 MOLECULAR PATHOGENESIS OF INFECTIOUS DISEASES L T P C
3 0 0 3

OBJECTIVES

The course aims to

- Make the students to understand the advanced information on molecular pathogenesis of infectious diseases.
- Familiarize the students in molecular mechanism of molecular pathogenesis.

UNIT I INTRODUCTION 9

Discovery of microscope, Molecular Koch's postulates, Concepts of disease, Virulence, Pathogenic cycle, Vaccines and its historical perspective, Biofilms, quorum sensing, multidrug resistance.

UNIT II HOST DEFENSE AGAINST PATHOGENS AND BACTERIAL DEFENSE STRATEGIES 9

Skin, mucosa, cilia secretions, physical movements, physical and chemical barriers to bacterial colonisation, Mechanism of killing by humoral and cellular defenses, Complement, Inflammatory process, Phagocytosis, Colonization, Adherence, Iron acquisition mechanisms, Bacterial defense strategies.

UNIT III MOLECULAR MECHANISMS OF VIRULENCE 9

Virulence, Colonization factors, Microbial toxins, Secretion systems: General secretory pathway, Two-step secretion, Contact dependent secretion, Conjugal transfer system and Autotransporters.

UNIT IV MECHANISMS UNDERLYING MOLECULAR PATHOGENESIS (COMMON ENTERIC PATHOGENS) 9

Shigella: Entry, Induction of macropinocytosis, Invasion of epithelial cells, Intracellular motility and spread, Apoptotic killing of macrophages, Virulence factors involved. *E.coli*: Enterotoxigenic *E.coli* (ETEC), labile & stable toxins, Entero-pathogenic *E.coli* (EPEC), type III secretion, Cytoskeletal changes, intimate attachment; *Enterohaemerrohogic E.coli* (EHEC), Mechanism of bloody diarrhea and Hemolytic Uremic Syndrome, Enteroaggregative *E.coli* (EAEC). *Vibrio Cholerae*: Cholera toxin, Co-regulated pili, filamentous phage, survival.

UNIT V MECHANISMS UNDERLYING MOLECULAR PATHOGENESIS (COMMON NON-ENTERIC PATHOGENS) 9

Mycobacterium tuberculosis: The Mycobacterial cell envelope, Route of entry, Uptake by macrophages, Latency and persistence, Entry into and survival in phagocytes, Immune response against MTB, MTB virulence factors, Emergence of resistance. Influenza virus: Intracellular stages, Neuraminidase and Haemagglutinin in entry, M1 & M2 proteins in assembly and disassembly, action of amantadine. Plasmodium: Lifecycle, erythrocyte stages, transport mechanism and processes to support the rapidly growing schizont, parastiparous vacuoles and knob protein transport, Antimalarials based on transport processes.

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1 Understand the interaction of host and the pathogens.
CO2 Understand and interpret the clinical data
CO3 Apply the knowledge for the development of drug formulations
CO4 Design and develop new drug to inhibit the mechanisms of pathogenesis
CO5 Understand mechanisms of pathogenesis by common non-enteric pathogens

REFERENCES

1. William Coleman, Gregory Tsongalis, Molecular Pathology "The Molecular Basis of Human Disease", 2nd edition, Nov 1, 2017.
2. Madigan, Michael T. "Biology of Microorganisms", 13th edition, 2010.
3. Waksman, Gabriel and Michael caparon "Structural Biology of Bacterial Pathogenesis". American Society for Microbiology, 1st edition, 2005.
4. Salyers, Abigail A. "Bacterial Pathogenesis: A Molecular Approach" American Society for Microbiology; 2nd Revised edition, 2002.
5. Stanley, "Genetic analysis of Pathogenic Bacteria", 2002.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3				
CO2	3	3		2		1
CO3	3	3		1	1	
CO4	3		1	1	2	2
CO5	3		1	1	2	2
OVERALL CO	3	3	1	1.25	1.67	1.67

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BT3058	PLANT DESIGN AND PRACTICE	L	T	P	C
		3	0	0	3

OBJECTIVES

The course aims to

- Make the students to aware about plant designing.
- Provide the knowledge to assess cost and capital investment in product development and good manufacturing practices.

UNIT I PLANT DESIGN 9

Fermentor design, vessels for Biotechnology, piping and valves for biotechnology, Pressure relief system. Materials of construction and properties. Utilities for plant and their design introduction.

UNIT II PROCESS ECONOMICS 9

General fermentation process economics, materials usage and cost, capital investment estimate, production cost estimate. Two case studies — one traditional product and one recombinant product.

UNIT III PHARMACEUTICAL WATER SYSTEM 9

Grades of water, sanitary design, water treatment system, Water distribution system, validation.

UNIT IV VALIDATION OF BIOPHARMACEUTICAL FACILITIES 9

Introduction, why validation, when does validation occur, validation structure, resources for validation, validation of systems and processes including SIP and CIP

UNIT V GOOD MANUFACTURING PRACTICES 9

Structure — quality management, personnel, premises and equipment, documentation, production, quality control, contract manufacturing and analysis, complaints and product recall, self inspection. GLP and its principles.

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1 Understand design, materials for constructions, and different parts used in the bioreactor.

CO2 Develop cost effective natural and recombinant products.

CO3 Understand and apply the innovative methods for water conservation, sanitation disposal and its treatments.

CO4 Apply and know to the validation of a biopharmaceutical manufacturing facilities.

CO5 Carryout quality analysis along with the ability to solve the issues.

REFERENCES:

1. G. Vidya Sagar, Text book “Pharmaceutical Industrial Management” 2nd Edition, 2023.
2. Peter, Max S. and Timmerhaus, Klaus D. Plant Design and Economics for Chemical Engineers, 4th ed., McGraw Hill, 1991.
3. A compendium of Good Practices in Biotechnology, BIOTOL Series, Butterworth-Heiemann, 1993
4. Seiler, Jiing P. Good Laboratory Practice: The why and how? Springer, 2001
5. Lydersen, B.K. et al., Bioprocess Engineering: Systems, equipment and facilities, John-Wiley, 1994

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	1	2	3
CO2			2	1	3	3
CO3	2	3	3		2	3
CO4	1	2	3			2
CO5	3	3	3	2	2	1
OVERALL CO	2.25	2.75	2.6	1.33	2.25	2.4

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BT3059 HUMAN HEREDITY AND GENETICS L T P C
3 0 0 3

OBJECTIVES

The course aims to

- Provide knowledge on the fundamental aspects of human heredity and inheritance
- Make the students familiar with the tools available to test the inheritance of congenital diseasesand gene therapy

UNIT I BACKGROUND, HISTORY AND HEREDITY 9

Introduction to Genetics, Mendelian Genetics. Definitions- Alleles, Phenotypes, Genotypes, Dominance, Incomplete Dominance, co-dominance, Recessiveness, Homozygous, Heterozygous, Hemizygous , Penetrance and Expressivity. Multiple Alleles, ABO blood groups, Bombay phenotype, Epistasis, Pleitropy. Mendelian inheritance in Humans – Segregation and Independent. Assortment — Marfan Syndrome, Porphyria variegate. Prader — Willi Syndrome and Angelman Syndrome. Types of inheritance, Autosomal Recessive, Autosomal Dominant, Sex-linked Dominant and Sex-linked Recessive. Pedigree Analysis of the different types of inheritance.

UNIT II CYTOGENETICS 9

Human chromosome set. Analyzing chromosomes and Karyotype. Making a karyotype and obtaining cells. Aminocentesis, chorionic villi sampling-Variation in chromosome number of sets. Polyploidy, Aneuploidy, Autosomal Monosomy, Autosomal trisomy. Risks for autosomal trisomy. Aneuploidy of the sex chromosomes. Turner syndrome, Kleinfelter Syndrome, XYY. Structural Alterations –Deletions and translocations, Fragility and Uniparental Disomy.

UNIT III DEVELOPMENT AND SEX DETERMINATION 9

Sex determination in humans. Human development: Fertilization to Birth. Trimester of Birth. Teratogens, Radiation, Infections agents and Chemicals. Fatal Alcohol Syndrome. Controlling Reproduction, Contraception and Assisted Reproductive Technologies. Role of environment and chromosomes. Role of Hormones, Androgen insensitivity, Sex testing in sports, Sex phenotype changing and Sex phenotype at puberty. Mutations. Equalizing chromosomes in males and females. Mosaicism, X-inactivation, Expression genes on the X-chromosome. Sex- influenced and Sex-limited traits in humans. Mitochondrial inheritance.

UNIT IV POLYGENES AND MULTIFACTORIAL INHERITANCE 9

Polygenes and Variations in phenotype. Additive model. Averaging out the phenotype for polygenic inheritance. Multifactorial inheritance and traits. Effect of the environment.

Threshold effect and the expression of multifactorial traits. Interaction between genotype and the environment. Fingerprints to estimate heritability, Twins, homo zygotic and Dizygotic. Skin color, Cardiovascular diseases-Genetics and Environment. Intelligence and IQ. Searching for genes for intelligence. IQ and Race.

UNIT V GENE MAPPING, TESTING AND BIOETHICS 9

Gene mapping, Testing, Physical mapping, Heteromorphisms, Deletions, Translocation, Dosage mapping. In-situ Hybridization, Somatic Cell hybridization, and positional cloning. Genetic testing and Gene therapy. Clinical Genetics and Genetic counseling. Eugenics and Bioethics.

TOTAL: 45 PERIODS

OUTCOMES

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

CO1 Understand the fundamental aspects of human heredity
CO2 Understand and interpret the factors which influence the heritance
CO Have knowledge on available tools and test for diagnosis of congenital diseases and gene therapy
CO4 Analyze the concepts of multifactorial inheritance and zygotes
CO5 Design the gene therapy model using theoretical knowledge.

REFERENCES

1. Tamarin, R.H., "Principles of Genetics", Tata McGraw Hill, New Delhi, 2002.
2. De Robertis, E. D. P. and De Robertis, E. M. F., "Cell and Molecular Biology", 8th Edition, Lippincott Williams & Wilkins, New York, USA, 2001.
3. Gardner, E.J, Simmons, M.J, and Snustad, D.P., "Principles of Genetics",8th Edition, JohnWiley & Sons, Singapore, 2003.
4. Strickberger, M.W., "Genetics", 3rd Edition, Prentice Hall of India, New Delhi, 2008.
5. Klug, W.S. and Cummings, M.R., "Concepts of Genetics", Pearson Education, New Delhi,2003.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	1	2	3
CO2			2	1	3	3
CO3	2	3	3		2	3
CO4	1	2	3			2
CO5	3	3	3	2	2	1
OVERALL CO	2.25	2.75	2.6	1.33	2.25	2.4

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BP3054 BIOGENERICS AND BIOPHARMACEUTICALS L T P C
3 0 0 3

OBJECTIVES

The course aims to,

- Introduce the students about manufacturing processes and characterisation of biosimilars.

UNIT I BIOGENERICS INTRODUCTION 9

Definition: Generics and its advantages; Biogenerics and Biosimilars; Why biosimilars are not (bio) generics; The advent of Biosimilars; The role of patents in the drug industry; Protein-based biopharmaceuticals; Manufacturing processes; Global market; International

Non-proprietary Names (INN) nomenclature system biosimilars regulation (EU position, US pathways, Government initiatives).

UNIT II BIOSIMILARS AND ITS SCENARIO 9

Approved follow-on proteins/Biosimilars; Characteristics of high selling peptides and proteins,; Products with expired patents; Challenging originator's patents; Target products for FOB (follow- on biologics) /Biosimilars development peptides; Recombinant Non Glycosylated proteins; Recombinant glycosylated proteins; Industries dealing with biogenerics and its market value; World scenario; Indian scenario.

UNIT III CHARACTERIZATION OF BIOSIMILARS 9

Approaches to the characterization of biosimilars; Problems in characterizing biologics(Types of biologic, Peptides, Non-glycosylated proteins, Glycosylated proteins, Monoclonal antibodies); Equivalence issues; Post-translational modifications; Effect of microheterogeneity; Pharmacokinetics; Pharmacodynamics; and Clinical efficacy; Analytical Methods for the characterization of biosimilars (Chromatography, Protein sequencing, Mass Spectrometry, UV absorption, Circular dichroism, X-ray techniques, Nuclear magnetic resonance, Electrophoresis, Western blotting, Bioassays, ELISA, Immunoprecipitation and other procedures).

UNIT IV IMMUNOGENICITY OF BIOPHARMACEUTICALS 9

Computing to immunogenicity (product-related factors and host-related factors), consequence of immunogenicity to biopharmaceuticals; Measurement of immunogenicity.

UNIT V CASE STUDIES 9

Case studies: Erythropoietin, Insulin, Somatotropin, Interleukin-2, Interferon Granulocyte-macrophage-CSF, DNase, Factor VIIa, Factor IX, Factor VIII, Activated protein C, Tissue plasminogen activator, Monoclonal antibodies etc., Immunogenicity of biopharmaceuticals: Immunogenicity; Factors contributing.

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course the student will be able to,

CO1 Acquire knowledge about basic concepts of biogenerics and biosimilars

CO2 List the industries dealing with biosimilars and its market value

CO3 Carry out various analytical methods for the characterisation of biosimilars.

CO4 Understand the factors contributing immunogenicity to biopharmaceuticals

CO5 Summarise the biopharmaceutical concepts using case studies

REFERENCES:

1. Niazi, Sarfaraz K. "Handbook of Biogeneric Therapeutic Proteins:Regulatory, Manufacturing, Testing, and Patent Issues". CRC Press, 2006.
2. Ho, Reedney J. Y., MiloGibaldi. "Biotechnology & Biopharmaceuticals Transforming Proteins and Genes into Drugs", 2nd edition, 2013.
3. Gary Wash, "Biopharmaceuticals: Biochemistry and Biotechnology" 2 nd edition, 2013
4. Sarfaraz K.Niazi "Biosimilars and Biologics:Implementation and Management" , First edition, 2017
5. Shayne Cox Gad "Handbook of Pharamaceutical Biotechnology" ,First edition,2007

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	1	2	3
CO2			2	1	3	3
CO3	2	3	3		2	3

CO4	1	2	3			2
CO5	3	3	3	2	2	1
OVERALL CO	2.25	2.75	2.6	1.33	2.25	2.4

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BP3052 CLINICAL TRIALS AND BIOETHICS

L	T	P	C
3	0	0	3

OBJECTIVES

The course aims to,

- Provide fundamental learning about clinical trial management in drug development and project management in clinical trials.
- Provide knowledge on pharmacovigilance, quality control and ethical management in clinical research.

UNIT I INTRODUCTION TO CLINICAL TRIALS 9

Fundamentals of clinical trials; Basic statistics for clinical trials; Clinical trials in practice; Reporting and reviewing clinical trials; Legislation and good clinical practice - overview of the European directives and legislation governing clinical trials in the 21st century; International perspectives; Principles of the International Committee on Harmonisation (ICH)-GCP

UNIT II REGULATIONS OF CLINICAL TRIALS 9

Drug development and trial planning - pre-study requirements for clinical trials; Regulatory Approvals for clinical trials; Consort statement; Trial responsibilities and protocols - roles and responsibilities of investigators, sponsors and others; Requirements of clinical trials protocols; Legislative requirements for investigational medicinal products.

UNIT III MANAGEMENT AND ETHICS OF CLINICAL TRIALS 9

Project management in clinical trials - principles of project management; Application in clinical trial management; Risk assessment; Research ethics and Bioethics - Principles of research ethics; Ethical issues in clinical trials; Use of humans in Scientific Experiments;Ethical committee system including a historical overview; informed consent; Introduction To ethical codes and conduct; Introduction to animal ethics; Animal rights and use of animals in the advancement of medical technology; Introduction to laws and regulations regarding the use of animals in research

UNIT IV INFORMED CONSENT 9

Consent and data protection- the principles of informed consent; Consent processes; Data Protection; Legislation and its application; Data management – Introduction to trial master filesand essential documents; Data management.

UNIT V QUALITY CONTROL AND GUIDELINES 9

Quality assurance and governance - quality control in clinical trials; Monitoring and audit; Inspections; Pharmacovigilance; Research governance; Trial closure and pitfalls-trial closure; Reporting and legal requirements; Common pitfalls in clinical trial management.

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course the student will be able to,

CO1 Acquire knowledge about the fundamentals of clinical trials.

CO2 Understand the guidelines and regulation of clinical trials of new drugs.

CO3 Describe project management in clinical trials and about various ethical issues while

conducting clinical trials.
CO4 Explain the importance of an informed consent in clinical trials
CO5 Interpret the data obtained from clinical trials

REFERENCES:

1. Lee, Chi-Jen; etal., "Clinical Trials or Drugs and Biopharmaceuticals." CRC / Taylor & Francis, 2011.
2. Matoren, Gary M. "The Clinical Research Process in the Pharmaceutical Industry."Marcel Dekker, 1984.
3. Nardini C. "The ethics of clinical trials". E cancer medical science. 2014.
4. Ashcroft RE, Viens AM. "The Cambridge Textbook of Bioethics." Cambridge: Cambridge University; 2008.
5. Bernard Lo, "Ethical Issues in Clinical Research: A Practical Guide", 2010.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	1	2	1	-
CO2	1	3	2	1	2	3
CO3	3	2	1	-	3	2
CO4	3	2	2	3	2	2
CO5	2	3	1	2	2	1
OVERALL CO	3	2	1	2	2	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BP3051 CHEMISTRY OF NATURAL PRODUCTS

L	**T**	**P**	**C**
3	**0**	**0**	**3**

OBJECTIVES

- The course aims to enhance theoretical knowledge of biosynthetic pathways of different phytoconstituents

UNIT I CARBOHYDRATES AND RELATED COMPOUNDS 9

Sugars and sugar — containing drugs polysaccharides and polysaccharide –containing drugs cellulose gums and mucilages, pectin

UNIT II GLYCOSIDES AND TANNINS 9

Biosynthesis of glycosides, Phenol and alcohol glycosides, anthraquinone glycosides, cyanophore glycosides, saponin glycosides, cardiac glycosides, isothiocyanate flavonol lactone glycosides tannins volatile oils, resins and resin combinations.

UNIT III ALKALOIDS AND ALICYCLIC COMPOUNDS 9

Pyridine and piperidine alkaloids, Tropane alkaloids, QuinolineAlka Kids, isoquinoline alkaloids, Indole alkaloids, Imidazole alkaloids, Steroidal alkaloids, Alkaloidal amines purine bases.Terpenes, camphor, menthol, carotenes

UNIT IV VITAMINS, PURINES, FLAVONOIDS 9

Chemistry, medicinal and pharmaceutical uses of vitamin A, D, E, K, B_1, B_2, B_6, B_{12} and Folic Acid.Chemistry and structural elucidation of uric acid, interrelation between caffeine, theophylline and theobromine.Classification and application of flavonoids (hespiridineetc).

UNIT V MOLECULES FROM NATURAL SOURCES 9

Classification of Drug molecules of Plant/marine/microbial and animal sources - cytotoxic / antineoplastic agents, cardiovascular drugs - antimicrobial substances – anti-inflammatory andantispasmodic agents.

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1 Carry out phytochemical tests

CO2 Explore knowledge on synthesis, medicinal uses of glycosides and tannins

CO3 Describe biosynthetic pathways and uses of alkaloids

CO4 Explain the chemistry, pharmaceutical uses of vitamins and phytoconstituents

CO5 Develop knowledge about natural product based drugs and describe the scientific basis for traditional use of medicinal plants

REFERENCES:

1. Evans, W.C., 'Trease and Evans Pharmacognosy', 15th Edition, Saunders, 2002.
2. Wallis, T.E. "Textbook of Pharmacognosy", 5th Edition, CBS Publishers, 2005.
3. Kokate, C.K. "Pharmacognosy", 29th Edition, NiraliPrakashan, 2004.
4. Bhimsen A. Nagasampagi, Meenakshi Sivakumar, and S.V. Bhat. "Chemistry of Natural Products", 2005.
5. Subhash C. Mandal, Vivekananda Mandal, Tetsuya Konishi, "Natural Products and Drug Discovery - An Integrated Approach", 2018

ii.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	1	2	3	-
CO2	1	3	2	3	2	1
CO3	3	2	1	-	3	2
CO4	3	2	2	1	3	2
CO5	-	2	1	2	2	3
OVERALL CO	3	2	1	2	3	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BT3002 BIOSAFETY AND BIOETHICS L T P C
3 0 0 3

OBJECTIVES

The course aims to

- impart knowledge on biosafety, bioethics, biopolicy, standard operating procedures and good laboratory procedure and practices,
- make them aware of the legal and institutional framework for biosafety in national and international levels and knowledge about various agreements and protocols for biosafety

UNIT I SAFETY COMPONENTS IN INDUSTRIES 9

Need for safety in industries; Safety Programmes – components and realization; Potential hazards – extreme operating conditions, toxic chemicals; safe handling

UNIT II SAFETY PROCEDURE AND CASE STUDIES 9

Implementation of safety procedures — periodic inspection and replacement; Accidents — identification and prevention; promotion of industrial safety EG: Government Regulator's Approach to Risk - Chernobyl and Bhopal Case Studies.

UNIT III RISK ANALYSIS 9

Overall risk analysis--emergency planning-on site & off site emergency planning, risk management ISO 14000, EMS models case studies. Quantitative risk assessment — rapid and comprehensive risk analysis; Risk due to Radiation, explosion due to over pressure, jet fire-fire ball.

UNIT IV RESPONSIBILITIES AND RIGHTS 9

Collegiality and Loyalty – Respect for Authority – Collective Bargaining – Confidentiality – Conflicts of Interest — Occupational Crime — Professional Rights — Employee Rights — Intellectual Property Rights (IPR) - Discrimination.

UNIT V GLOBAL ISSUES 9

Multinational Corporations – Business Ethics - Environmental Ethics – Computer Ethics - Role in Technological Development – Weapons Development – Engineers as Managers – Consulting Engineers – Engineers as Expert Witnesses and Advisors – Honesty – Moral Leadership – Sample Code of Conduct.

TOTAL: 45 PERIODS

OUTCOMES

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

CO1 Define biosafety and bioethics in the context of modern biotechnology
CO2 Familiarize with the standard operating procedures for biotechnology research and biosafety levels
CO3 Solve social and ethical issues related to plant/animal biotechnology
CO4 Explore knowledge on intellectual property rights
CO5 Summarize global issues and moral leadership

REFERENCES

1. Fawatt, H.H. and Wood, W.S., “Safety and Accident Prevention in Chemical Operation“,Wiley Interscience, 1965.
2. Marcel, V.C., Major Chemical Hazard- Ellis Harwood Ltd., Chi Chester, UK, 1987
3. Skeleton, B., Process Safety Analysis: An introduction, Institution of chemical Engineers,U.K., 1997.
4. Hyatt, N., Guidelines for process hazards analysis, hazards identification & risk analysis,Dyadem Press, 2004.
5. Mike Martin and Roland Schinzinger, “Ethics in Engineering”, McGraw Hill, New York(2005).
6. Charles E Harris, Michael S Pritchard and Michael J Rabins, “Engineering Ethics —Concepts and Cases”, Thompson Learning, (2000).

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	3	2	-	2
CO2	3	2	-	-	2	3
CO3	3	-	2	3	-	-
CO4	1	2	-	1	-	3
CO5	3	3	-	2	-	2
OVERALL CO	3	2	3	3	2	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BT3060 BIOSENSORS AND DIAGNOSTIC APPLICATIONS L T P C
3 0 0 3

OBJECTIVES

The course aims to

- Familiarize students with emerging trends in medical devices
- Impart knowledge for early detection, selection of appropriate treatment, monitoringtreatment effectiveness and disease surveillance

UNIT I SENSORS AND TRANSDUCERS 9

Rationale of electronic biosensors; Essence of three types of electronic biosensors (i.e., potentiometric, amperometric, and cantilever-based sensors); Three essential metrics that define modern electronic sensors; detection time, sensitivity, and selectivity; Physics of detection time that allows one to organize every available sensor in a systematic way; Fundamental limits of detection of various classes of sensors; Opportunities and challenges of integrating sensors in a system platform.

Principles and applications of Calorimetric, Piezoelectric, semiconductor, impedimetric, based transducers; Biochemical Transducers: Electrode theory: electrode-tissue interface, metal- electrolyte interface, electrode-skin interface, electrode impedance, electrical conductivity ofelectrode jellies and creams

UNIT II OPTICAL SENSORS AND BIO RECOGNITION SYSTEMS 9

Photo detectors, optical fiber sensors, indicator mediated transducers; General principles of optical sensing, optical fiber temperature sensors; Pulse sensor: photoelectric pulse transducer, strain gauge pulse transducer Enzymes; Oligonucleotides Nucleic Acids; Lipids (Langmuir-Blodgett bilayers, Phospholipids, Liposomes); Membrane receptors and transporters; Immunoreceptors; Chemoreceptors.

UNIT III ELECTRODES AND IMMOBILIZATION 9

Microelectrodes, body surface electrodes, needle electrodes, pH electrode, specific ion electrodes/ Ion exchange membrane electrodes, enzyme electrodes; Reference electrodes: hydrogen electrodes, silver-silver chloride electrodes, Calomel electrodes; Enzyme immobilization; Peptide immobilization; Antibody immobilization; Oligonucleotides and Nucleic Acid immobilization; Cell immobilization; Mono-enzyme electrodes; Bi-enzyme electrodes: enzyme sequence electrodes and enzyme competition electrodes.

UNIT IV FUNDAMENTALS AND APPLICATIONS OF MICROFLUIDICS 9

Capillary flow and electro kinetics; Micro pump, Micro mixers, Micro reactors, Micro droplets, Micro particle separators; Micro fabrication techniques (different types of lithography methods); Application of micro-fluidics (e.g. Lab- in –Chip).

UNIT V CASE STUDY ON VARIOUS DIAGNOSTIC APPLICATION 9

Biomarkers: Disease and pathogen specific information, availability by sample type Applications(blood, serum, urine, sputum, saliva, stool, mucus); Specificity, sensitivity, shelf life, portability; Clinical chemistry; Test-strips for glucose monitoring; Urea determination; Implantable Sensors for long-term monitoring; Drug development and detection; Environmental monitoring; Examples of various diseases (Cancer, HIV/AIDS, Tuberculosis, Malaria, Lymphatic Filariasis, Schistosomiasis, Dengue, Chikungunya).

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1 Understand the principles of biosensors classification and construction.

CO2 Apply the knowledge to analyze the configuration/distinction of optical sensors and bio-recognition systems.

CO3 Have basic understanding on electrode selection, bio-immobilization and microfluidics.

CO4 Fabricate new microfluidics system for industrial applications

CO5 Understand and analyze real life applications of biosensors and diagnostic tools through case studies.

REFERENCES:

1. Alice Cunningham, (1998), Introduction to Bio Analytical Sensors, John Wiley & Sons.
2. Jiri Janata, (2009), Principles of Chemical Sensors, 2nd Ed., Plenum Press.
3. F. Schellr, F. Schubert, J. Fedrowitz, (1997), Frontiers in Biosensors, Birkhauser.
4. F. Ligler, C. Rowe Taitt, (2002), Optical Biosensors. Present & Future. Elsevier.
5. Brian Eggins, (2002), Chemical Sensors and Biosensors, John Willey & Sons.
6. Graham Ramsay, (1998), Commercial Biosensors, John Wiley& Sons.
7. Ursula Spichiger-Keller, (1998), Chemical Sensors and Biosensors for Medical andBiological Applications, Wiley-VCH.
8. Berthier Jean, and Silberzan Pascal, (2010), Microfluidics for Biotechnology, 2nd Ed. ArtechHouse.
9. Frank A Gomez, (2008), Biological Applications of Microfluidics, Wiley.
10. Gareth Jenkins, Colin D. Mansfield, (2013), Microfluidic Diagnostics: Methods andProtocols, Springer.
11. J G. Webster, (1998), Encyclopedia of Medical Devices and Instrumentation. Vol I, II, III, IV,Wiley-Blackwell.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	2	-	-	2
CO2	-	3	2	-	2	2
CO3	2	3	2	3	-	3
CO4	-	3	3	-	-	-
CO5	-	-	3	3	-	-
OVERALL CO	2	3	2	3	2	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BT3003 BIOPROCESS MODELING AND SIMULATION L T P C
2 0 2 3

OBJECTIVES

The course aims to

- Introduce the students to the fundamental aspects of modeling of various biological systems and a make them familiar with the bioprocess applications.

UNIT I MODELING OF BIOLOGICALSYSTEMS 12

Modeling Principles, model development from first principles. Modeling approaches for Biological systems – structured and unstructured systems; Compartment models; Deterministic and stochastic approaches for modeling structured systems

UNIT II MODELLING OF DIFFUSION SYSTEMS (BIOFILM AND IMMOBILIZED ENZYME SYSTEMS) 12

External mass transfer, Internal diffusion and reaction within biocatalysts, derivation of finite model for diffusion-reaction systems, dimensionless parameters from diffusion-reaction models,the effectiveness factor concept, case studies; oxygen diffusion effects in a biofilm, biofilm nitrification.

UNIT III MODELING BIOREACTOR 12

Bioreactor modelling: Ideal and non-ideal bioreactors; Stirred tank models; characterization of mass and energy transfer distributions in stirred tanks, Tower Reactor Model; Flow modeling, bubble column flow models, mass transfer modeling, structured models for mass transfer in tower reactors, process models in tower reactors, airlift models

UNIT IV LINEAR SYSTEM ANALYSIS 12

Study of linear systems, linearization of non-linear systems; Simulation of linear models using MATLAB; Parameter estimation and sensitivity analysis; Steady state and unsteady state systems; stability analysis; Case study of recombinant protein production.

UNIT V HYBRID AND OTHER MODELING TECHNIQUES 12

Advanced modeling techniques such as fuzzy logic, neural network, hybrid systems and fuzzy logic systems; case studies.

TOTAL: 60 PERIODS

OUTCOMES:

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

CO1 Understand the modeling of biological systems and bioreactors.

CO2 Design new models for biological systems, biofilm and immobilized enzyme systems, andbioreactors

CO3 Carry out simulation of models using software (MATLAB).

CO4 Analyze the simulation studies and stability and sensitivity of the system.

CO5 Apply advanced modeling techniques

REFERENCES:

1. B. Wayne Bequette, “Process Dynamics: Modeling, Analysis and Simulation”, Prentice-Hall, 1998.
2. Said S.E.H. Elnashaie, Parag Garhyan, “Conservation Equations and Modeling of Chemicaland Biochemical Processes”, Marcel Dekker, 2003.
3. I.J. Dunn, “Biological Reaction Engineering: Dynamic Modelling Fundamentals with Simulation Examples”, Wiley-VCH, 2003.
4. B.W. Bequettre, “Process Dynamics, Modelling, Analysis and Simulation”, Prentice HallInternational series, 1998**.**

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	2	3	2	1	-
CO2	3	2	3	3	-	-
CO3	3	3	2	-	3	3
CO4	3	1	3	-	-	1
CO5	1	2	3	-	-	-
OVERALL CO	2	2	3	2	2	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BP3053 MOLECULAR DIAGNOSTICS

L	**T**	**P**	**C**
3	**0**	**0**	**3**

OBJECTIVES

The course aims to

- Sensitize students about recent advances in molecular biology and various facets of molecular medicine.

- Make the students utilize the techniques of molecular medicine for pre- or post-natal analysis of genetic diseases and identification of individuals predisposed to disease ranging from common cold to cancer.

UNIT I GENOME BIOLOGY: HEALTH, DISEASE DETECTION AND ANALYSIS 9

DNA, RNA and Protein: An overview; chromosomal structure & mutations; DNA polymorphism: human identity; clinical variability and genetically determined adverse reactions to drugs. PCR: Real-time; ARMS; Multiplex; ISH; FISH; ISA; RFLP; DHPLC; DGGE; CSCE; SSCP; Nucleic acid sequencing: new generations of automated sequencers; Microarray chips; EST; SAGE; microarray data normalization & analysis; molecular markers: 16S rRNA typing; Diagnostic proteomics: SELDI-TOF MS; Bioinformatics data acquisition & analysis.

UNIT II DIAGNOSTIC METABOLOMICS 9

Metabolite profile for biomarker detection in the body fluids/tissues under various metabolic disorders by making use of LCMS & NMR technological platforms

UNIT III DETECTION AND IDENTITY OF MICROBIAL DISEASES 9

Direct detection & identification of pathogenic-organisms that are slow growing or currently lacking a system of in vitro cultivation as well as genotypic markers of microbial resistance to specific antibiotics.

UNIT IV DETECTION OF INHERITED DISEASES 9

Exemplified by two inherited diseases for which molecular diagnosis has provided a dramatic improvement of quality of medical care: - Fragile X Syndrome: Paradigm of the new mutational mechanism of the unstable triplet repeats, von-Hippel Lindau disease: recentacquisition in the growing number of familial cancer syndromes.

UNIT V MOLECULAR ONCOLOGY AND QUALITY ASSURANCE AND CONTROL 9

Detection of recognized genetic aberrations in clinical samples from cancer patients; types of cancer-causing alterations revealed by next- generation sequencing of clinical isolates; predictive biomarkers for personalized onco-therapy of human diseases such as chronic myeloid leukemia, colon, breast, lung cancer and melanoma as well as matching targeted therapies with patients and preventing toxicity of standard systemic therapies. Quality oversight; regulations and approved testing.

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1 Understand various facts of molecular procedures and basics of genomics, proteomics and metabolomics that could be employed in early diagnosis and prognosis of human diseases.

CO2 Acquire knowledge on biomarker detection in body fluids

CO3 Identify and detect pathogenic micro-organisms

CO4 Design the biomedical tool for the detection of inherited diseases

CO5 Develop molecular diagnostics tools for the detection of cancer

REFERENCES:

1. Campbell, A. M., & Heyer, L. J, "Discovering Genomics, Proteomics, and Bioinformatics", San Francisco: Benjamin Cummings, 2006
2. Brooker, R. J., "Genetics: Analysis & Principles", New York, NY: McGraw-Hill, 2009
3. Glick, B. R., Pasternak, J. J., & Patten, C. L., "Molecular Biotechnology: Principles and Applications of Recombinant DNA", Washington, DC: ASM Press, 2010
4. Coleman, W. B., & Tsongalis, G. J., "Molecular Diagnostics: for the Clinical Laboratorian", Totowa, NJ: Humana Press, 1997.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	3	1	2	3	-
CO2	3	3	2	1	3	2
CO3	3	2	1	3	2	2
CO4	2	1	1	2	3	3
CO5	2	1	1	2	2	3
OVERALL CO	3	2	1	2	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BT3051 APPLIED GENOMICS AND PROTEOMICS

L	T	P	C
3	0	0	3

OBJECTIVES

The course aims to

- Provide advanced theoretical knowledge on the organization and function of genomes and functional genomics
- Impart knowledge on the advanced methods and approaches in proteomics.

UNIT I ARCHITECTURE OF GENES AND GENOMES 9

Genomic architecture of eukaryotes and prokaryotes. Genomes of organelles (chloroplast, mitochondrion); Characterization of genomes through genetic and physical mapping methods; Fluorescence In-Situ Hybridization (FISH); Comparative Genomic Hybridization (CGH); Whole genome shot-gun sequencing and its applications.

UNIT II LARGE SCALE GENOMICS AND FUNCTIONAL GENOMICS ANALYSES 9

Single nucleotide polymorphism (SNPs) and Genome-wide association (GWA) analysis; Gene expression analysis by cDNA and oligonucleotide arrays; Micro array experimental analysis and data analysis. Methylome analysis using microarray; ChIP-on-Chip analysis. Next Generation Sequencing (NGS) based sequencing of DNA and RNA.

UNIT III ISOLATION AND SEPARATION OF PROTEOME SAMPLES 9

Over-view of strategies used for the identification and analysis of proteins; Protein extraction from biological samples (Mammalian Cells and Tissues, Yeast, Bacteria, and Plant specimen); Two-dimensional Gel-electrophoresis of proteins (2DE) and Difference Gel Electrophoresis (DIGE); Liquid chromatography separations in proteomics (Affinity, Ion Exchange, Reversed-phase, and size exclusion).

UNIT IV MASS SPECTROMETRY IN PROTEOMICS 9

Introduction to Mass spectrometry; Common ionization methods used for proteomics; Enzymatic cleavage of proteins. Structure and function of MALDI-TOF mass-spectrometry, LC-MS analysis of proteome samples. Protein identification using peptide mass-finger printing and MS/MS strategies.

UNIT V PROTEOMICS THROUGH LARGE-SCALE PROFILING 9

In-vitro and In-vivo labeling of proteins (ICAT and SILAC) followed be mass-spectrometry profiling. Analysis of posttranslational modification (PTM) of proteins; Characterization of protein-protein interactions using yeast two-hybrid system, Protein microarrays and its applications; Proteomics informatics and analysis of protein functions.

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1: Understand advanced theoretical knowledge on the organization and function ofgenomes

CO2: Perform functional genomic analyses

CO3: Decide appropriate methods for isolation and separation of proteomes

CO4: Interpret and analyze the proteins by mass-spectrometers

CO5: Design the schemes for different proteomics approaches involving large-scale protein profiling

REFERENCES:

1. S.P. Hunt and F. J. Livesey, (2000) Functional Genomics, Oxford University press
2. N. K. Spur, B. D. Young, and S. P. Bryant (1998) ICRF Handbook of GenomeAnalysis Volume 1 & 2, Black well publishers
3. G. Gibson and S. V. Muse, 3rd ed., (2009) A primer ofGenome Science, SinauerAssociates, Inc. Publishers
4. R. J. Reece (2004) Analysis of Genes and Genomes, John Wiley & SonsLtd
5. Rinaldis E. D. and Lahm A (2007) DNA Microarrays. Horizon bioscience.
6. Simpson R. J."Proteins and Proteomics - A Laboratory Manual".Cold SpringHarbour Laboratory Press, 2002.
7. Twyman R. M. "Principles of Proteomics". Taylor & Francis. 2004
8. O'Connor C. D. and Hames B. D. "Proteomics". Scion, 2008.
9. Schena M. "Protein Microarrays". Jones and Bartlett, 2005.
10. Smejkal G. B. and Lazarev A. V. "Separation methods in Proteomics". CRC Press,2006.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	3	1	2	3	-
CO2	3	3	2	1	3	2
CO3	3	2	1	3	2	2
CO4	2	2	1	2	3	3
CO5	2	2	1	2	2	3
OVERALL CO	2	2	1	2	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) andSubstantial (High) respectively

BT3004 TISSUE ENGINEERING AND REGENERATIVE MEDICINE

L	**T**	**P**	**C**
3	**0**	**0**	**3**

OBJECTIVES

The course aims to

- Teach the hierarchical organization, interactions and functions of cells to recapitulate a similar microenvironment ambient for constructing tissue scaffolds.
- Impart knowledge about the principles of tissue engineering involving the use of stem cells, bioactive factors, biomaterials and to understand the clinical need for tissue engineering in treating and augmenting various scenarios involving loss of functional tissues

UNIT I INTRODUCTION 9

Introduction to tissue engineering, cell growth and numbers, tissue organization, hierarchical arrangement of tissues and their types. Tissue dynamics and homeostasis. Cell-based therapies, angiogenesis, Cell attachment integrins, cell differentiation, migration, cell division and cell death. Cell signalling- growth factors- cell ECM interactions, cell-cell interactions.

UNIT II TISSUE ARCHITECTURE 9

Cell and tissue culture, basics of tissue culture, primary cell isolation, cell and cell lines, cell fate process and cell functions, basis, characterization and methods of cell separation. Role and fate Biomaterials in tissue engineering, scaffold fabrication and processing, hydrogels, fabrication methods, advancement in drug and growth factors delivery, Bioreactors for Tissue Engineering.

UNIT III ORGAN CULTURE IN BIOMATERIALS 9

Biomaterials: Properties of Biomaterials, Surface, bulk, mechanical and biological properties. Scaffolds & tissue engineering, Types of Biomaterials, biological and synthetic materials, Biopolymers, Applications of Biomaterials, Modifications of Biomaterials. Organ printing, invitro models of tissue regeneration, Tissue regeneration by growth hormones, spatial-temporal control of tissue regeneration, Bioartificial organs, and therapies in the market.

UNIT IV BASIC BIOLOGY OF STEM CELLS 9

In vivo cell & tissue engineering- Bone, blood vessels, skin, liver, nerve, pancreas, kidney and muscles. 3D bioprinting- types and applications, Introduction to regenerative medicine, human ESCs in regenerative medicine, clinical applications of IPSCs and MSCs, Stem cell bioengineering

UNIT V CLINICAL APPLICATIONS 9

Recapitulating tissue and organ structure, the importance of vascularization, immune modulation, cell sheet technology, organ on a chip, application of engineered tissues, cell reprogramming, Regenerative medicine from bench to bedside, challenges and perspectives, ethical concerns on regenerative medicine research

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1 Understand tissue engineering in biomedical applications
CO2 Elaborate tissue microenvironment and its major modulators
CO3 Design 3D printing technology.
CO4 Apply stem cell technology in tissue engineering
CO5 Perform tissue engineering in clinical challenges

REFERENCES :

1. Palsson, B.O. and Bhatia, S.N., Tissue Engineering, Pearson Prentice Hall, 2004.
2. Lanza, R.P., Langer, R. and Vacanti, J., (Eds.). Principles of Tissue Engineering, 2/e, Academic Press, 2011.
3. Zhang, L.G., Fisher, J.P., and Leong, K., 3D Bioprinting and Nanotechnology in Tissue Engineering and Regenerative Medicine, Academic Press, 2015.
2. 4. Bruce, A, Alexnder, J, Julian, L, David, M, Martin, R, Keith, R, and Peter, W., Molecular Biology of the cell (Sixthe Edition), W. W. Norton & Company; Sixth edition (November 19, 2014)

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	2	1	1
CO2	2	1	3	1	1	3
CO3	1	1	2	2	3	3

CO4	1	1	3	2	1	3
CO5	2	1	3	1	1	2
OVERALL CO	2	1	3	2	1	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) andSubstantial (High) respectively

BT3005 PLANT GENETIC ENGINEERING AND BIOTECHNOLOGY L T P C
3 0 0 3

OBJECTIVES

The course aims to

- Provide knowledge on the concepts of plant tissue culture and genetic engineering principles, and make the students aware of the status of plant transgenics and regulations
- Enlighten the students about molecular pharming and other industrial applications

UNIT I PLANT GENOME AND GENE EXPRESSION 9

Plant genome organization – Arabidopsis and Rice nuclear genome, Endosymbiotic theory - Chloroplast and mitochondrial genome organization, Cytoplasmic male sterility; RNA editing, Regulation of gene expression, epigenetic regulations, protein targeting**.**

UNIT II TISSUE CULTURE 9

Totipotency and plasticity, Explants. Cultures - single cell, callus, cell-suspension, protoplast, leaf, mroot, shoot tip and meristems, embryo, anther, microspore and ovary culture. Somatic embryogenesis, organogenesis and hardening. Industrial applications of tissue culture Phytopharmaceuticals: Major classes of phytochemicals (secondary metabolites) and their pharmacological properties Liquid Cultures of Plant Cells: Initiation and maintenance of callus and suspension cultures; Bioreactors – types and principles and their applications for secondary metabolite

UNIT III PLANT TRANSFORMATION VECTORS 9

Features of a plant transformation vector. Constitutive, inducible and tissue specific promoters, terminators and regulatory elements; Selectable markers and reporter genes; Modification of heterologous gene (animals, microbes) for plant transformation Nuclear and plastid transformation; Agrobacterium mediated and direct gene transfer methods. Binary vectors, Gateway vectors and RNAi vectors.

UNIT IV PLANT METABOLIC ENGINEERING 9

Herbicide tolerance [Round Up Ready], Bt crops, Golden Rice, Transgenic crops designed for tolerance to abiotic and biotic stress. Transgenic systems to derive carbohydrates , plantibodies, edible vaccines, enzymes, biopharmaceuticals, bioplastics, biofuel, silk and elastin. Gene to functional protein processing steps in plants; Elicited cell cultures for maximizing yield of metabolites

UNIT V MARKER ASSISTED BREEDING AND IPR 9

Phenotypic, enzyme and molecular markers, co-dominant and dominant markers, Basics-linkage analysis and QTL mapping, Global status and bio-safety concerns for production and release of transgenic plants. Plant breeders rights, copyright, trade mark and patents

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1- Acquire basic knowledge on organization of plant genome and regulation of gene expression
CO2- Explore knowledge about basic tissue culture techniques
CO3- Get acquainted with plant transformation protocols
CO4- Design experiments for the development of transgenic plants
CO5- Describe molecular markers and transgenic regulations through case studies

REFERENCES:

1. Adrian Slater, N. W. Scott and M. Fowler. 2014. Plant Biotechnology: The Genetic Manipulation of Plants, Second Edition, Oxford University Press, UK.
2. Roberta H. Smith. 2013. Plant Tissue Culture Techniques and Experiments, 3rd Edition, Elsevier Inc., UK.
3. Bahadur, B., M.V. Rajam, L. Sahijram and K.V. Krishnamurthy. 2015. Plant Biology and Biotechnology, Vol. 2, Springer, New Delhi.
4. Richroch, A. S. Chopra and S. Fleischer. 2014. Plant Biotechnology, Springer International Publishing, Switzerland.
5. Alverz and M. Alejandra. 2014. Plant Biotechnology for Health: From Secondary Metabolites to Molecular Farming. Springer International Publishing, Switzerland.
6. Fett-Neto, A.G. 2016. Biotechnology of Plant Secondary Metabolism. Springer Science+Business Media, New York.
7. J.Hammond, P.McGarvey and V.Yusibov (Eds): Plant Biotechnology. Springer Verlag, 2000.
8. R.J.Henry: Practical Application of plant molecular biology. Chapman and Hall.1997
9. J. Reinert und P.S. Bajaj (Herausg.): Applied and Fundamental Aspects of Plant Cell, Tissue, and Organ Culture, Springer Verlag Berlin, Heidelberg, 1977

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	1	3	1	2	1
CO2	1	1	2	2	3	3
CO3	2	1	3	2	1	1
CO4	1	1	2	3	2	2
CO5	1	1	2	3	2	1
OVERALL CO	1	1	2	3	2	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) andSubstantial (High) respectively

BT3006 COMPUTATIONAL FLUID DYNAMICS

L	**T**	**P**	**C**
3	**0**	**0**	**3**

OBJECTIVES

The course aims to enable the students to

- Perform time-accurate computations of two-dimensional incompressible flows using vortex particles and accelerate two dimensional solvers using time-marching schemes employing a newmulti-grid scheme.
- Develop high resolution codes that work without fine tuning for a large range of Mach numbers

UNIT I FLUID DYNAMICS **9**

Introduction, Reasons for CFD. Typical examples of CFD codes and their use. Validation

strategies. Derivation of Governing Equations of Fluid Dynamics: Mass conservation and divergence, Navier-Stokes and Euler equations. Energy equations. Conservation formulation and finite volume discretisation. Partial differential equations: classification, characteristic form. PDEs in science and engineering.

UNIT II BASIC NUMERICS 9

Mathematical behavior of hyperbolic, parabolic and elliptic equations. Well posedness. Discretization by finite differences. Analysis of discretized equations; order of accuracy, convergence. and stability (von Neumann analysis). Numerical methods for model equations related to different levels of approximation of Navier Stokes equation: linear wave equation, Burgers equation, convection-diffusion equation. First and second order numerical methods such as upwind, Lax-Friedrichs, Lax-Wendroff, MacCormack, etc. Modified equation - dissipation and dispersion

UNIT III COMPRESSIBLE FLOW 9

Euler equations, conservative/non-conservative form. thermodynamics of compressible flow, scalar conservations laws: Conservation, weak solutions, non-uniqueness, entropy conditions. Shock formation, Rankine-Hugoniot relations. Numerical methods for scalar conservation laws. Properties of the numerical scheme such as CFL-condition, conservation and TVD. First order methods. System of conservations laws. Numerical methods for Euler equations: MacCormack and artificial viscosity for non-linear systems. Numerical/physical boundary conditions. Shock tube problem. High resolution schemes for conservations laws. Numerical methods for Euler equations. Boundary conditions, Riemann invariants. Compressible flow in 2D. Numerical methods for Euler equations, cont. Grids, algebraic mesh generation by transfinite inter-polation. Flow around an airfoil

UNIT IV FINITE VOLUME AND FINITE DIFFERENCE METHODS 9

Laplace equation on arbitrary grids, equivalence with finite-differences, linear systems: Gauss-Seidel as smothers for multi-grid. Staggered grid/volume formulation + BC. Unsteady equations: projection and MAC method, discrete Poisson pressure equation. Time step restrictions. Steady equations: distributive iteration and SIMPLE methods.

UNIT V FINITE ELEMENTS 9

Diffusion problem. Variational form of the equation, weak solutions, essential and natural boundary condition. Finite-element approximations, stability and accuracy, the algebraic problem, matrix assembly. Navier–Stokes equations. Mixed variational form, Galerkin and FE approximations, the algebraic problem. Stability, the LBB condition, mass conservation.

TOTAL: 45 PERIODS

PROGRESS THROUGH KNOWLEDGE

OUTCOMES:

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

CO1 Acquire knowledge in fluid dynamics and numeric methods to study the characteristic flow of fluids

CO 2 Get in-depth knowledge in computational analysis of different flow patterns

CO 3 Design fluid flow systems with stability and accuracy

CO4 Understand the finite volume methods

CO5 Explain finite volume methods and algebraic concepts.

REFERENCES:

1. Randall J LeVeque, Finite Volume Method for Hyperbolic Problems, Cambridge University Press, 2002.
2. K.A. Hoffman and S. Chiang, Computational fluid dynamics for scientists and engineers, engineering education system. 2nd edition 1993.
3. J.C. Tannehill, D.A. Anderson, R.H. Pletcher, Computational Fluid Mechanics and Heat Transfer, CRC Press, 3rd Edition, 2011.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	-	1	3	-
CO2	1	2	1	3	2	-
CO3	1	2	1	3	1	1
CO4	1	1	3	1	1	1
CO5	2	2	3	1	1	1
OVERALL CO	1	2	3	1	1	1

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) andSubstantial (High) respectively

BT3054 GMP AND VALIDATION IN BIOPROCESS INDUSTRIES L T P C
3 0 0 3

OBJECTIVES

The course aims to

- Provide knowledge of current validation practice across the bioprocess industry and able to assess new process concepts and understand regulatory acceptability for bioprocessindustries

UNIT I TRENDS FOR VALIDATING BIOLOGICAL PROCESSES 9

Importance of process validation for manufacturing drugs and medical devices, Definitions, Process validation, Prospective Validation, Concurrent Validation, Retrospective Validation, Critical Process Parameters, Critical Quality Attributes, Scaled-down model, Worst-case, FDA Guidelines

UNIT II PROCESS VALIDATION: GENERAL PRINCIPLES AND PRACTICES 9

General Considerations for Process Validation, Concept of Bioprocess in Bulk Drug Manufacturing, Concept of Biotechniques in industrial validation, Integration of various biotechniques to maintain quality in downstream processing, CGMP regulations for validating biopharmaceutical (drug) manufacturing.

UNIT III GOOD MANUFACTURING PRACTICE FOR BIOPROCESS ENGINEERING 9

Statutory and regulatory requirements for process validation, Production Methods and Considerations, Automation and control issues, System functionality, Principles for Layout of Bulk Production Facilities, Green Field Development, Brown Field Development, cross-contamination from other sources and linked systems, Clean In Place techniques, interactions with shared systems

UNIT IV APPROACH TO PROCESS VALIDATION 9

Process Design, Process Qualification, Continued Process Verification, attributes relating to identity, strength, quality, purity, and potency; Information and data organization from laboratory-, pilot-, and/or commercial-scale studies, validation of computerized systems.

UNIT V CASES STUDIES IN PROCESS VALIDATION 9

Process validation for recombinant therapeutic proteins like erythropetin, insulin, GMCSF, viral, bacterial vaccines.

TOTAL: 45 PERIODS

OUTCOME

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

CO1 Understand the implications of validation for process development

CO2 Have knowledge about the general principles and practices of process validation of biopharmaceutical manufacturing processes.
CO3 Apply manufacturing practice for bioprocess engineering
CO4 Design, verify and validate process using case studies
CO5 Give solution for process validation in industrial processes

REFERENCES

1. Process Validation in Manufacturing of Biopharmaceuticals, Third Edition, Anurag S. Rathore, Gail Sofer, CRC Press, 2012
2. Encyclopedia of Industrial Biotechnology: Bioprocess, Bioseparation, and Cell Technology Phamaceutical Process Validation, Nash, R.A., 2003.
3. Handbook of pharmaceutical analysis. CRC Press, Ohannesian, L. and Streeter, A. eds., 2001
4. Pharmaceutical equipment validation: The ultimate qualification guidebook,Cloud, P., 1998, CRC Press

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	2	1	3	3
CO2	1	1	3	1	3	1
CO3	1	1	1	2	3	2
CO4	2	1	2	1	3	2
CO5	2	2	3	1	2	3
OVERALL CO	2	1	3	1	3	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) andSubstantial (High) respectively

BT3055 METABOLIC ENGINEERING L T P C
3 0 0 3

OBJECTIVES

The course aims to

- Familiarize the student with quantitative approaches for analyzing cellular metabolism and make the students aware of the use of theoretical and experimental tools that can give insights into the structure and regulation of metabolic networks.
- Make the students identify the optimal strategy for introducing directed genetic changes in the microorganisms with the aim of obtaining better production strains using case studies.

UNIT I METABOLIC FLUX ANALYSIS 9

Introduction to metabolic engineering, comprehensive models of cellular reactions with stoichiometry and reaction rates; metabolic flux analysis of exactly determined systems for lactic acid ,citric acid and systems, Shadow price, sensitivity analysis.

UNIT II TOOLS FOR EXPERIMENTALLY DETERMINING FLUX THROUGH PATHWAYS 9

Monitoring and measuring the metabolome, Methods for the experimental determination of metabolic fluxes by isotope labelling of linear, branched and cyclic pathways using NMR, metabolic fluxes using various separation-analytical techniques. GC-MS for metabolic flux analysis, genome wide technologies: DNA /phenotypic microarrays and proteomics.

UNIT III CONSTRAINT BASED GENOMIC SCALE METABOLIC MODEL 9

Development of Genomic scale metabolic model, Insilico Cells:studying genotype-

phenotype relationships using constraint-based models, case studies in *E. coli, S. cerevisiae* metabolic network reconstruction methods, optimization of metabolic network, Identification of targets for metabolic engineering; software and databases for genome scale modeling.

UNIT IV METABOLIC CONTROL ANALYSIS AND KINETIC MODELING 9

Metabolic Control Analysis, control coefficients and the summation theorems, Determination of flux control coefficients. Multi-substrate enzyme kinetics, engineering multifunctional enzyme systems for optimal conversion, and a multi scale approach for the predictive modeling of metabolic regulation.

UNIT V CASE STUDIES IN METABOLIC ENGINEERING 9

Metabolic engineering examples for bio-fuel, bio-plastics and green chemical synthesis. Identification of rational targets by elementary mode analysis and genome scale model in various systems for the production of green chemicals using software tools. Validation of the model with experimental parameters.

TOTAL: 45 PERIODS

OUTCOME

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

CO1 Understand and identify the optimal strategy for introducing genetic changes in the microorganisms with the aim of obtaining better production strains.

CO2 Apply knowledge on metabolic flux analysis by NMR and GCMS

CO3 Develop databases for genome scale modelling

CO4 Understand and acquire knowledge on metabolic regulation

CO5 Design novel concept of green chemical synthesis

REFERENCES

1. Stephanopoulos, G.N. “Metabolic Engineering: Principles and Methodologies”. Academic Press / Elsevier, 1998.
2. Lee, S.Y. and Papoutsakis, E.T. “Metabolic Engineering”. Marcel Dekker, 1998.
3. Nielsen, J. and Villadsen, J. “Bioreaction Engineering Principles”. Springer, 2007.
4. Smolke, Christiana D., “The Metabolic Pathway Engineering Handbook Fundamentals”, CRC Press Taylor & Francis, 1st edition 2010.
5. Voit, E.O. “Computational Analysis of Biochemical Systems : A Practical Guide for Biochemists and Molecular Biologists”. Cambridge University Press, 1st edition 2000.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	-	2	3
CO2	3	-	3	1	3	3
CO3	3	-	3	1	3	3
CO4	3	-	3	2	3	3
CO5	3	-	2	2	2	1
OVERALL CO	3	2	3	2	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) andSubstantial (High) respectively

BP3055 MOLECULAR MEDICINE AND MECHANISM L T P C
3 0 0 3

OBJECTIVES

- The course aims to
  provide knowledge on the molecular mechanism of the disease

UNIT I INTRODUCTION TO MOLECULAR MEDICINE 9

Organization of the Human Genome, Chromosomes and Genes – Recombinant DNA and Genetic Techniques – Transcriptional Control of Gene Expression – transmission of Human Genetic Disease –Human Genome Project – Cell Cycle Oncogenes and Tumor suppressor Genes – Molecular Diagnostic Testing – Genetic Counseling – Transgenic Mice as Models of Disease, Introduction to gene therapy.

UNIT II CARDIOLOGY 9

Molecular Cardiology Congenital Heart Disease–Inherited Cardiomyopathies–Coronary Atherosclerosis – Endothelium – Derived Nitric Oxide and Control of Vascular Tone – Hypertension – Cardiac Arrhythmias – Cardiovascular Gene Therapy.

UNIT III PULMONOLOGY 9

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

UNIT IV ENDOCRINOLOGY 9

Mechanisms of Hormone Action – Diabetes Mellitus – Pituitary Function and Neoplasia Hormone Deficiency- Disorders –Thyroid Disorders – Disorders of the parathyroid Gland – Congenital Adrenal Hyperplasia– Adrenal Disease – Multiple Endocrine Neoplasia Type, Mechanisms of Hypoglycemia Associated with increased Insulin Production.

UNIT V NEPHROLOGY 9

Renal Development – Mechanisms of Leukocyte Extravasation – Ischemic Acute Renal Failure– Potassium Secretory Channels in the Kidney – Alport Syndrome – Nephrogenic Diabetes Insipidus – Polycystic Kidney Disease – Renal Neoplasms: Wilms' Tumor and Renal-Cell Carcinoma.

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course the students will be able to
CO1 Explore knowledge about the human genome and gene therapy.
CO2 Describe cardiovascular diseases and its treatment
CO3 Explain the various strategies to control pulmonary disorders
CO4 Understand the hormone deficiency disorders.
CO5 Summarise renal disorders

REFERENCES:

1. Jameson, J. L., Francis, S.C., "Principles of Molecular Medicine", Human Press, 1998.
2. Ross, D.W. "Introduction to Molecular Medicine", 3rd Edition, Springer, 2002.
3. Ross, D.W. "Introduction to Oncogenes and Molecular Medicine",Springer, 1998.
4. Pasternak, J.J. "An Introduction to Human Molecular Genetics", 2nd Edition, Wiley Liss, 2005.
5. Strachan, Tom and Andrew P. Read. "Human Molecular Genetics, Bios, 1996.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	2	2	3

CO2	3	-	3	-	-	2
CO3	3	-	3	1	-	-
CO4	3	-	3	1	-	-
CO5	3	-	3	1	-	-
OVERALL CO	3	2	3	2	2	3

(1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) andSubstantial (High) respectively

BC3051 SYNTHETIC BIOLOGY L T P C
3 0 0 3

OBJECTIVES

The course aims to

- Familiarize with the concepts of modern DNA assembly techniques to build biological circuits
- Familiarize with the principles of designing biological circuits with control levels.

UNIT I SYNTHETIC BIOLOGY – BIOLOGICAL COMPONENTS/CIRCUITS 10

Definition and scope, applications of Synthetic biology and milestones in development, principles of artificial gene synthesis, promoters, ribosomal binding sites (RBS), coding sequences and terminators, Logical operators – Repressilator, Toggle-switch, Mammalian tunable synthetic oscillator, Coupled bacterial oscillator , Bacterial tunable synthetic oscillator, Globally coupled bacterial oscillator

UNIT II NUMERICAL METHODS FOR SYSTEMS ANALYSIS AND DESIGN 8

Fundamental on the theoretical and computational modelling of replicating systems, Bioinformatic analysis and characterisation of genes and biomolecules, Mathematical model of processes for metabolic pathways and genetic regulatory circuits, Parameter estimation in biochemical pathways, optimal experimental design, dynamic optimization of biosystems.

UNIT III METABOLISM OF NUCLEIC ACIDS AND LIPIDS 9

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

UNIT IV FABRICATION OF GENETIC SYSTEMS 9

Introduction to BioBricks and standardization, assembly methods, induction and addition of measurable element, (Eg.GFP) to an existing natural biological circuit, overview and scope of GenoCAD, Clotho framework.

UNIT V CASE STUDIES IN ENGINEERED SYSTEMS 9

RNA-based regulatory system for independent control of transcription activities of multiple targets, Applications of Engineered Synthetic Ecosystems, pT181 antisense-RNA-mediated transcription attenuation mechanism and applications, Ethics and patentability,.

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1 Understand the regulation of the genes and properties of gene products can be altered with synthetic biology methods.

CO2 Apply the scientific approach to discover, examine and develop biological systems

CO3 Examine the knowledge of numerical methods for system analysis and design.

CO4 fabrication of genetic systems

CO5 Critically analyse the results and generate testable hypotheses for synthetic biology

experiments.

REFERENCES: :

1. Synthetic Biology: Tools and Applications by Huimin Zhao, Academic Press; 1 edition (2013), ISBN-10: 0123944309, ISBN-13: 978-0123944306
2. Bioengineering: A Conceptual Approach by MirjanaPavlovic, Springer; 2015 edition, ISBN-10: 3319107976, ISBN-13: 978-3319107974
3. Biological Modeling and Simulation: A Survey of Practical Models, Algorithms, and Numerical Methods (Computational Molecular Biology) by Russell Schwartz, The MIT Press; 1 edition (2008).

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	2	2	2
CO2	3	2	3	2	2	2
CO3	3	2	3	2	2	2
CO4	3	2	3	2	2	2
CO5	3	2	3	2	2	2
OVERALL CO	3	2	3	2	2	2

(1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) andSubstantial (High) respectively

FD3051 FUNCTIONAL FOODS L T P C
3 0 0 3

OBJECTIVES

The course aims to

- impart the knowledge on the importance of functional ingredients and nutraceuticals.
- Make students understand the utilization of functional ingredients in development of new food products including health foods, functional foods and specialty foods.
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UNIT I IMPORTANCE OF MICRONUTRIENTS AND BIOACTIVE COMPONENTS9

Nutritional status and dietary requirement of different target group and deficiency diseases, in special reference to micronutrients. Dietary and therapeutic significance of nutrients, bioactive components in dairy products like lactose, whey proteins, milk minerals, CLA, fermented milks etc. Infant nutrition and dietary Formulations for meeting normal and special needs of infants, current status of infant foods, additives for infant foods. Foods for aged persons, design consideration, ingredients for geriatric foods.

UNIT II FOOD FORTIFICATION 9

Food fortification - techniques for fortifying foods with minerals and vitamins, High protein foods prospective nutraceuticals for fortification of foods. Nutritional significance of dietary fibers, classes of dietary fibers, fortification techniques for fibers in foods.

UNIT III FOOD FOR HEALTH SIGNIFICANCE 9

Technological aspects of reduced calorie foods, alternatives for calorie reduction, low calorie sweeteners, bulking agents and their application, fat replacers and their utilization in low calorie dairy foods. Nutritional and health significance of sodium in foods, Alternatives for sodium in foods, techniques for reducing sodium in processed dairy foods. Bio-flavours and

flavour enhancers. Herbs, various classes of herbs, their therapeutic potential and application in foods, determination of bioavailability of nutrients

UNIT IV FOOD FOR DISEASE CONTROL 9

Definition and various classes of phytochemicals, Special foods/nutrients their role in CVD, Cancer and immune system enhancer, utilization in functional foods, phytosterol, phytoestrogens, glucosinolates, organosulphur compounds, flavonoids, carotenoids, etc.
Special foods/nutrients for persons suffering with milk allergy and lactose intolerance with special emphasis on nutrients and foods. Sports foods – ingredients, components in sports foods, sports drinks, design consideration, ergogenic aids in sports nutrition.

UNIT V CLASSIFICATION AND SAFETY 9

Definition, classes of functional foods, status of functional foods in world and India. Concept of new product development, classed of nutraceuticals and functional foods. Safety; marketing strategy and consumer response; economic analysis and costing of novel foods, recent advances in different categories and type of foods, Prebiotic substances and their utilization in functional foods, symbiotic foods, technological aspects and recent development in probiotics, prebiotics and synbiotics.

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1 Acquire knowledge on nutraceuticals and functional foods.
CO2 Apply knowledge on food fortification and value addition.
CO3 Describe and demonstrates the role of food in nutritional well-being.
CO4 Understand the diverse classes of phytochemicals and their significance in promoting health, preventing diseases, and enhancing the immune system.
CO5 Develop new products

REFERENCES:

1. Chadwick, R. Functional Foods. Springer Publ., Berlin. 2003.
2. Desai, B. B., Handbook of Nutrition and Diet. Marcel Dekker, New York. 2000.
3. Gibson, G., and William, Cristine. Functional Foods. CRC Press, Boca Roston, Boston. 2000.
4. Goldberg I (Ed.), Functional Foods. Chapman & Hall, New York. 1994.
5. Haberstroh, Chuck E., Fat and Cholesterol Reduced Foods. Gulf Publishing Company, Huston. 1991.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	-	1	3
CO2	2	1	2	1	2	2
CO3	3	2	3	2	1	2
CO4	1	1	1	2	1	1
CO5	2	2	1	1	2	3
OVERALL CO	2	1.4	2	1.2	1.4	2

(1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively